



Summary report
including guidelines and outcome of the interviews

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Summary of the report

This report documents the outcomes of the analysis of interviews carried out with physicists working in GENERA Consortium member and partner institutions. It constitutes the Deliverable 2.3 of the GENERA project.

The goal of interview analysis is to **identify gender balance conditions in physics through assessing career paths of successful female and male physicists as well as the major challenges and obligations in their workaday life and evaluating the supporting and hindering conditions for their career progress**. Additionally, physicists' attitudes towards gender equality in science – including knowledge and evaluation of as well as support for institutional interventions aiming at counteracting gender inequality in physics – are explored. The idea standing behind the study is to provide recommendations for Gender Equality Plans in physics.

Two separate methods of interviewing have been applied: the semi-standardized interviews and the expert interviews. With the use of semi-standardized interviews, the individual aspects of workaday life of physicists, perceived and experienced gender discrimination and strategies to overcome barriers to career development have been verified. Expert interviews were carried out with physicists occupying leading positions in their organizations. The expert interviews were focused on gender discrimination and measures for fostering gender equality.

The members of GENERA consortium conducted 83 interviews, including 67 semi-standardized interviews with physicists and 16 expert interviews with leaders of the researched institutions.

Below we summarize the main findings from the study ordered in 8 major themes covered in the interviews.

Career paths of female and male physicists

- **New emerging career pathways**

The study reveals the transformation of the scientific pathways of the European physicists – the linear and predictable career model is being replaced by the shattered and precarious pathways of the labour market participation. The access to permanent or at least a bit more stable employment is very difficult. The model implies intensive mobility, short-term contracts, grant-funded positions and little predictability of the career.

- **More holes in the leaky pipeline**

Reconsidering the popular leaky pipeline metaphor, in the new career model the pipeline has many more potential holes, when women-scientists could leave scientific work.

- **Challenges in family-work reconciliation**

Family-work reconciliation is more difficult within a new career model. In the context of a precarious and unpredictable pathways, young female (and male) scientists postpone decision of having children or resign from childbearing. The arguments include most of all unsecure employment situation, but also demand for mobility, competitiveness and pressure of constant work.

Work conditions and environment

- **Physics is a passion which demands more and more working hours**

Physicists positively evaluate their own engagement in work and often underline personal enthusiasm related to being a physicist. More critical reflection appears in the context of organizational commitment, which includes assessments of own satisfaction

with respect to work conditions. While some of the interviewees demonstrate high level of satisfaction when it comes to a type of contract, salary, access to laboratories and equipment, others express rather dissatisfaction concerning:

1. a new self-financing model impacting both employment policies of a given institution and research;
 2. being flexible when it comes to the demands of the academic labour market (e.g. being open to migration, short-term contracts);
 3. unclear and fuzzy boundaries of work time;
 4. proliferation of tasks and responsibilities and general work overload.
- **Team work matters**
Physics is perceived as a discipline based on team work, especially when it comes to experimental subfields on the one hand, and conducting research through implementing international projects. Majority of the interviewees is satisfied with their work environment, which they find stimulative and supportive. Critical evaluations concern competitiveness among physicists which is not always based on fairness and clear norms.
 - **Physicists as managers**
In the context of emerging additional responsibilities, related to e.g. administration, project management, teaching, a new role of a researcher has been underlined. Metaphorically speaking, **physicists become managers** responsible for taking of their time, team, career and finances for the research.

Mobility, migration and internationalization of science

- **International means successful**
International mobility is considered an indispensable element of a scientific career, critical for science development and for improving the functioning of academia. In some physics domains, it remains unavoidable due to needed access to equipment for conducting experiments. Mobility is a tool for developing and intensifying international collaboration, thus limited access to mobility can hinder one's career. It is important to stress here that stage of one's career (being young or senior researcher) can differentiate experiences and barriers related to mobility.
- **The pressure to be on the move as a burden**
The forced migration in search of job positions constitutes a burden to young researchers faced with temporary job positions availability. The difficulty to reconcile mobility with care obligations is a challenge especially in women's career development, but multiple migration experiences become problematic to both women and men. In double career couples, the need to follow a partner may cause downgrading or abandoning scientific path.

Evaluation of scientific networks

- **Better to belong – networks as career pushers**
Among main advantages resulted from participation in the networks, physicists list an access to information and its importance for career development. Scientific networks often serve as a crucial source of information about the newest publications, important discoveries, conferences and events. In a more instrumental understanding of its use they also provide an access to journals and publications. The networks are sometimes perceived as career pushers as they help to gain visibility and make new contacts what may in the future result in new collaboration opportunities or even job offers. Some of

them promote gender equality in their structures and among their members what has been noticed and positively evaluated by the respondents.

- **Informal means good**

Some interviewees express a belief that the best solution to develop one's career and scientific goals is to have an informal, small group/a team of collaborators. In this context formal membership in the networks is not always something desirable by physicists.

- **Women-only networks are important, yet not recognized**

Women-only networks are not very popular and well-known among physicists. Yet, if a researcher decides to join such structure, usually appreciates the benefits stemmed from it. These networks create a friendly social space for women, who can share their opinions, reflections and experiences with each other outside of sexist culture. Scientific organizations for women contribute to gender equality promotion.

- **Weak points of the networks – lack of recognition, sexist culture, fees**

Given the diversified experiences of the physicists, several weak points of the networks should be also mentioned. Firstly, their goals and benefits coming from membership are not always known and recognized by physicists. This aspect is related to both female-only networks and more universal structures and organizations. Secondly, the latter are sometimes still perceived as male dominated and not inclusive for women (in terms of sexist culture). Thirdly, being part of official networks often requires paying fees what for some of the respondents was quite problematic as they do not receive financial support from their universities / organizations in this matter.

Mentorship

- **Deficiency of female role models**

The GENERA study reveals an important role of mentors and role models in making and sustaining decision about pursuing own academic career. Mentors are defined broadly by interviewees as:

1. Teachers present in primary and secondary education;
2. Close relatives and family, providing necessary support during the entire career development;
3. Supervisors and other researchers;
4. Role mentors, understood both as famous scientists and important persons from private life. In this context, the lack of female role model is evident.

- **Good mentor, good career**

When it comes to roles of supervisors, their involvement in helping to find a job, including young researchers in scientific networks, searching for financial support for the research, building a productive team and friendly atmosphere at workplace, is highly appreciated and sometimes substantial for own development. Sometimes mentors are also positively evaluated for their personality and high ethical standards at work. Mentorship oriented specifically to women is rarely experienced by physicists, but the need of such guidance was expressed by several interlocutors.

Reasons for domination of men in physics and existing barriers to women's success

- **Growing awareness on gender imbalance in physics**

The discussion around the gender imbalance in physics turns from “the problem of women with physics” to the “problem of physics with women” indicating for the raising awareness over female low representation or even absence.

- **Social gender norms crucial for the scientific workplace**

The most commonly mentioned reasons for male domination in physics are located *outside* the field and relate to socio-cultural norms and values. They include processes of socialization and reproduction of gender stereotypes in youth (male figure of a scientist, different predispositions of gender towards scientific work) and the cultural expectations towards women’s role within family with priority given to male career. Other determinants for low women representation relate to the *specificity of the field*, with a demand of the full dedication to science, as well work organization – precariousness at the early career stage, demand for mobility, high competitiveness.

- **Masculine working culture carries on**

Cultural norms and stereotypes clash with international organizational issues create difficult conditions for women’s career – cultural norms that work in favor of men, when matched with new principles for work organization can have even more deterrent effect for women’s career. This is seen in two areas. First, the cultural norm of men as a scientist creates a masculine working culture, with growing demands for competitiveness and dedication to work. Second, reconciling work and private life becomes more difficult in a more precarious model of career demanding mobility, as well as it brings new challenges for partners in dual career couples to continuing scientific work.

Experience of different treatment - microaggression and discrimination

- **Microaggression – a common experience**

Female physicists more often declare being unequally treated in their workplace than their male counterparts. Subtle forms of different treatment – conceptualized here as microaggressions – prevail over the overt gender discrimination. Identified forms of microaggressions experienced by a significant part of female physicists include assumption of inferiority, restrictive gender roles, sexist jokes, invisibility and sexual objectification.

- **Microaggressions can make female physicists leave science**

The significance of microaggressions is far-reaching: they signal deprecation of professional position of female physicists, evoke negative emotions in women and their accumulation may contribute to leaving science.

Institutional aspects of gender equality

- **Scientific institutions can foster gender equality**

Physicists widely recognize a role of institutions – including research institutes – in fostering gender equality in science. According to most of the respondents the main area of intervention for institutions is the wider cultural environment of science, including educational process.

- **Family should be more welcomed**

Interviewees see also a necessity to take deliberate actions towards better reconciliation of work and private life. The most desirable solution seems to be childcare facilities provided by the employer.

- **Need for supporting transparent rules of employment, stable jobs and mobility**

As far as measures in hiring, retention and promotion are concerned the respondents underline a need to assure that the criteria and processes of evaluation are always objective and transparent as well as long lasting. Equally important seems to be acting

against precariousness of physicists, understood as insecurity and instability of work due to the dominant pattern of employment through multiply temporary contracts. Facilitation of mobility is also seen as a vital task for institutions.

- **Insufficient knowledge of gender equality measures**

Many physicists declare that their knowledge about gender equality measures and actions taken by their institutions is limited, which is believed to be the effect of ineffective dissemination of information on the undertaken activities. Additionally, those who affirm awareness of existing gender equality solutions, find them sometimes misguided and ineffective.

- **Ambivalence towards affirmative actions**

While institutional interventions targeted at pupils and solutions for enabling reconciliation of work and private life are mostly evaluated positively, implemented measures concerning recruitment and promotion meet with various evaluations.

The most disputable measure for gender equality in science is affirmative action. The majority of interviewees point to negative aspects and side effects of implementing special measures, and especially quotas. These solutions are argued to indeed counteract the idea of gender equality by breeding prejudice against women and being discriminatory for men. Further, they are believed to be harmful to the quality of science by lowering its criteria of evaluation and breed resistance due to their imposed character. The prevalent argument for implementing special measures is the belief that they are the accelerators of desired social change towards gender equality.

Recommendations for Gender Equality Plans in physics

The analysis of interviews allowed to identify a number of specific institutional and cultural barriers that female – and to a certain degree also male – physicists face in their career paths. To remove these barriers certain measures need to be implemented in research organizations. Beneath a handful of recommendations for such gender equality measures is discussed. Yet, it is important to stress that in any case specific needs of an organization should be taken into account, so that Gender Equality Plans can serve as a successful tool in fostering gender equality in a given context.

Raising gender awareness and disseminating knowledge

- Importance of raising awareness about determinants of low women representation in physics;
- Including different groups of physicists (male, female, young, senior, from different subfields) to the debate on gender equality in physics;
- Disseminating information about different actions, measures and initiatives among physicists. Any actions and measures towards gender equality need to be always widely disseminated and engaging as many as possible stakeholders. The information about the measures should be presented in an attractive and communicable form;

Promoting anti-discriminatory attitudes, knowledge and actions

- Organizing anti-discriminatory trainings and workshops for all men and women – with special attention given to recognizing and coping with covert gender discrimination and micro-aggressions;
- The necessity to sensitize both research institutes' leaders and employees to the problem of covert gender discrimination and micro-aggressions which seem to be inevitable, especially due its' frequent unrecognizability and alleged harmlessness;
- As special measures seem to be widely questioned, they should be used cautiously and tailored to the institutional needs by weighting their pros and cons. Their implementation should be preceded by well-designed informative action.
- Supporting various initiatives that promote gender equality among physicists by building broader anti-discriminatory networks;
- Creating formal and informal women support groups and networks.

Developing gender sensitive mentoring programs

- Developing mentoring programs for women and men at early stage of their career;
- Including empowerment measures for women and gender equality perspective to the mentoring programs

Promoting a family-friendly and fair workplace

- Promoting a family-friendly atmosphere in a workplace by e.g. organizing a changing room for children in department, children playrooms, accessible childcare facilities located close to a workplace.
- Promoting fairness and transparency in the employment policy;

- Promoting transparency in procedures concerning access to scientific equipment, conference/short mobility funding, presentations at internal workshops etc.;

Promoting diversified forms of mobility

- Promoting international mobility by taking into consideration various needs and capacities of researchers;
- Promoting diversified forms of mobility, e.g. long- and short-term mobility, an individual and with a family mobility.

Introduction

This report documents the outcomes of the analysis of interviews carried out with physicists working in 11 GENERA Consortium member institutions and in one institution having the status of an observer partner. It constitutes the Deliverable 2.3 of the GENERA project.

The goal of Task 2.3, carried out under the GENERA's Work Package 2 Status of research intensity advancing GEP activities in Europe's RPOs and RFOs and led by the Jagiellonian University's team of GENERA researchers, is to **identify gender balance conditions in physics through assessing career paths of successful female and male physicists as well as the major challenges and obligations in their workaday life and evaluating the supporting and hindering conditions for career progress**. Additionally, physicists' attitudes towards gender equality in science – including knowledge and evaluation of as well as support for institutional interventions aiming at counteracting gender inequality in physics – are explored. The main idea standing behind the study is to provide recommendations for Gender Equality Plans in physics.

The conducted interviews and their analysis have focused on three specific issues. First, the obligations and challenges in the workaday life of physicists are checked for their gender relevance. This analysis covers the problems of new emerging pathways and new challenges in the career paths, work conditions and work environment, mobility, networking and mentorship. Second, the interview results are examined to identify the dimensions of gender inequality in physics and compare views on their determinants. In particular the perceived reasons for domination of men in physics and existing barriers to women's success as well as personal experiences of unequal treatment are discussed. Third, the interview results are verified for strategies to overcome barriers and other system immanent limitations that hinder female researchers in their career development. This analysis covers physicists' opinions on the role of research institutions in fostering gender equality, their attitudes towards introducing special measures and their assessment of specific activities undertaken by their institutes to enhance gender equality.

The selection of themes in both semi-standardized and expert interviews have been supported with the findings from a comprehensive review of literature on gender aspects of science and academia (*Report D2.2 on how to improve the research cultural environment*).

The report is divided into 2 main blocks. In the first part we discuss methods that were used to conduct interviews and their main challenges. In the second part we present in detail findings from data analysis ordered in 8 major themes covered in the interviews. These themes include: Career paths, Work conditions, Mobility, Networks, Mentorship, Reasons for dominations of men, Experiences of discrimination, and Institutional aspects of gender equality. Additionally, the appendix consists in interview study methodological guidelines.

Methods

In order to gather all necessary information for dealing with the problems discussed above two separate methods of interviewing have been applied. The first one – the semi-standardized interview – were introduced to the interviews carried out among physicists, both female and male. This method is based on an assumption that people in general as social actors construct their “subjective theories” about their life and experiences. The notion of “subjective theory” refers to the fact that “the interviewees have a complex stock of knowledge about the topic under study” (Flick 2006: 155). Some of the information could be delivered by the respondents in an explicit way, the other information (“implicit assumptions”) must be articulated with a support of methodological aids (e.g. several additional questions). A general rule is that in every sub-section of the interview the interviewer starts with an open question (usually very general) and then asks several following more detailed questions. With the use of semi-standardized interviews, the individual aspects of workaday life of physicists, perceived and experienced gender discrimination and strategies to overcome barriers to career development have been verified.

The second method – the expert interviews – was applied to the interviews with physicists occupying leading positions in their organizations (such positions usually meant rectors, deans, directors, project leaders, etc.). This technique is usually applied in the research with a very specific and restricted area of study. It helps to exclude from the interview all unproductive topics that may occur e.g. during the narrative interviews. The expert interview is therefore centred around a very specific topic and organized by a list of questions. The expert interviews were focused only on gender discrimination and measures for fostering gender equality.

The main aims of this qualitative research were to:

- analyze women’s and men’s career paths in physics, especially structural, political, organizational and cultural barriers to and factors that enhance their success;
- identify successful approaches and innovative ideas for gender equality measures in physics oriented research field and successful gender actions of institution and countries for strengthening women’s careers in physics and leading to reaching better gender balance in their participation;
- define set of immediate implementation activities for all other partners and countries to be included in Toolbox and Gender Equality Plans.

The members of GENERA consortium conducted 83 interviews, including 67 semi-standardized interviews with physicists and 16 expert interviews with leaders of the researched institutions. To include various perspectives, experiences and standpoints the research sample for semi-standardized interviews was diversified to include both female and male physicists as well as researchers occupying various academic positions (from postdoctoral researchers and research assistants to full professors in physics) and specializing in many sub-disciplines of physics. Three interviews were conducted with physicists from emerging fields.

Table 1. Study sample

Country	Physicists				Leaders (L)		TOTAL
	Female (F)		Male (M)		Female	Male	
	Young (Y)	Senior (S)	Young	Senior			
Germany – 3 institutions	7	2	1	1	4	3	18
Netherlands	1	-	-	1	-	-	2
Italy – 2 institutions	3	4	2	2	-	1	12
Spain	4	3	1	1	-	-	9
Switzerland	1	1	-	1	1	1	5
Romania	1	3	1	2	1	1	9
France	2	1	1	1	1	-	6
Poland – 2 institutions	5	7	2	5	1	2	22
Total number of interviews	24	20	8	14	8	8	83

The 12 institutions from 8 countries represented in the sample are research performing organizations, including both physics research institutes and physics departments of universities.

The inquiry was performed in 2016 and 2017. The partner institutions followed a research manual comprising semi-structured and expert interviews scenarios¹. For each interview a structured note with exact citations from a narrative was prepared.

Challenges regarding the fieldwork

Although the data have been collected according to the research plan, several challenges related to gathering information and preparing structured notes for further analysis had to be responded to by the research team. First and foremost, in terms of the sample not every regional team managed to include physicists working in emerging subfields to the study. The national samples differed from each other with respect to: 1/ a number of conducted interviews (from 2 to 11), 2/ internal diversification of the interviewees when it comes to gender, age (young or senior researchers), position (being in a leading position). The structured notes used for the analysis are as well very diversified: while some of them were composed of long, narrative and informative citations from the interviews, the others presented only short citations and descriptions. Not all notes covered every topic addressed in the interview script.

Coding and analysis

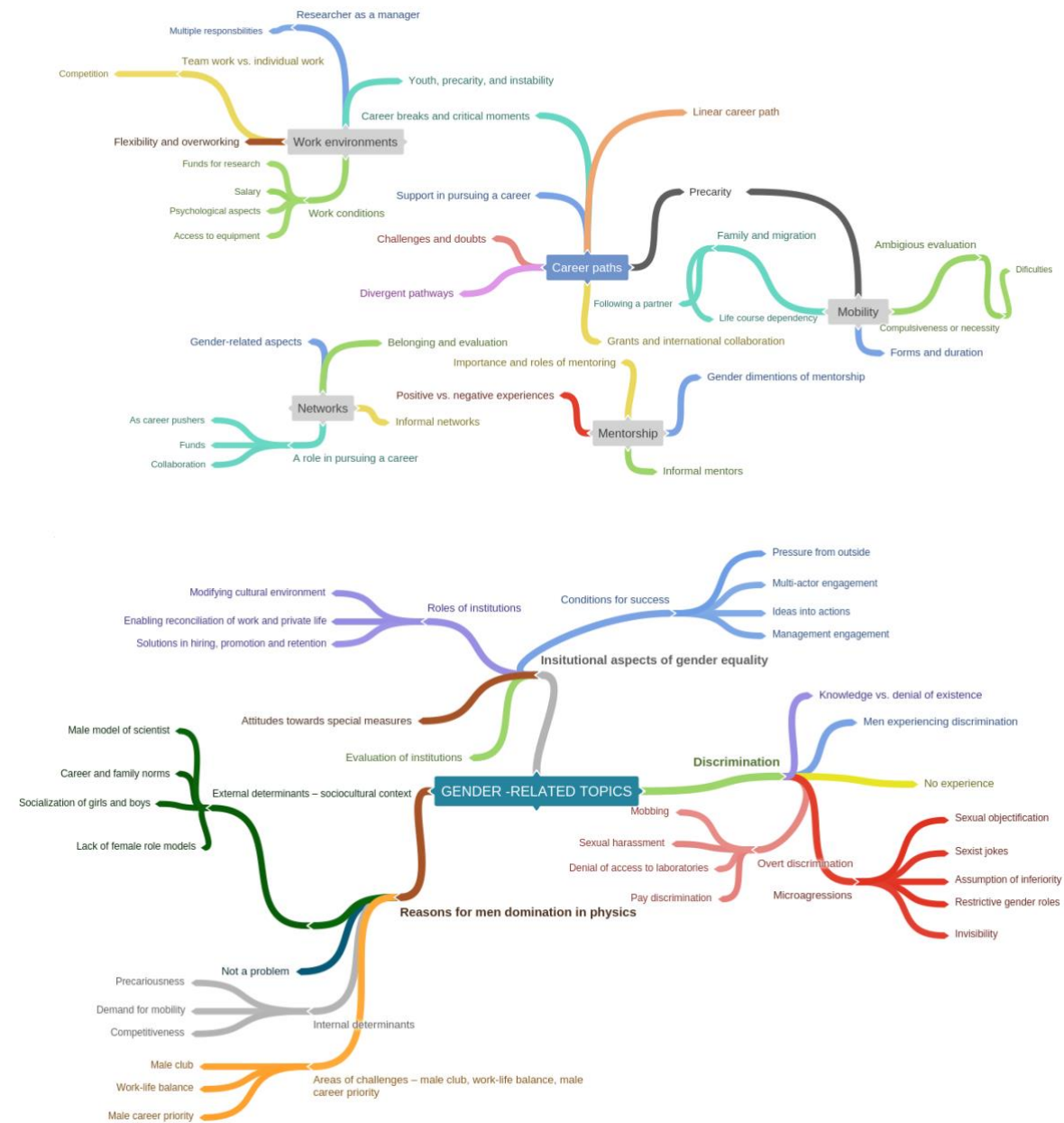
In the study both open and theory-driven codes were applied. Codes in qualitative research are often defined as "a word or short phrase that symbolically assigns a summative, salient, essence-

¹ In one partner institution (Spain) the study was conducted on the basis of a different scenario due to the fact that another, very similar, internal research was carried out. Most of the topics covered by both projects were however analogous, what enabled use of gathered materials for the GENERA analysis.

capturing" (Saldana 2010: 3). Open coding describes a process of reflective reading through collected data and creating tentative codes emerging from the materials. The codes are then integrated in more abstract and universal patterns. Theory-driven coding means using theories and research findings to create codes before actual coding of the material. In the context of GENERA inquiry, *Report D2.2 on how to improve the research cultural environment* has been used as such a theoretical base. In the analysis the JU team undertook the following steps with regards to coding:

1. General categories (topics) on the basis of the literature review (*Report D2.2 on how to improve the research cultural environment*) have been used for the division of the materials into several thematic blocks, including career paths and their challenges, work conditions and environment, mobility, networks, mentorship, reasons for domination of men in physics, experiences of different treatment, and institutional aspects of gender equality;
2. The structured notes (and transcripts from one institution) were uploaded to QDA Miner program and assigned to each region (a country). Basic variables (gender, research experience: young/senior, position: being in a leading position) were assigned to every uploaded document.
3. Each researcher (four sociologists were involved in the analysis) applied open coding to the given materials.
4. Finally, the codes were verified, ordered, and integrated in more general categories in order to avoid repetitions.

The trees of codes guiding the analysis are illustrated by the following pictures.



1. Career paths of women and men physicists – new emerging pathways and new challenges

Towards a new career model of a physicist: unpredictable, shattered and precarious pathways

The study reveals the transformation of the scientific pathways of the European physicists, similar to that experienced in other fields within academic world and even other professions – from the linear and predictable career model to one characterized by the shattered and precarious pathways of the labour market participation.

The linear and predictable career model in its ideal form is marked by stable employment usually in one institution (or few of them) on a full-time position for a prolonged period of time. This model implies the gradual advancement within an institutionalized framework, predictability of one's career path and an attachment to a university or a research institute. The entrance to the academia is difficult but once within it, there is a high probability of remaining. The linear model still persists in some of the studied countries (e.g. Poland, Italy), nevertheless with the new model also co-existing. The interviewed senior researchers often followed this model, but there were also some divergent pathways in their case.

Linear and predictable model

From the start of PhD studies my career was typical for the employees of the institute. 4 years of the PhD studies, then I waited for the review of the doctoral thesis. And more or less 8 years for habilitation. 74_F²

Shattered and precarious model

Very linear, I had my children very early so my PhD took a little longer. I studied in [name of a country] then I moved abroad for 2 post-docs and then came back to [name of the same country] and got a permanent job within a few years. 01_F

I am 37 years old, I have done several post-doctorates and I still don't have a long-term contract. (...) I hope I won't have this [situation] in 3 or 4 years. 33_M

Within **shattered and precarious pathways**, there are multiple entry moments to employment, as the need to apply for a position, re-appears almost after every step of the career. The pathways are less predictable and are characterized by the especially difficult period of precariousness at the early career stage. Once completed PhD, the recently graduated applies for the non-permanent positions usually of the period of 2-3 years (post-docs). The model implies heightened mobility, as work opportunities are often abroad and demand changing countries or continents. The advancement is non-predictable – the postdoctoral fellow may remain at the same level of the scientific ladder for an extended period of time.

I think this is a huge problem of the institute and an issue that the [institution] should solve. There are so few career upmove occasions, that researcher will stay for decades in the entry level, without any motivation to do better. 41_F

² Quotations used in this report have been fully anonymised. For each quotation we only indicate the number of the interview (01-83), interviewee's gender (F, M) and leadership position (L).

I know a couple of colleagues, who (...) now moved to England. (...) There the job market is completely different. So there you get a permanent position much earlier in your career. 06_F

The science labour market transformations are noticed both by young and senior researchers. The negative evaluation is especially voiced by the young generation. Due to the lack of permanent posts, some interviewed physicists were forced to participate in several post-docs in multiple countries (see chapter on “Mobility, migration...” on “Extensive burden of forced mobility”). Those interviewed who after one or two post-docs managed to obtain permanent positions usually evaluated positively their post-doc experiences, but those who did not manage to reach permanent employment after several post-docs remain frustrated with the lack of employment opportunities. They underline: high competitiveness, lack of career predictability, little stability, low attachment to institution that may hinder engagement, as well as difficulty to get engaged in some long term collaboration.

*It's the classical problem: I'm sure they want to hire me, but **we have to find the money** to open a permanent position and it's not so easy. It's **sometimes difficult to feel involved** and invested with its mission thoroughly, when we do not know if we will still be there in few years. A post-doc is very short, only 3 years on a research project. **We don't have so much time** and we don't know if we can continue our work after or not. Honestly, I have no idea where I'll be in 3 or 4 years, and **it's pretty frustrating**. 37_F*

*I am 37 years old, I have done **several post-doctorates** and I still don't have a long-term contract. It's starting to be a bit **difficult to cash in**; I sometimes ask myself if I've made a good choice of career guidance and if I should not change. At the same time I love my job, it's frustrating. I think the crazy number of precarious jobs is really a huge problem, and that is what makes many young people hesitate to choose this career. (...) **I could work now in a company**. But I like so much what I'm doing, it compensates this issue. I hope I won't have this in 3 or 4 years. 33_M*

*I don't **have a sense of belonging** because I know that **I'm precarious**, and it's not sure I'm going to stay here. 43_F*

The lack of permanent positions creates **a generation gap** in the research – this was especially stressed as a problem by senior scientists. The lack of young researchers in an institution is due to little investments and effects negatively whole community within in.

We tried to support every person with hope that maybe they will get interested in physics, stays for longer and we will have someone, someone who could rejuvenate our institution staff. We have some generation gaps, this is a problem. 68_M_L

It is not a pleasant workplace and it is not easy to work in our institute because there has not been invested on new people with new skills and then, after 10 years of abandon, the research quality is reduced. Workplace is not stimulating and there are not opportunities for growth. 39_F

It is interesting to add that in the eyes of some interviewed senior scientists the situation today was evaluated as better than some decades ago when posts were more limited, and there were little opportunities to apply for external funding. In the biographical accounts of some senior scientists one notices as well some periods spent outside academia, or unemployment spells. There were also situations in the previous generations of precarious employment or even unpaid

positions, e.g. some senior researchers said that due to lack of permanent position they were on short-term contracts for even 10 years – but within one institution.

I've started in my Institute with a research grant and after I had 10 contracts for 12 years before being permanent. 42_M

I had for six year a collaboration contract as student at my actual research institute without wage. Not asked I took a long time before having a proper contract, so I think my career was quite slow at the beginning. 41_F

I'm not sure what the supply of job positions was, but I think it was smaller than now, because there was less money for academia, so the supply of job positions was smaller. Currently there are more job positions, not only academic, but also in grants. The positions in grants appeared in last ten years, previously the grants were not enough to have any post-doc or a doctoral student (...) One received PhD and one had to look for a job and either you had this position or you dropped out. 54_M_L

I left with my husband who received a post-doc position, and I went without about promise that I will be employed. So when I arrived I sent application to many research organizations (...) I was even a volunteer as the University, I was not paid, but I had access and that's important. Scientific world is open, when a person comes and says that they are volunteering, institutions are happy to give them a space to do what they want. 58_F_L

Precarious pathways – characteristics and processes

Today the internationalization of science requires from researchers **intensive engagement in mobility** – a lack of positions in one's country strengthens this tendency of searching for employment in other locations. Advantages of the mobility are underlined by most interviewees, nevertheless the extensive mobility model is not welcomed – while an experience of working abroad is valuable, becoming a vagabond scientist is seen as counterproductive. Mobility is attached to the early stages of the career and young age, and prolongation of this phase is negatively evaluated. The advantages and difficulties for female researchers are described in the chapter on “Mobility, migration and internationalization of science”: first, the family duties and partner work obligations constitute a barrier to mobility, secondly in dual career couples it is more often women that is expected to give priority to a male partner's career:

I was working 11 years abroad on nonpermanent or permanent positions. 79_M

After the PhD, you will normally spend around 15 years with 2 or 3 year-contracts and moving all over the world. This is not a very attractive career prospect. 30_M

I didn't used to find it difficult but you have to consider, I started moving around places already in January 2005. (...) And now of the several years [of moving around], I find it increasingly difficult to do this over a longer period of time, not really knowing when this state is going to come to an end. 15_F

Second trait of today's employment patterns described in the interviews is a growing presence of the **grant-based positions**. The responsibility for securing funds for one's employment is placed on the candidate not on an institution. The need to find money to fund one's post is a lengthy and time consuming process, followed by administrative burdens in grant management, which distracts from scientific activities. Still, interviewed researchers stress that the moments

when they received the grants constituted usually an important milestone in their careers (confirming excellence), and they were important turning points, as simply allowing them to continue their work as physicists:

Milestones in my career include getting a PhD grant, becoming part of the staff... 32_F

The turning point has been the ERC [grant]. 48_F

Quite recently, the financial situation and the support for researchers are really complicated. We have to spend most of our time to make applications and huge paperwork for almost nothing. The ratio between the effort and what you get for it is just a disaster. So if I had known this evolution early, I think I would have done something else. 35_M

After the grant system is exploited, there should come a stage of obtaining a permanent position. The interviewed physicists observe that the grant-based employment is available only at some stages of a career – there are plenty of opportunities for PhD scholarships and quite many for Post-docs, while the funding opportunities at later stages of the career is not so available anymore in such extent. Getting a permanent post constitutes a critical point in the career – permanent positions are rare and those who obtain those are by some interviewees perceived as “lucky”. This contradicts with the meritocracy perspective of some other respondents, but on the other hand may indicate the belief that excellence in today’s conditions may not be sufficient to remain within academia.

*You must have also a plenty, plenty, plenty of luck. And I have the feeling that **in science you need just even more luck than in industry**. And thus, that there is an end someday, so some day you will be a professor or you will be permanently employed. And from these few permanent positions there are even less for professorships. So, in this groups, someday there will be one professor and one or two scientists with permanent contracts. 22_F*

It is a very competitive field, and I feel... to be honest, when there is a position and 10 people would apply I think I will not get the permanent position. (...) Many PhDs, but no prospects to get a permanent job. 51_F

I know what I have to do which is working hard and publishing a lot. But other things are not in my hands, such as the number of positions that will be offered in the future. 24_F

In the new model, the unemployment periods can happen in between positions. In the senior researchers account, these appeared usually after obtaining PhD. As one respondent from Spain described, she “suffered the *threat* of being unemployed several times.” Similarly, in between positions may happen periods of atypical employment e.g. a young female researcher did internship to wait for the PhD position.

I was unemployed for a year and a half. (...) when I was defending my PhD thesis I was already in second pregnancy. (...) I had a plan to give birth and stay at home for 9 months, but later, after these 9 months actually it was that I had no employment for another 9 months. 56_F

Just after my master, there was some issues, financial and administrative, to create a PhD position for me. My supervisor tried anything, but it didn’t work. Finally they

recruited me on a paid internship for a few months, to make a transition and allow me to work. 37_F

I took one year of parental leave following the birth of my second child. [while searching for another position]. 03_M

I was unemployed for a year. 27_F

While the job positions in a given thematic area may be difficult to obtain, some researchers decide to undertake research **in a different subfield**. Such decisions are evaluated as having a slow-down effect for the career, but there were also opposite cases. The change of subfield is usually described as problematic as the more focused career model, when a person sticks to a theme of research, seems the most expected.

[Interviewer: That means when you move together then it is likely that at least one of you is unemployed?] Yes, yes, in any case. Because of this and that was one of the reasons why I took the Post-doc here. Despite the fact that the topic was thematically quite far away. (...) I have a pretty general degree, also general education, and then I changed fields a few times and yes, I was told, yes, but they love people who have such a, such a [Interviewer: broad?] yes, exactly, such a broad education or something like that and now it turns out: no. (...) so at least in Xxx [country of the interview] it is the case that most people do their Bachelor thesis, their Master thesis, their PhD and their Post-doc in the same group and for that they are experts. And they get all the grants [proposal writing] and they get (.) probably a professorship eventually. 07_F

It is difficult finding a senior position in Xxx [one of the experiments run by an international collaboration] if you have changed fields. They don't want to pick you, when they can find someone who has a lot of experience with that detector for most of their career. (...) I have progressed fairly fast through my career but not directly because I switched fields after my PhD. 03_M

Pathways of physicists – differences between countries

The career pathways are changing between research generations – through our limited data we can say that the linear model with low tradition of mobility between institutions/countries still dominates in some countries – such as Poland, Italy and Romania, to some extent also Spain. The shattered model is more common in Germany, France, Switzerland or Netherlands. It is important though to stress that also in the first group of countries we observe a transformation of employment forms – while the system has not yet transformed as such, we see that one way to deal with a lack of regular positions is today realization of multiple grant-based positions one after another. From outside the person employed on multiple short term grant-based contracts within one institution appears embedded within the system, while in fact this person experiences consecutive periods of precariousness– this was already a case e.g. in previous generations in Italy.

Table 2. Most common pathways of physicists from different countries on the basis of interview data.

France	Shattered pathways, new model of a career with intensive mobility and migration – having worked in few countries in each case. The career model is PhD-post-doc – post-doc... or finally permanent position.
Germany	New model with forced mobility at the early career stage – post-doc abroad after PhD, later trying to find a permanent post in Germany. Some mobility within Germany between institutions.
Italy	Linear pathways, staying in one institution, little mobility. Precariousness also in a linear model – a chain of short term contracts in one university for female senior researchers (or single father), finally leading to permanent post. For younger researchers, positions that are project funded (grants) after PhD grants.
Poland	The career model is: PhD-habilitation-permanent position. Linear pathways, usually an experience of working at one institution. Some senior researchers entered academy at the later stage after working outside for some time due to lack of positions in academia. Longer mobility periods integrated within employment, particularly at post-doc level. Emerging grant-based model: example of person whose positions are funded through grants still all located in the home institution but with integrated mobility, rather short term mobility.
Spain	Pathway is partially linear and partially shattered. The PhD grant is a first milestone, obtaining post doc position (often grant-based) is a second milestone, a third one – permanent position. Those can be made in one institute – no pressure of mobility. In the senior researcher accounts, permanent positions were obtained directly after PhD completion (no post-doc).
Romania (limited data)	The career rather experienced as linear, but some researchers who arrived to an institution from abroad had an experience of shattered pathways.
Switzerland (too few cases, limited data)	Indications for precarious model. The career model is: PhD-post-doc-permanent position.
Netherlands (too few cases)	Indications for precarious model.

More holes in a pipeline - challenging moments in the career for female researchers

The difficulties in finding a permanent position after the multiple short-term contracts are the most difficult aspect of nowadays career as a scientist, it is important to say that this is a problem

for both men and women. Nonetheless, these transformations have different effects on women and men scientists and they both undertake different strategies to navigate these.

When considering the new model of a career path and reconsidering the popular leaky pipeline metaphor (Bennett 2011, Etzkowitz, Ranga 2011), it appears that the shattered pathways create new potential moments of the leakage, or in other words – drop out. In a linear model the most possible moment of drop out was during the PhD or after concluding PhD, or in case of not completing habilitation (even if in some institutions there were institutionalized ways to retain such researchers on some secondary posts). In a new model, **the pipeline has more potential holes**. After the completion of each post-doc, there is a need to reconsider one's career and also to go through recruitment procedures for a new position. When there are so many points of "re-entrance" this causes more risk of leaving science.

Matched with hesitation or self-doubts voiced often by the interviewed female physicists, unfavorable atmosphere, encounters with bias, preference for male career model and others – this creates potential moments of leaving.

Every time a contract was coming to end, I wondered: "should I stay or should I leave the career?" I have been lucky I did not give up. 28_F

In their stories women were generally prone to voice doubts about their career, about their presence and contribution to science. They complained about the competitiveness, and precariousness, as well often voiced the doubts in their skills – some of them were aware that possibly those doubts can cause the situation that women leave science and were linked to the internalized stereotypes of science as a male profession. Female respondents were more open to critical position towards their choices and indicated moments of doubts, men rather presented linear pathways and concentrated on description of the career from the science perspective – nevertheless men as well complained about the new situation concerning employment. The moments when doubts or hesitation appears are linked to the career path (particularly the period of the university studies), physics as a field (e.g. masculinized culture, microaggressions, discrimination), but also to private life (e.g. having children, relationships, dual career couples employment decisions).

Summarizing, similarly to other critiques of leaky pipeline metaphor (e.g. Bennett 2011), our study shows that the career model is more and more often not similar to a pipe, but shattered and unpredictable with divergent pathways (see more in the last subsection of this chapter). Nevertheless, the results also point to the fact that while the linear and predictable career model is the one expected and rewarded, even if so difficult to realize or also unwanted, there appears a need to renegotiate the normative model of a physic career. The new model could be more embracing, allowing and recognizing divergent pathways, interdisciplinarity and cross-fertilization between fields/subfields, valuing contribution within teaching, administration, socially-oriented initiatives (e.g. promotion of science) and recognizing need for private life commitments (cf. Bennett 2011, Miller, Way 2015). Finally, in some cases, the pipeline may be just simply blocked for new entrances – of both women and men – due to lack of permanent positions offer.

Family formation decisions and precarious career paths

The female respondents indicate the moment of family formation as impacting on their career path. For many of them, having children causes a slowdown in the career (confirmed by

quantitative survey: Ivie, White 2015), and results in several limitations which include: impossibility to be as mobile as before having children, limited time for work because of care obligations or tiredness. Even those who did not have children, notice that needing to consider partner's career choices can have also limiting impact e.g. when it comes to choosing a location.

If you look at the career of female physics professors that are now 50 or 60, both often they don't have children as the male colleagues almost always have. 18_M_L

Children were influent in the sense that they limited the options I could consider (...) Of course it impacts your career if you get a maternity leave once and again, you travel less, go to few conferences and publish less, just because you are exhausted. 27_F

The most problematic is international mobility, especially when having small children that require constant care and support from other family members. 56_F

In the interviews, it is remarked that there exists an image of a scientist being an elderly bachelor and a pressure of women to remain childless. Other studies as well notices that in STEM family is perceived as hindering success in research (e.g. Godfroy-Genin 2009). One respondent is even describing how her PhD supervisor required from her declaration on resignation from childbearing before completing doctorate:

It is shocking how female researcher profile is oriented towards single or married with another researcher. 30_M

If you decide to have children, you stop publishing. You cannot keep this pace of work with family. You have to slow down. Career breaks are not valued in science. If you stop to form a family, you have expelled yourself from the system. 31_F

When I searched for PhD supervisor (...), he said something like that: no child, you need to promise me or a child or a doctorate. And then, I of course said, fine. I thought what will be, will be, but from the perspective of a 44 years old without children, I see that this was binding. (...) I have it coded in my head that having children does not fit with work. (...) only later I started to meet women physicist with four children, active in civic society, heads of departments, and are doing well. 65_F

It is important to say that family is not only seen through the lenses of limitations. The family is also given value and many remark that both spheres of life have for them great value. Some of the respondents having children try to abolish the vision of a scientist as a person who does not have children, bringing forward the vision of balance between those two spheres of life. There are also those who tell that family or children can be seen as auxiliary to career and notice that engagement in family life and contact with their children gives them a certain distance to their work or that a break due to pregnancy allowed her to overcome work crisis as she had more time to reflect better on her career plans (cf. Godfroy, Genin 2009).

We did measurements and then it appeared that what was supposed to be basis for my habilitation is not appropriate. And then, came my second pregnancy and second break, thanks God! I needed it. And when I came back I realized I need to give on basic research and do something which is easier, where you do not need so much time to get a result, but few months. (...) second pregnancy – when I it was needed and I reorganized my future plans. 61_F

The interviewed parents underline that with determination, good organization, institutional and personal support it is possible to realise a scientific career and have children. Having a partner who is an engaged parent with the additional support from institutions and extended family is mentioned as critical.

Well, I..., so-called dedication to science, I think it is very controversial to say that you can devote yourself to science (laughter), because I know people who have scientific achievements and family and so they devote to both. It is a certain compromise, a person tries to feel comfortable, but surely there is also the issue of choosing to go abroad and [to establish] international cooperation. (...) I believe that sacrificing family life for science is not a proper definition, because if the family is organized well, there is a lot of support, family support. 60_F

*Yes, yes, he supports my career, for instance he has taken parental leave. That means **we shared the parental leave** and each of us took 7 months (...) he stays at home when our son is sick or something. So there he does support me. 06_F*

***My husband is very supportive** in my career, helping with the child, adapting his schedule after mine when it's necessary and others. 75_F*

*For me it has been very simple: I knew two weeks before my delivery that the city gave us a place for the baby in September in the **kindergarten**. As my daughter is born in June, September was exactly the end of my maternity leave. I was so lucky it's nearly outrageous for all the other families who have sometimes to wait months for a place! 34_F*

*(...) thanks to the fact that the husband could stay with children and the **grandmothers** could take leave from time to time, because both of the grandmothers are employed, and help us, I could go often abroad. 53_F_L*

The flexibility of the working time in scientific work is also underlined by parents as an important element of reconciliation work and family duties. Self-regulation of working hours in a competitive labour market though can create a pressure of a constant work and result in a total colonisation of private life by work (read more in “Work conditions and environment”). Those scientists who are mothers try to regulate the hours spent in work but the limited amount of hours that could be devoted to work make them often frustrated or disadvantaged in comparison to those who do not have children and can stay endless time in laboratories or offices. On the other hand, parents underline the advantages of the flexible working time and indicate that it helps them in balancing duties in work and in family:

As I try to devote to my child when I'm home, I don't open my computer before she sleeps. It means I have fewer hours to work, even if I have still the same workload. It's frustrating from this point of view: I'm very happy to be a mother, but it obviously hurt my worktime. 34_F

I had the chance to balance my work and my duties as I preferred, thanks to the flexibility of my work. 41_F

It is always hard [to reconcile work and family life] but it is easier for sure when having flexible working hours, for sure it is easier. 56_F

In the context of precarious and unpredictable pathways, the decision to form a family and have children becomes difficult. Young female scientists postpone decision of having children or resign from childbearing because of their unsecure employment situation – this decision is hard especially when both of potential parents have precarious work contracts. The period of precariousness at the early career stage (post-doc period after PhD) coincides with the time of having children (usually women are about 27-30 when completing their doctorate). As described also in the chapter of mobility, the post-doc period includes usually international mobility – the expectations towards post-docs are high and demand full-engagement. This particular pressure on high engagement in early career is noticed by other studies: “individuals facing tenure review must demonstrate high levels of competence and research productivity in the earliest years of their academic career to avoid losing their jobs” (O’Laughlin, Bischoff 2005:83). The post-doc period being intensive, some suggest that the best time for women scientist to have children is during their PhD – this shows for the actual belief that the physicist career path choice demands the adjustment of a private life to work expectations.

My impression is that now when it takes so long to have a permanent post, for women the best moment [to have children] would be during a PhD. Afterwards during post-docs if you are missing half a year of a post-doc that's very difficult. Then you are really behind in your CV compared to others... If you are in such a competitive field as becoming a scientist it is never easy to have half a year off. If you wait until everything is perfect as a woman you are too old. 01_F

Precariousness influenced my life in terms that I and my boyfriend couldn't go live together. Now I've been wondering about being a mother and, even if I know that earlier is better I also know that it is not going to be possible in several years unless I decide using my saved money. 43_F

Women at the end of the PhD are concerned about how to realize something concrete, such as to make a family. I like doing research, but if the stability perspective is in ten years from now, it is a problem. (...) it is a problem to be both non-permanent researchers to hypothesize the building up of a family. 46_F

[Interviewer: does your professional life impact or hinders realization of family duties?] Yes. [Interviewer: some conflicts emerge?] Yes, yes, yes. It is what we were talking about earlier – the employment policy – and my unstable situation at the university. It was hard for me to intentionally decide to enlarge a family when I had a contract signed for 3 years and after these 3 years no one knows what, for 3 years after 6 hard years fighting for doctoral results – I claim that yes [it has impact]. 57_F

Divergent pathways of female physicists

Emerging fields and interdisciplinary approach

Research indicates for wider presence of women in the emerging fields linked to physics such as physical medicine, biological physics as well as physics education research (Hasse, Trentemøller 2011; Barthelemy, Van Dusen Henderson 2015; McPhee 2016). Thus, the interviewees are asked about their opinion about this issue and about reasons for such processes. It is important to stress that a share of respondents did not confirm such a trend. But in some countries (for example, in Poland and Romania) this trend is observed by the interviewed physicists – they indicated mostly subfields such as medical physics and biophysics as adequate examples. Those subdisciplines according to interviewees are represented in some cases mostly by female scientists.

Um, yes, so, I believe you are more like to find women when, in astronomy, so at least in larger proportions, um, or as well, I believe more like in biophysics (...). 08_F

I had a meeting with a delegation from biophysics field. There were only women and only one man. 77_F

We also have biophysics which seems to be more for women, there is evidently more women than men, both in doctoral studies and under- and postgraduate studies”; “biophysics is more feminized, that’s for sure. 53_F_L

I have thought of the department of statistical physics, where part of work is related to biophysics (...), this is relatively new research direction. 54_M_L

When asked for the reasons behind such processes, the physicists indicated that new subfields are potentially an alternative to a masculinised field of physics allowing more career opportunities to women (cf. Götschel 2010). They as well point to their interdisciplinary character and lack of stereotypes attached to it. One of the reasons mentioned behind the wider presence of women in emerging fields was a more applied character of the conducted research, which – according to respondents – is preferred by women (cf. Hasse, Trentemøller 2011; Barthelemy, Van Dusen, Henderson 2015). It is important to say that in such explanation respondents relate to “innate” characteristics of women, thus also reproducing certain stereotypes. Finally, researchers also indicate that stereotypically some fields are assigned to women – e.g. biology, so in effect attracting more female students. All those explanations were rather hypotheses, as interviewees usually have difficulty to find adequate explanation for this process.

a) Not dominated by men thus perceived as more welcoming to women

At the junction of physics and medicine there is medical physics, where perhaps there are more women (...) while physics is this kind of science that is filled with men, when a new subfield emerges it is not laden with the firstborn sin, that it is assigned to this or another sex. And additionally if this subfield is interdisciplinary with one of the disciplines better populated with women, this might affect positively even in spite of negative image of physics? That’s how I can explain this. 59_M_L

b) Women more willing to do interdisciplinary research

Women can work across different disciplines, men stick to one, narrow, just physics. So When I look around, [women] they link... they have cooperation, competences they gained here are being matched with other competences... (...) [Where does it come from?] I have no idea. 64_F

c) Less limitation in the careers

I didn’t hear about that before but I can understand this choice. I know about female colleagues who feel limited in their career, so they try to look in an alternative. Emerging fields could be one. 33_M

d) Looking for discipline of applied character

I noticed at a conference, if there is a biophysics section, or medical physics, there is a lot of young women presenting. I do not want to say it is easier, but this is, also why I have chosen experimental physics, this is concrete, something that can be applied, that

can serve other people. Maybe it comes from our nature that we do not want to do something that is all abstract (...) When I deal with nanomaterials that can serve for treatment of cancer, this is much more telling and maybe more attractive. 70_F

(...) women started being engaged in physics which can be applied and goes beyond abstract reflections, (...). Although I can't say that running an experiment, revision and data analysis is not complicated, it requires as well specific skills, intellectual too, planning, anticipation and surely more women are here, especially in biophysics (...).57_F

e) Women choose less technical field

[Interviewer: Ah okay and the subfields which combine for instance biology and physics are probably not as respected? Or how is that?] Yes, it is a little difficult. But there is of course either more technology or more biology. That always depends (...). [Interviewer: and the more technology, the more (.)] More men (.). Exactly. [Interviewer: Because biology is no real science.] Yes, exactly. So for instance I remember, when I was still studying, the women, who studied biology, complained that there was not a single man in their program. Not a single one. In that engineering school as well. And then it was said, I do not know where that is coming from." 07_F

f) Stereotypes at the level of school education that guide students choices

Family/school induce the idea that maybe it is more proper/functional for a girl/woman to work in a less technical field. 82_M

Noteworthy, some respondents notice that emerging fields, as well as physics didactics are not perceived as a “true science”, thereof they are evaluated as less important by physicists. As Whitten (1996) suggests, physicists believe their field stand at the top of the hierarchy of sciences, with biophysics, and physics education at the bottom.

“[Interviewer: You said that, um, biology is more feminine and nanotechnology is more masculine. Do you have an explanation for why that is? So for you personally, based on your experience. Both are natural sciences.] Yes, whereby in physics it is said that biology is not a really science, but it doesn't matter (laughing). No science. No true science. 07_F

Didactics

While many of research participants work at university, teaching is a part of their work engagement (see “Teaching” in Work conditions and environment). The teaching vocation is not being recognized (cf. Whitten 1996), and there is rarely an institutionalized mode to engage exclusively with this part of the academic work:

In some research institutions there are such positions dedicated to physicists who become experts but don't want to get higher academic degrees, but there is practically no such thing here. There is no such thing in this department. There are no such posts as the senior lecturer, who does little research and focuses on didactics. Practically no such people are employed any more. The career path is only one. 61_F

In our sample, one researcher engaged in physics didactics underlines the difficulty to receive recognition for physics education, both personal but also institutional. The publications in physics education receive much lower impact factor than those in physics as such, what creates

difficulty in progressing in career due to impossibility of habilitation. Interestingly, she as well has founded an organization promoting education of natural sciences to children in elementary schools.

(...) the position [I was holding] was with indication for didactics so I started going to didactics conferences. In 2006 I went for my first conference of physics didactics and it opened my eyes to the fact that (...) people do research on physics didactics, because I had not known that earlier and then I thought “let’s do this too” (...) Lack of awareness [that there are different research paths in physics than in one’s home department] results in stereotyping and reluctance and a lot of things that kind which are, in consequence, nasty for us. As it is with [my] habilitation and this impossibility [to defend it here]. 56_F

Switching to industry as an option

Industry is mentioned by the interviewees as a potential option for employment – there are respondents who already plan to switch to industry, while some others still consider this as an option. Working for industry is described a bit as a pragmatic decision (linked to financial or logistic argumentation), in contrast to being a scientist which is seen as a passion or a vocation. The arguments for working in commercial companies include on one hand work conditions – respondents mention that the employment is more stable, it does not demand mobility, and the salaries are much higher. Also way of working is described as more satisfying – working in teams, having more immediate results. For dual career couples, industry is a way to find work for both of them in one location (usually one remains in science and another one works for a commercial company). On the other hand, industry is also seen as an interesting sector when a person can achieve success or engage in challenges utilizing their scientific knowledge which potentially have wider impact.

*Comparing my salary with my husband, yesterday we did our taxes clearing – my husband has also PhD in physics but he works for the industry – so **my salary is three times smaller than his**, so there is this disappointment. 61_F*

*You earn more in economy (...) I will go into the economy anyway. (...) science only, it is just not me. **I would prefer to really work together with several people**. Well, here you work alone almost the whole time. 23_F*

*And this is really a big issue why many people change into industry, into a less interesting job. The money is not the issue in general, but rather **the secureness which you get in industry**. And this is the most obscure: That our industry is more secure ... 20_M_L*

*“[I: Is he supportive of your career?] Yes. I would say so. We are having important discussions at the moment, because we are both looking for post-docs or maybe I want an industry job and one of us is going to have to compromise more than the other. And at the moment I feel like somehow socially it should be me. The stigma is there. I don't want to feel it, but I think it's just part of society still is this “women follows”. (...) [I: How likely is it that you both find something that you want to do at the same location?] **Both of us doing academia is almost impossible. Going into industry is possibly more likely**, but that really depends on the cities. And the country. 10_F*

But now however when I have this grant, I strongly consider working for the industry, because right now (...) there is this need for scientists and for people who do data

*analysis, who collect data by using artificial intelligence. It's **very interesting [topic], and what's more it has a great influence on what is going on in the world** and it's very well paid. And finally I think that moment when people need it, will pass. 62_M*

Industry appears also an escape option in case of negative experience in physics – in a quote below, the respondent tells about a situation of a female student who left science to industry due to experienced discrimination.

[I: Have you personally, have you personally experienced discrimination? So either yourself or seen it happen to someone else that they are discriminated against during your career?] Yes, well, so there, there, right, I had a PhD student here at the institute who reported that she was bullied (uncertain chuckle), basically by her male colleagues, that she was not included and discussions and conversations were abruptly ended as soon as she entered to the room and so, it was quite obvious, that there was no good working atmosphere. [I: Was that resolved?] No, that was not resolved. The PhD dropped out and, yes, now she has another position, so she is not doing a PhD anymore, but she is working in the industry in the private industry. [I: So basically physics has lost a scientist?] Mhm (affirming) Exactly. [I: Because of this discrimination experience.] Mhm (affirming). 06_F

2. Work conditions and environment

Introduction

The qualitative inquiry, in which individual narratives of male and female physicists were collected, provides us with a rich, comprehensive and diversified image of current work environments and work conditions in different European localities of physics. Sociological studies on academic and research work environment usually analyze individual evaluations through the prism of **job engagement** and **organizational commitment**. While the first dimension sheds some light on one's devotion to the essential aspects of the work, the latter emphasizes willingness to remain a member of the institution and to contribute to its development. When it comes to the narratives gathered under the framework of GENERA project, the majority of the physicists' evaluations point out high level of job engagement, often correlated with a perception of physics as "hobby", "passion" and a discipline that has to be accompanied with a personal enthusiasm.

I had affection to the career, [work] environment, friends. 27_F

The main challenge related to such engagement concerns blurred and changeable boundaries of the work, often impacting work and personal life reconciliation.

There is always something else that you could do and I think it is very difficult to really be able to define when your work is done and now I know that by not working at weekends and in the evenings in the way that other people do, it might be detrimental to my career, but I know that potentially I am saying, I am choosing here, my own work-life balance. I am choosing something that I am happy with, rather than necessarily what someone else would perceive as being the right way to do science, because you were told by your, by your supervisors that this should be your life and if you don't you feel guilty. 10_F

Organizational commitment of the research participants is reviewed in much more diversified way. Due to a growing number of administrative responsibilities (e.g. related to supervising or research grant management), teaching and teaching-related obligations as well as new roles of the researchers (e.g. related to dissemination of the results or leadership), the interviewees often demonstrate nuanced and ambivalent attitudes towards the research institutions they work for. Interestingly here, not all of them express a sense of belonging to the workplace, sometimes scientific collaboration goes beyond a parent research organization due to difficulties in social interactions with colleagues and supervisors.

I'm not so integrated in my research institute, I mainly work with researchers from another institute and local committee for environment. The atmosphere at my institute had never been good, I do not find an interesting person to work with. 42_M

I'm hired by the [unit], which is a little bit apart of the rest of the theory group, we are in a sub corridor... Sometimes I feel a little bit separated from the other researchers, in this point of view. When we go to big meetings, I'm always surprised to discover people I never met even if we work in the same laboratory! 37_F

While talking about their positions, roles and commitment to the workplace, the respondents often underscore a general overload in terms of tasks and responsibilities, an importance of supervisors and leaders in pursuing one's career and a permanent lack of time and resources (especially financial) for conducting inquiry.

As you say [here], I didn't spend years to have "bac+10" to earn just ridiculous salary you get here and with all the administrative duties and papers, you don't even have the pleasure of doing the science you want to do. 35_M

Another important dimension of the work environment assessments concerns **psychosocial aspects** of the workplace, often defined as those related to an appearance and specificity of stress factors, coping strategies in stressful situations and sources of social support. Interesting here is that studies of the psychosocial work environment often try to explain "how job demands and social structures and interactions in the organization influence the psychological well-being of employees". Such a perspective thus can bind together macro- and meso-levels of social relations and orders with personal and individual facets of the employees' welfare. This way of analyzing the impact of work conditions will be applied to GENERA data.

The following section discusses crucial dimensions of work environments and conditions with special attention given to gender aspects and precariousness of the employment. Structurally this section is divided into a general description of work conditions, an elaboration of the respondents' evaluations of work environments, and an analysis of changing roles of the researchers.

Work conditions

While describing their workplaces, the interviewees focus on several different aspects related to their employment. At the forefront they usually underlined an importance of unlimited accessibility of equipment and financial resources necessary for conducting research, an access to various sources of scientific inspiration (e.g. seminars, workshops, supervision and mentoring), a type of contract and a satisfaction with respect to salary.

The collected reflections, evaluations and opinions can be divided into two separate paths. The first one embraces mainly positive reviews of work conditions whereas the second path concerns critical evaluations regarding their current workplace. What is interesting here is that the latter opinions were more often expressed by female than male researchers. In some regional contexts such negative reflections in this respect were almost absent (e.g. Romanian, Spanish, and German) while in others they dominated to a certain extent the narratives (e.g. Polish). A duality of the evaluations has been revealed in other studies: researchers are often satisfied with their jobs in terms of "intrinsic motivation", related to the job itself. But they as well express dissatisfaction when it comes to work conditions as "their work environments are getting less favorable under the managerial reforms". In other words, scientists like their job, but not necessary work conditions available to them. Among advantageous characteristics of the work conditions observed in the GENERA study are:

- Access to the basic equipment and office supplies:

Ah, those are very good. The working conditions are, are generally very good, so, you have (..) everything you need (laughing). Which is not much for us, but anyways, you have everything you need. So computer, office, rooms, that are available, quiet, which you sometimes need (both laughing). 09_M

Compared to other places where I worked, I think we're pretty well housed here. Everything is not perfect, but I have overall access to what I need to work. 33_M

- Access to advance equipment and laboratories fundamental for research:

In doing our experimental work we rely on competitive equipment. We have the same equipment that you find in all great research institutes all over the world. 76_F

- Salary and a type of contract

Although financial satisfaction has been expressed explicitly only in few interviews, on the basis of more general assessments of work conditions we may assume that the majority of respondents are rather happy with their salaries.

I've now a permanent contract after long time of fixed-terms contracts, I'm happy with the workload. 42_M

More critical perspective on working conditions contributes to a discussion on a situation of younger researchers within the academic or scientific worlds. It's worth noting that a fair share of the interviewees was employed on the basis of time-limited contracts. The problem of a lack of stability was noticed in various organizations and regions. Although some of the interviewees admit that they understand a general policy of science institutions to support mobility and knowledge exchange by offering a short-term contract and encouraging physicists to "be on the move", they also observe ambiguous or disruptive implications of such approach for a family and personal life (read more in Mobility, migration...).

The only thing in the system that I do not like is that you always have these temporary contracts and for the most part in [the research organization] it is the case that basically only the directors have permanent positions. Maybe one, two scientists, but (...) it is a little bit of a pity that people are always only here for a short period of time and then have to leave again. Because, yes, it helps that ideas continue and I understand the motivation of [the research organization] to maintain such a system, but for those, for the personal life of people, it is not really practical (laughing). 09_M

It is emphasized that a post-doctoral period can be particularly challenging when it comes to negative consequences of job security shortage and stress related to it. Similar reflections appear in the realm of PhD students' situations, in which they not always receive sufficient financial support and have access to social benefits during the PhD programme (e.g. in Poland where PhD students are often not employed, young female researchers after giving birth do not have access to full-paid maternity leave) (read more Career paths...). Furthermore, the lack of stability and efforts to gain job stability, can lead to a permanent competition with others in a similar situation.

When I was a post-doc it was a nightmare of stress. (...) You always need to prove you are better than others to get responsibility. 05_F

Other studies have documented different facets of changing academic portrait by showing that "academics under this form of managerialism are fragmented as the university hires part time rather than full time academics, and provides contract based employment rather than tenured positions". Such a fragmentation may also critically influence on the processes of shaping a collective identity of physicists. Some of the interviewees were hired on the basis of a research grant they applied for.

I have no certain position. I am here with my own funding (...). I could work anywhere. 03_M

Critical reflections embrace as well accessibility of office spaces and laboratories and equipment. The problem of underfinancing research organizations and universities not only hampers an individual scientific development, but also hinders knowledge sharing and developing new ideas in a broader sense.

In laboratories there is old equipment and it's been here since the 1980s. Usually laboratory are closed, because there is not staff or because there are not money or because there is a lack of ideas and even if they were there was not support from policy makers. 39_F

Office space is always a problem. We don't have enough office space, we don't have money for hiring post-docs. 01_F

It is worth noting that sometimes the equipment accessibility might be influenced by informal and personal relations. One of the respondents describes her current position in the department through the gender lens and the prism of a conflict with one of the faculty member. According to her, an access to the equipment could be hampered by the discord in the future.

When it comes to me personally it is not too cheerful and here in the department we have this equipment that is hard to beat within university, because as far as I am concerned there is no such an equipment elsewhere (...). And this equipment we were able to buy few years ago but I don't know on what basis it was assigned to only two people who do this [CAT scan] in the department and I don't know how it would be if I decided to use it for research (...), I don't know how it would be due to personal conflicts that exist here, not even between those persons who are in charge of this equipment but between [me and] a person who supervises those people. 57_F

Furthermore, the study demonstrates difficulties in financing research from research organization or university funds. Shortages of financial resources make academics and researchers seek for new potential sources of financial support. The responsibility for assuring research funds is often shifted from an employer to an employee as researchers become primarily responsible for the preparations of grant applications and more generally speaking – for ensuring finances for the inquiry. Such situation may also bring about several other disruptive consequences:

- Emergence of a new **self-financing model** in the academic world, which results in, among others, **being hired depending on receiving external financial support** for the research (and one's position);

It was known from the very beginning that I should write some project, get some grant from [name of the granting institution] because otherwise they won't hire me here. 57_F

You have to finance yourself. 76_F

Since I came with my own money, it was easy [to hire me]. 01_F

- **Youth-oriented grant programs** (or perceived as youth-oriented) causing tensions between researchers' generations

You see, right now for young people there is El Dorado, you could say that. (...) So young people have now a lot, a lot of possibilities to go somewhere, organize something and so on. [Talking to the interviewer] You probably also experience this... that there are many

research grant programs for people younger than 35 years of age and it's easy to get it. As for us elderly, I see our generation is put to pasture (...). 71_M

- Participating in conferences depending on having a research grant, not having access to such financial sources means exclusion from a part of academic activities;

If you want to go to a conference you need to have externally funded grants. The Faculty won't cover your costs even if you have a speech at the best conference. 55_F

- Proliferation of tasks and related to this difficulties in work and personal life reconciliation;

All these responsibilities affect my research and one thing that I can do in this situation is to sacrifice my personal life. I cannot omit my didactics or administrative duties, to have a greater productivity. So the only idea that comes to my mind is to use my teaching experience in order to have some achievements. That was my goal when I started my research team, because we can publish together with my students and PhD candidates and my name is the first one. 61_F

- Growing sense of inequality between regions, universities and researchers:

It really shocked me to see the difference between research in the United States and Europe. How do you want to do quality work when you are not given financial investment, no collaborators, no real support? [Our country] wants to be at the forefront of research but it does not really give the means. 35_M

It is a rat race to get that one special position. I tend to compare science to top sport. If you want to win the gold medal (the permanent position) you have to work hard. Part-time work does not exist, only being part-time paid (...) How unfair, unhealthy or unwhatever it is. It is the game and you have to play it, otherwise you lose. And this counts for both women and men. 52_M

A separate issue emerging in relation to working conditions was **flexibility** understood as, on the one hand, freedom in shaping one's own research scope, design and implementation and planning a work day, on the other hand as the ability to meet the requirements of the academic labour market (e.g. openness to mobility or frequent change of place of employment). It is worth noting that both aspects were assessed ambivalently. When it comes to the first understanding of flexibility, an individual agency in deciding about e.g. working hours was in many ways highly appreciated as it facilitates work and personal life reconciliation. Positive evaluations were given primarily by parents (mostly mothers).

I've been scheduling everything by myself for years. (...) My boss is wonderful (...) so I schedule everything absolutely by myself. 56_F

For many years I used the flexibility offered by my work as researcher to deal with my family problems and to be a good single father. 42_M

*I like in general, I like that you can choose your working hours more or less free in science. So, you don't need to be there always from nine till five, so you have the choice to come whenever you like. That's a big advantage. That's what I find **a big advantage too when you would like to have children. Because you can come to work sometimes a***

*bit later if the child didn't want to leave or something like this. [...] That's what I find especially good in science. That's what I find really good. The **disadvantage is that you have to be in the lab sometimes very long**. But I believe it could be that this is due to the fact that you don't have a family. You always think, well, I can stay longer. I can stay longer. I believe if you have family then and go earlier one will complain. 22_F*

But, as the latter citation shows, noticing various challenges regarding flexibility of working hours also appears in the narratives. First and foremost, such critical reflections concern unclear and fuzzy boundaries of work life. In such argumentation flexible working schedule sometimes makes that work never ends. According to the respondents, **a deep commitment to work, staying longer than officially expected in a workplace**, working during weekends and holidays become **“a new normal” of excellence in science** (cf. Sinderman, 1985).

I'm completely free to schedule my activities and my time at work, I have always been. To be a researcher in a public research organization it allows you to have a lot of flexibility, which it could mean that you need to work in Saturday or in Sunday or during night also, but this is because it's a job you love. 39_F

Exactly. So at the moment I am accused of leaving work early and that I am not working every weekend, but I mean, what do you want to do there? You cannot be sick all the time too and work 100 hours per week. We all work between 60 and 80 hours. At some point you cannot do that anymore. 07_F

I think really think that there is a mindset of "do not complain, just work hard". I think there could be some improvement. 51_F

This new normality of flexibility and overworking at the very same time may also have a negative influence on social relations in a workplace as according to some interviewees researchers start to assess each other in terms of their involvement and presence at work.

And in my group, with my PhD and the people I work with now that's what's expected. I can give an example. I think this is reflecting very badly on me in terms of (laughing). But for example, if you have to submit something to a git or a repository, maybe you would do it later in the evening. You might have finished it earlier, but commit it later, because then it is logged. You've done it at some time which is outside of the ordinary working hours so it looks maybe like you've worked outside of your working time. I might even tell PhD students that sometimes you know just wait a little bit, log it a bit later, it looks a bit - you know. 10_F

The second understanding of **flexibility** means that a physicist has to **adjust his or her career and plans to the academic market**, for example by accepting a possibility of changing a workplace after having a short-term contract, being mobile in general (see the section on Mobility, migration...), living in instability in terms of a job contract, a need of self-financing by applying for research grants. Such flexibility most often appears in the realm of younger scholars, for whom post-doctoral programs shape their career paths.

Now, for the start, it's temporary for one year. I believe [...] they never know how long it lasts in a spin-off. Because they recently hired me, [...] the order situation must be good. Well, they are sure that it is enough for one year and then we have to see what's after. I mean if there are more offerings they will renew my contract. If there are no other orders I have to find something new. But I believe for the change from science to industry

is it kind of good to be in a spin-off, because I get all steps from the beginning, the whole workflow. That's what I like, therefore I decided for it. 22_F

(...) I can imagine that when someone works in an experiment, it can be stressful, or there are such situations, related to obtaining a degree. Even when an experiment has to be done to obtain PhD and it is delayed because there is something wrong with the experiment (...) a part of apparatus breaks or something else goes wrong, and this can be stressful. As far as theoretical physics is concerned stress is related only to competition, it means that before one gets a permanent position, there is this system of post-docs, (...) after the doctorate one goes on two-year or three-year post-doc and stays in one place in the world, and then in another place in the world and tries to find a permanent position and this can be very stressful and this can influence family relations. 54_M_L

These two understandings of flexibility may influence psychosocial aspects of the physicists' well-being as they were often described as stressors in every-day work life.

Evaluations of the work environment

The work environment in the report is defined primarily in relation to the main characteristics of social relations, hierarchies and interactions between an employee and an employer, as well as among researchers. It also includes a social atmosphere in the workplace and a presence of the stress factors and their impact on individual well-being. Given the importance of individual well-being for pursuing a career and for work and personal life reconciliation, psychosocial facets of interactions with colleagues and supervisors seem to be crucial. Although the majority of the interviewees support the very idea of collaboration, some of them reveal certain tensions emerging between perceiving a career as something achieved together, through close and intense cooperating with each other, and seeing a career only through individual goals and achievements. It was underscored that in spite of an official demonstration of collaboration, in fact everybody "fights for their own position".

I would say yes, really, not necessarily openly. But of course there is competition, because everybody is on - most people are on short-term contracts. And publications are what you need - I mean in my group we don't really publish enough and we are not pushed to publish as much as we should. [...] Which will be problematic for the future. Ehm, the other half of our institute. The more data analysis-based side. They publish a lot more. Sometimes you hear about things, like, oh, this person has published this thing and I was, they were working on it more. You hear little things, it is not as open as 'I hate this other guy' or whatever, but it's a competitive world. You are supposed to be working together, but ultimately, everyone has to fight for their own position. 10_F

So, basically I mean I have my own task that I want to get done. 14_F

Such reflections led us to think how physics is perceived by the interviewees in terms of collaborative vs. individual dimensions of their work and to what extent this profession is based on competitiveness.

Various aspects of team work

Close collaboration was often perceived as an essential characteristic of physics due to the experimental aspect of the discipline present in many interviews. Some of the interviewees underline that this aspect of work springs from the core of the physics research to which various

people with diversified skills, knowledge and capacities have to be involved. Only theoretical physics is perceived as more individualized in terms of every-day work. Among positive results of the team work the interviewees mentioned knowledge and skills exchange, making contacts with other researchers, a possibility of joint publications. An additional value of cooperation within e.g. a faculty lies in building a sense of a community between physicists.

In the faculty is variously, generally I think we have the potential to work together and now as a person related to administration I think we do not use it everywhere, as a community we should not allow to be atomized and think only in terms of our own group, it is good to share some research, as we share part of the apparatus. 58_F_L

Besides such a formal collaboration related to research grant projects, some of the respondents shed some lights on informal, personal aspects of team work by showing an **importance of a good atmosphere in a workplace**. According to them friendly environments may enhance scientific achievements as well.

Every morning we take coffee together, with all the team including students or trainees. It allows us to discuss informally, to talk about personal or professional news, to see if everyone is doing well, if someone has difficulties. It is very important to keep good links in the team. 35_M

We have very good relations, I won't say they are like family...(...) but it is very pleasant. 56_F

One of the characteristics of physics, often taken for granted, is the assumption about collaborative nature of the research work, especially in the realm of experimental science. A **level of cooperation is enhanced by the grant system which requires** close partnerships between different research organizations, but also often demands collaboration within one institution. Collaboration with external groups and institutions is usually evaluated positively and goes beyond the boundaries of the discipline.

We have a long tradition of partnership because the employees work together on a common project financed by EU. 41_F

I succeeded - and this is what I consider to be a great plus of my profession - to work with both biologists, genetics, mathematicians, and so it was not always just physics. 58_F_L

Collaboration is also reviewed as an evident challenge in two visible contexts. The first one concerns personnel disputes in the group of researchers and the lack of systemic solutions to their mitigation. In this situation, the researchers often feel isolated and reluctant to make further attempts for cooperation. This also has a negative impact on their careers, because for this reason they give up, for example, the submission of grant applications.

I tried to apply for various grants, but it was also hard for me to get along with my colleagues from the group and I thought that when there are such big conflicts and argues at the stage of writing the project, I do not go into it. Well, because then the project has to be implemented and by whom? Also as if the specialization is quite narrow and I think it would be hard for me to find co-workers to replace my colleagues. 65_F

The second aspect concerns the impact of competing with each other during cooperation. For some respondents, competition is a part of a scientific career and is perceived as a “natural” part of the physicist's work. Such defined competitiveness refers to, for example, the number

of publications, successes in obtaining grants and other scientific achievements. But the collected narratives also show the negative aspect of competitiveness, in which unjust behavior and actions occur. It is often forced by the systemic situation, for example when postdoctoral researchers compete with each other for permanent employment.

And now it is difficult, because even inside of the group too. We are 3 post-docs now and of course we all want papers, or course as a first author, because otherwise we won't get a position afterwards and then it is difficult, because there are no three experiments. And then one person is coming in a little earlier and the other one a little later and then it is a little bit like, who somehow shows the professor that they were there longer, to get it and then, and it happened to me a couple of times that people said 'Yes, I am going home now and so you can also go home' and then the next day I learned that they stayed until midnight. And they really turned everything off, as if they were going home. And I mean what do you want to do in that case. So you can try to communicate and to ask 'what are you doing now?' and 'can we do that together' or something like that but when people say 'yes', but are doing it all differently anyways, then well. But I think that this is just because of the competition and that we are under such pressure. 07_F

When it comes to gender dimensions of collaboration, in the majority of the interviews this aspect of working together remained invisible in two ways. The first invisibility means that the respondents didn't mention any aspect related to gender and collaboration as they didn't look (consciously) at the team work through the gender lens. The second way concerns a situation in which gender was not perceived as an important facet of collaboration, but rather as a transparent factor.

I studied a lot with male students because they were the majority, but when I worked with females it was fine as well.. But it has not been uncomfortable studying with male colleagues. 43_F

Only in a few cases this dimension becomes visible and perceived as influential. These situations often refer to conflicts and discriminatory practices ("men think that we are stupid too") at the workplace. The following citation also shows that lack of sufficient language skills may lead to creation of an inner circle of people on the basis of their nationality/same language within a department or a research group. This can seriously hamper cooperation between researchers and intensify existing stereotypes.

I thought everything was okay [within the group] and then I found out yesterday (..) that the two men are somehow thinking as well, that both of us women – so we are the female professor and two women and two men – and now I found out that the men think that we are stupid too. [Interviewer: How did you find out about that?] Because the three others are basically speaking the same language. So the three foreigners are coming from the [foreign] country and are talking a lot more amongst themselves than I talk to them, because they do not speak English that well. 07_F

Changing roles of the researchers

Both female and male interviewees underline changing roles and job description when it comes to being a physicist. Although not all of them experience teaching responsibilities (this applies only to academic positions with didactics), being a leader or having administrative duties, "a growing workload" appears in almost every interview. A broad sociological portrait of being a physicist emerging from the GENERA study reveals a growing plurality of roles and tasks faced by both young and senior researchers. The younger generations of physicists (e.g. during a

postdoctoral program) underline that they do not have face too many administrative or supervision-related obligations due their positions within the scientific world. However, their fragile and unstable employment conditions force them to undertake additional research and publishing activities in order to ensure themselves a good employment in the future. Senior researchers repeatedly present their workload through the lens of responsibilities concerning a supervision of younger colleagues, teaching, administration, reporting and managing of research projects, and applying for research grants. Yet, some of them demonstrate their agency and autonomy in rejecting or avoiding some of the non-research-oriented tasks.

I try to avoid any additional duties in terms of administration or some special activity. I usually say no because I just want to focus on my research and I know it could be very diffusing. 63_F

Furthermore, the portrait is also diversified in terms of gender dimensions. Female researchers more often than men indicate a need for a greater appreciation and recognizing a value of teaching as well as accentuate challenges and difficulties related to reconciling their work with personal life. The overwork was discussed during the interviews in terms of three important contexts: administrative responsibilities, teaching and a new emerging role of a researcher, in which he or she becomes a manager.

Administrative responsibilities

As mentioned above, younger researchers usually do not complain about administrative responsibilities as they do not play a leader role in the institutions.

I devote all my time to my research. In my position I'm lucky I don't have teaching obligations or administrative issues. 37_F

The problem of overload with duties becomes more visible in senior researchers' narratives. Dealing with administrative responsibilities (e.g. periodical reporting, counseling) leaves a little time for the research. Some of them perceive these tasks as somehow "natural" or obvious obligations related to their age and experience.

You have to involve a lot in administrative tasks, most of them quite bureaucratic, so your time for doing research became less and less. 76_F

Overworking with bureaucratic tasks concerns as well managing research projects, in which principal investigators are not only responsible for coordination and conducting inquiries, but also for meeting all report-related expectations. While in some cases the research organization may offer sufficient support in project management, in other the responsibility is shifted to the researchers.

I've managed EU funds some years ago and was a lot of work also because often I did not have much support from my administrative office. Now I've no more funds to manage and my work is much more relaxed. 40_F

Teaching

The issue of the excessive workload appears not only in the context of administrative responsibilities but also in the realm of teaching obligations. A number of the interviewees demonstrate a lack of balance between time devoted to teaching and to conducting research.

You must give compulsory teaching time at university. Here it represents more than 200h of courses to give in the year. Not to mention, of course, the preparation or the corrections. This represents an enormous investment of time and energy. I like teaching, but 200h? I think it's disproportionate when you look at the time that goes by at the expense of pure research. 35_M

Some of the respondents underscore the fact of teaching not being recognized as part of the scientific excellence. In a few contexts (e.g. Poland, France) being a teacher and a supervisor is presented as overwhelming, yet important part of one's professional career. However, successes and achievements in this regard, are often not included in regular evaluations of the individual scientific accomplishments. Such situation has been named by one the research participant as "schizophrenic" – on the one hand there is an organizational demand regarding teaching, and on the other scientific achievements embrace only (or mainly) research-related activities.

At the moment, I slaughter myself a little. I was able to find some two free weekends lately, but in general I have no vacations, no holidays, I just sit from morning until night, often turn off the lights here [at the Institute] (...), so I work a lot, dozen hours or so a day to get things done, but in fact it's not something I have in my job contract, because in contract it is [written] that we are paid for didactics, but evaluated by scientific achievements. And this is a bit schizophrenic in being a scientist in [name of a country]. Most of the tasks I impose on myself independently. Unless, there is some scientific cooperation, somebody subcontracts me some research, and then – you know - I have to do that. 55_F

I enjoy my activity of dissemination [teaching in schools]; it gives me a high personal feedback. Nevertheless, I regret that nothing is recognized about this activity. It is an intellectual challenge. 49_F

It is worth noting that in some contexts (e.g. in Poland) it's impossible to receive a professorship only in didactics, although at the same time a great involvement in teaching is demanded.

One and only weak point is that (...) practically [here] it is not possible to make a habilitation, even a PhD in didactics of physics, chemistry and biology (...). 56_F

Researcher as a manager

A repetition of the narratives, in which the interviewees accentuate a shift in a role of being a researcher allows us to claim that due to expanding bureaucracy in higher education systems and research institutions, financing research through grant systems, and relatively new science objectives (e.g. popularization or dissemination of the results), physicists as other professional scientists have to face **proliferation of roles and new management accountability**. Such situation reveals that physicists more and more often become managers as they are obliged to manage working time, teams, financial resources and their own careers (cf. Sinderman, 1985).



Such changing role of a researcher leads to many tensions appearing within a role itself. The researcher is no longer just a researcher or a scientist. She or he has to learn new competences and skills related to e.g. project management, paper work, cooperation with business etc.

I've complained to the high level direction about a terrible fact: the working conditions deteriorate every year due to the explosion of administrative tasks. Between databases, business sheets, missions, budget, holidays management... I really have the impress to be a secretary, I have a huge frustration to have made 8 years of studies to finally do administrative tasks, or even low level secretary tasks, just fulfill papers and papers. 34_F

In my personal case, the bureaucratic aspect is increasing and it has required new competences: I am attending a project management course. 50_M

Some of the interviewees underscore that in spite of multiple obligations, they have a certain capacity to organize their working week in a satisfactory way. More nuanced analysis shows that it is related to both regional contexts and character of the workplace (whether it is an academic institution providing teaching or a research organization).

My professional career is diverse: I do research and I also do management tasks. To some extent I can decide how much work I put in each of them and the combination is satisfactory. 32_F

3. Mobility, migration and internationalization of science

International cooperation supported by mobility is key to scientific knowledge production in physics

The development of science is attributed by researched physicists to the exchange of ideas that today happens also internationally, within the thematic – formal or informal – networks or groups (see also chapter “Networks”). The need to moving internationally for working with high quality mentors or supervisors, sharing ideas, and equipment is a **part of culture of physics as a field**. The mobility experiences link researchers to each other and create a net of international connections between them that are important for establishing further institutional or personal cooperation leading to common publications and projects.

It is a field of action where you cannot work by yourself. You need to collaborate, change ideas and experiments. 76_F

The development of physics is unthinkable without mobility, cooperative work, sharing results and apparatus. (...) in physics every result must be consulted, compared, argued. (...) today it is unimaginable to do anything without a broader consultation with the scientific community, there is no such laboratory or college that could do it well without journeys and without exchange of thoughts. 58_F_L

I think it's [mobility] really important, we need collaborations...it helps in order to expand your knowledge and expand your experience. 05_F

[Mobility and migration] are of great importance in my field, I can speak only about my sub-discipline - nuclear physics and hadron physics. [...] The infrastructure that we need [for the research] is available in only a dozen or so locations around the world, so it's a practical aspect that our research can be done in specific centers. It is difficult to build a [research] group with all the necessary competences and skills within a single research center. So these groups have to be built so that we all meet together. 61_F

The need to **use advanced and expensive infrastructure** forces physicists from certain sub-disciplines (e.g. nuclear physics, hadron physics) to travel to specific locations. For instance, CERN - the European Organization for Nuclear Research - is mentioned as a remarkable example of **necessity to collaborate in science** – stressing that physics cannot be funded by one country, but only through joint efforts and financial resources of many countries:

Particularly in physics area, you need to travel because we are more and more working in huge international collaboration, as no one country can pay alone for the experiment we are working on. Look at the CERN for example: how could Swiss finance alone such a project? 35_M

International mobility is perceived **as a crucial element of science development**. As such, international mobility allows, especially in the narratives of younger respondents (also representing emerging subfields of physics), to exchange knowledge, perspectives, experiences and methods of conducting research:

It's a good chance to exchange ideas. When you go to visit different laboratories, meet new physicist, it's the occasion to enlarge your knowledge and research. 36_F

Mobility is something positive because you can learn things abroad and then apply them here but I do not think mobility should be compulsory. 26_F

(...) during two scientific conferences I met two professors, one from Italy, the other from Ireland, who opened my eyes and perspectives a little, and thanks to them I proposed my professor to use new research methods that widen [our] perspective and expand what is synthesized and studied. 57_F

It is important to experience different dynamics and manners of conducting research. 03_M

Some of the senior researchers in contrast have doubts if mobility is essential for science development and instead emphasize **the role of internet communication that substitutes mobility** at least to some extent. Contrastingly, the internet resources are also indicated as extensive thus impermeable and that through contact one can learn better on the important developments.

If it [mobility] did help the science, so as well, but if it is crucial, I am not so sure. So I think you can very well work in one place and regularly go to conferences and always communicate with people via Skype, E-Mail as well. And everybody receives the papers that are published every day, everywhere on the planet. 09_M

[Mobility] allows me to see how you can work for real and this is a matter of gaining new models and new perspectives, so sitting in one place is good for nobody (...). Scientific community has sense only in case when people contact each other. Especially that amount of information being a result of published articles is that you cannot get to what is valuable, I've got a feeling that you can get it by meeting people and talking with them. 57_F

Indicating excellence: mobility is a must in a scientific career

Mobility is also a crucial tool for supporting scientists' development - multiple benefits of mobility were mentioned by the physicists. On the one hand, the plausible outcomes concern the expanding of scientific knowledge, learning from the excellent scientists or supervisors abroad, and creating connections. On the other hand, the interviewees underline personal development of a scientist: gaining self-confidence or independence, learning new ways of perceiving the social and professional world, including improving social skills. Travelling is also a way to learn about diverse organizational practices and institutional cultures of working – these experiences are valuable at the leading senior positions.

Absolutely, I mean, besides entirely exceptional situations, it is necessary. One has to change surroundings, change the atmosphere, see how work is done elsewhere, work with other people, with other groups. This brings another perspective, change of working style, seeing how work is done in the best centres, because a lot of people go to the best centres. This is essential, I cannot imagine a person that would sit in one place and 'poked' something. 54_M_L

Flexibility is extremely important because it shows you a new point of view. You can see your research world as external, you learn working in different field of work where there are lots of funds, there is high competition and there are lots of young researchers. In the north of Europe also you get through reality much more dynamics, and this is fundamental for a researcher. Obviously, it enriches your skills. 39_F

Here, during the recruitment process there is a lot of attention being paid to the fact if someone was abroad, for a longer time, because if s/he was abroad it means s/he is cool! But if somebody was sitting here teaching students than s/he is not so cool (...). I don't like lack of flexibility in this matter. I understand that it is necessary to go somewhere and check how it is to work elsewhere, but I don't know if this kind of uncritical look on a man who could have worked anywhere abroad and is evaluated better, is good? 55_F.

Many scientists mention the opportunity to widening horizons – stressing the **“opening eyes” effect** that could happen when visiting foreign institutions or meeting excellent researchers in other countries. The local cultures of science production can be questioned in light of such comparisons:

Lack of awareness [that there are different research paths in physics than in one's home department] results in stereotyping and reluctance (...) In 2006 I went for my first conference of physics didactics and it opened my eyes to the fact that (...) people do research on physics didactics, because I had not known that earlier and then I thought “let's do this too”. 56_F

Mobility is considered as one of core elements of **excellence** – it constitutes a criterion important in evaluation of scientific performance, and it creates new standards for participation in research. Such understanding of mobility lies in underlined significance of close collaboration with foreign and international research organizations, especially visible in implementation of the project-based studies. Being mobile and having experiences of international cooperation is positively evaluated during applying for research grants or job positions. In some countries, e.g. Germany, it is **impossible to progress in a career without mobility experience**. In the Netherlands one is supposed to spend a year or more abroad during a post-doc time, while for example in Poland it is not compulsory, but in the studied research institute it is strongly recommended.

You cannot perform if you don't go to conferences, workshops. You need to be part of the culture, otherwise you cannot get it. 82_M

You need to have mobility, otherwise you won't get a position. It is also important for your image. 27_F

Without moving you probably won't get a job. But also it's how you meet the other people in your field. You get to know other ways of doing science. The atmosphere is different, the people are different. I think it is important to see that. 01_F

Yes, um, you do not have to study somewhere else, but you have to, so that is what colleagues told me, that you have to have experiences abroad at some point. It can be as a post-doc, that you go abroad, but you should do it. 08_F

Situating mobility in the career path – it's for the young

International mobility is often depicted in the narratives as a **crucial factor for the career development**, yet its intensity is mostly related with early stages of the career. It is important to notice that *mobility* means both to short term mobility (e.g. research visits, conference attendance, experiments periods), but also longer periods abroad – here it is mostly linked to PhD or post-doc positions of duration from 1 to 4 years. Another form of geographical mobility

is actual migration – here meaning, moving to settle in a different country for a longer fixed position.

It is important to underline that demands for mobility **depend on the moment of the career**, similarly as the engagement in the mobility - the senior respondents usually stressed that they have other obligations (such as administrative duties) that disallow their engagement in intensive mobility. Thus, young researchers are those who are "on the move" - engaged in short and long-term mobility periods, as well as migrating in search for employment opportunities. The need for visiting other research centers and participation in international forums and research projects is mostly **assigned to young scholars and researchers**, who are obliged/supposed to travel and cooperate closely with foreign research institutions and teams. The period after completion of PhD, so called *post-doc*, is considered as very good chance to stay for longer in a foreign institution. These early career experiences, if gained in an excellent institution, favorable environment and under quality supervision, are indicated as decisive for the whole career. In the biographical accounts of researchers the connections created at the start of career tend to last for many years and are often developed into institutionalized forms of collaboration. We could assume that in case of young scientists (especially female) that cannot move after their PhD missing opportunity for a post-doc experience could have a degrading, even if indirect, effect on the career.

Travel shapes the young. Personally I was really happy to move in another country. Most of the time, when you are student, you don't have a lot of constraints and it's really a rewarding experience to travel. 33_M

One should travel, because it's good for one's scientific experience, it's also a new knowledge. [Travelling during post-doc] is good for a young person, because he/she can see how people work, and you can bring something good from there. And it's also good when you find new collaborators there, during post-docs long-term cooperation may start. 62_M

Some young scientists notice that mobility "counts for" career only after receiving the PhD (e.g. in the Netherlands you are supposed to spend a year or more abroad during your post doc time).

Yes, it [mobility] is very well received. And that is what is funny, because originally I wanted. I mean, I studied in Xxx [country in Europe] and then I also went to Xxx [country outside Europe] and then I was here and, that means that I have already worked in my three countries, but now that is disregarded somehow, because it only counts starting from your PhD somehow. 07_F

Reconciling mobility and private life – gendered perspective

The mobility expectation is more difficult to realize for women, as the moment when it is expected to happen (after PhD) coincides with time of family formation and childbearing. In result, the high value of mobility in evaluation may be damaging for those for whom mobility is impossible or challenging. Besides women in their family formation phase, there is a one case of a scientist from outside Europe that could not leave during PhD studies due to lack of passport – she also indicates the importance of mobility for self-development as a scientist at the early stage of the career. Another group that has more difficulties in travelling is those in administrative and leading positions, who point to the burden of daily matters as disallowing frequent mobility and making long term mobility impossible.

Considering short term mobility, the difficulty for travelling lies in family and care duties, especially in relation to care over small children, but also in later stages of career for elderly parents. In fact, the short term mobility is seen often as a challenge by women scientists, who needed to manage family and care duties (also in case of a single father). The support from the partner or other family members is seen as critical. Nevertheless, some female scientists conclude that they limit their travels to those necessary.

Before I used to move a lot, I really enjoyed it: conferences, workshop, colloquium... every time I had the opportunity to travel, I moved. Now, with a baby, of course it's more complicated. I need to check with my companion if he can take care of our child while I'm away, so I try to leave only when it's really necessary. 34_F

Such a dramatic picture that I can tell you is that at one point in my work the analysis [I performed] was completely closed and I wanted to consult it with my [...] mentor, such direct supervisor, I wanted to present him [the results] in detail and more deepened way than by email. I decided to go to Xxx [country in Europe], it was a 3-days trip, so I wasn't at home for 3 days, and that was the period when I breastfed and it was probably the most dramatic period of my life. As I returned the baby literally jumped on me. So these dramatic memories of those 3 days, those swollen breasts and that baby on the other hand at home, it was pretty dramatic. 61_F

In my case my family problems were at the base of not having periods abroad [Xx is a single father]. 42_M

The actual challenges linked to mobility, even if they are managed by the female scientists with usage of informal resources, may have adverse effects and bring upon an image of them as inaccessible. A researcher from Switzerland, describes that she almost was not invited to give a lecture, because organizers did not want to cause her trouble in organization of family life. Such “favours” may have a degrading and excluding effect on career of female physicists isolating them from environment and prestigious activities.

I used to travel a lot. Now I have my son, I don't travel that much. But if it just 2 or 3 days I am happy to go give a seminar. In fact when I have been asked I go. I was quite shocked last time I went, the organizer heard I gave good seminars, so he invited me, but he told me “I know that you have a kid so I was very hesitant to invite you. I didn't want to put you in a difficult situation”. You would never say that to a guy that has a kid right? 05_F

In case of long term mobility, the experience of female researchers is more similar to those of male ones, as the representatives of both genders experienced difficulties in mobility for longer periods (or migration decision) when having family rooted in a certain location. This includes especially situation of a partner being employed, children attached to schools, but also challenge in adaptation every time when changing jobs. For some men it is easier to make decision to move to another country if a wife does not work professionally or if her occupation is perceived as less important or valuable. Women often stress that the professional career of a partner disallows them to migrate or leave for longer period. The social expectation of a woman following man career demands, plays in favor of men physicists, nevertheless even some male respondents see impossibility of de-rooting their family through migration abroad or resigned from longer stay when children were small or had health problems.

I like to move, experiencing my stay in [name of the country] it's really great. But it depends of the age of the people: for me the mobility was not a problem, but now I would more hesitate to leave Xxx [name of the country] for another country. 33_M

When my [male] colleagues decided to do internships abroad, they took the whole family with them and it was one year internship, and that was not a problem, because their wives could take a break at work or they did not work, so for them it was possible to take care of children at a new place, take care of them so they could adopt a new environment. I have a lot of support from my husband, but I cannot imagine him leaving his work or having a break, and I cannot imagine me asking him to put off his job for a year and come with me because it's important to me. 61_F

Mobility for long periods is challenging from a human point of view. In my offsite experience, it would have been even more difficult because it would have led me away from my family. 46_F

Anyway it is a disadvantage, [...] you have to assume that you cannot stay at [name of institution] your whole life. And due to the fact that you are very, very specialized in a specific field, it will be improbably that you really find a job here. Nope, that means, you really have to change completely. Additionally, local where you move to. And the partner also plays a big role in it. Or when you have a family at that point, you just pull out the children from their community. I believe, that is [...] maybe one of the biggest problems in science that you have to be extremely flexible including everyone around you. Well, that means if you have a family, everyone needs to be flexible as well. 20_M_L

Dual career couples – a double challenge of mobility

The particular situation concerned dual-career couples, which is quite common in physics (cf. McNeil, Sher 1999). Having a partner also working in the physics field, or being a researcher in the other field, was evaluated in general very positively – such a person understand the way of working in science, has similar interests and can give advice. Nevertheless, for such couples mobility and migration decisions are challenging. The decision of moving depend on how possible it is for both of the partners to benefit from migration. The cultural expectation towards women to follow her partner matters and some women indicated that going abroad in such situations meant to them e.g. a career break or volunteer work. Nevertheless, there were also cases when men decided to move to another country to support partner in her career.

I stayed 4 years abroad in Europe, and 4 years in Xxx [country outside Europe], because my husband was moved for working and I tried always to follow him. We were good in combining our jobs. (...) Once I took a leave from work without pay because my director didn't want me to work abroad. 40_F

After MA graduation, I got married and we moved abroad. My husband worked in a university and I had a break. 70_F

I should probably also say that I have a boyfriend in Xx [country], who is working at the Xx [institution]. So that was another plus. For my work-life balance that was another draw to go back to the Xx [institution]. 10_F

The following account of a man who decided to leave academia puts in question the pressure to move, and describes the difficulties that a couple of two physicists face. In the relationship

the wife's career had priority, and ultimately the man dropped out. He questions the sacrifice of one's private life to science, as due to long-distance relationships, certain family decisions are put on hold (e.g. children, house). Possibility to work long-distance was indicated as a partial remedy:

Two scientific careers meant that since September 2012 we have not been living together. (...) As such we are a typical example of the two-body problem. (...) We try to cope to see each other every weekend (meaning that we travel a lot), meaning that we have almost no time for other hobbies or visiting friends and family in our home country. Luckily, my boss (...) was very supportive in our situation and allowed me to work regularly from home (...) As a consequence, we have put many other things (like having children or buying a house) on hold. (...) In the beginning that (working in different countries and long distance relationship) was quite ok, but now I see people around me having moved on in their lives, whereas I now feel we are falling behind. This really makes you wonder if you did anything wrong, made the wrong choices. Is a scientific career worth everything? 52_M

Excessive burden of (forced) mobility – in a search of permanent positions

The new context of **scientific career demands high mobility from the young researchers**, including not only short term mobility or post-doc research stays. In fact, it is a “scientific labour market” that demands from researchers frequent change locations – young researchers move around Europe in the search of fixed (or at least fixed for few years) job positions. There are cases in our study of those who moved to a foreign country to permanent post, which did not demand from them further moving – this pattern was usually evaluated positively. At the same time, some interviewed scientists are “on the move” for many years - every few years they need to move to a new country and new institution. This brings upon frustration, stress and feeling of instability. The unpredictability of employment and the inability to plan even a country where one would work lower the evaluation of the career and may lead to abandoning of academia. Researchers stress that they cannot stay in the institution they would want to work for. It also causes difficulties in integration in the research teams, so critical for physics. This is discussed more in the chapter “Career paths...”.

After the PhD, you will normally spend around 15 years with 2 or 3 years-contracts and moving all over the world. This is not a very attractive career prospect. 30_M

[Mobility] It's not a necessity. It's a good experience, but it has maybe to stay time-limited. For me my post-doc experience was really wonderful, my partner followed me even if he didn't have a job, it was our couple project to live something else for 2 years. But if it had gone on more and more years, it would probably have become a problem. When I see people who are doing their 7th post-doc in a 7th different country... I don't know how they can live like this; in my opinion I would have left the job if I had to work in such terrible conditions. 34_F

I liked arriving to Xxx because it was after years of moving, moving, moving, moving.... 27_F

This time I decided I had to move in order to continue with my career. In spite of the fact that my partner was here, I spent several years abroad. (...) It was a personal sacrifice but it was very positive because I worked and published a lot. 26_F

It is necessary on the CV. But to be honest, is it really necessary in the point of view of how much you can learn, I have my doubt... I mean, of course you learn different things in different places. But based on my experience on my 2 years post-doc, basically you arrive in a place, you have to adapt, and the time you realize you are there you are already gone. When you speak with people who have permanent position, who are in their job for 20 years, for them 2 years is just ridiculous, they don't even think about starting a project in such a short time. I like to move around, but I would like to have more choice about the country and how long I could stay.

37_F

The feeling that mobility is “forced” is not received well. Young researchers especially emphasized that it should be **possible to stay in the same country after completing one's PhD**. There might be no added value of moving between countries for the only reason that scholarships and funding are not available at the current location. This is stressed by the researched physicists in Germany, Switzerland and Spain. Let us stress that this intensive mobility is difficult for those with families and children. In some cases, the instability of career led to postponement of childbearing.

I have done my PhD here. Now I am doing a post-doc and now, um, I do not have any opportunities to stay in ..., because I have been here for so long. And now I have to leave again. It is really stupid. (...) That means I am here and I cannot stay, because I have been here for too long and now I can also not go back to (another country), because I know no one there who would hire me. 07_F

(...) a PhD student asked me if he could get a professorship just living in Northern Germany. I said it would be great if you could, but it would be absolutely impossible. You have to move countries. So for them, for that person, they know that their partner won't want to move, so they won't be a professor. And this is just - it's unfortunate, but it's so unlikely you could ever be a professor without having moved around. 10_F

After my post-doc I would have been happy to stay in Xxx [name of a country] if there had been a good opportunity there, instead I found a position in Xxx [country] and I have stayed here since. 03_M

The scientists specify as well **difficulties with management of their careers due to different mobility cultures**. While it may appear that mobility is embedded in doing physics in European institutions, in fact mobility patterns differ between countries. As underlined in the chapter “Career paths...”, in some countries the interviewees usually stay all their lives in one institution (e.g. Poland, Italy, Romania) experiencing travels, even long term, as “business trips”. In other countries e.g. Germany, France, Switzerland, or Netherlands their paths are much diversified. The age is also an important category, definitely showing the generational differences in being a physicist – those who face the precarious labour market in the recent years, have a different experience of scientific path than those in senior positions. Now the scientific career is often filled with uncertainty over their careers and potential employment.

(...) every time I need to build up a new network in a new country, which has slowed me down so much, that I ended up having a backlog on the career path to those you remained safe and sound at their PhD-institutes. 52_M

That means I am here and I cannot stay, because I have been here for too long and now I can also not go back to Xxx [name of a country], because I know no one there who would hire me. 07_F

At [our institution] I think mobility is evaluated in contradictory way: I mean sometime getting back from an external period would have [been] very difficult in terms of getting again the position. Now I think things are getting better, mobility is better evaluated. 42_M

The **integration of mobility within one's career path is a challenge** – this demands from a researcher having strategic thinking skills, as well as good supervision (see also chapter on “Work conditions and environment”). There are also different opinions about the best time to do the longer research stay abroad. The strategies differ depending on where one wanted to end up, as it revealed that depending on a country the decision to go abroad or not may be decisive for future employment opportunities. In some countries – the PhD phase is the most suitable, e.g. in Germany, as you are supposed to come back to Germany with foreign experiences, while for example a French-origin researcher claims that in case of France doing PhD outside France puts you at disadvantage. The case of young female scientist illustrates well the confusing employment (written and non-written) regulations:

So there are not that many post-doc positions and many post-doc positions are basically financed through single scholarships and now I cannot get one of those anymore, because they are all for foreigners, (...) so you are not allowed to be in X [name of the country] for so long to get those. (..) That is now, that is the only thing I can do, is apply for a Xxx [name of the institution] grant or something like that. But that's something I am not able to do as a young post-doc. (...) and now, for example, when I go back to France, I do not know anyone. That means the chance, so the probability, that I find a job is practically zero. Because everything works with like insider relationships [Old Boys Networks]. So you will never get in if you do not know the professors, if you do not know the group, if you did not study there. Everyone knows that. So that means if I want to go back to [name of the country], I even have a disadvantage, because I did my PhD abroad. 07_F

4. Networks

Introduction

Sociological research shows that **membership in scientific and science related networks influences women in a bit different way than men**. For female researchers “benefits gained from membership in networks include the ability to build social capital, promote new contacts, professional socialization and emotional support”, while male researchers underline first and foremost instrumental benefits for their own careers and rarely mention emotional aspects of it. The networks may have different forms and goals – e.g. as it is shown in the chapter about mentorship, informal support given by colleagues from work could also be sometimes considered as a way of networking. Other visible forms of associating could be: mixed gender networks, female only networks, networks dedicated to one (sub)discipline or for one region. When it comes to both formal and informal participation in such structures, not every GENERA study participant belongs to a network. Their evaluations of the benefits coming from the membership, usefulness of the networks and their importance for career development provide us with a complex picture of the contemporary networks accessible to physicists as well as various definitions of a network itself. The most crucial reflections regarding formal and informal structures and groups of support present in the collected interviews are:

- Mostly young and female researchers declare their membership in networks, more often than male and senior researchers, leaders less often than non-leaders;
- Young and senior researchers present different arguments when it comes to their reluctance to be a member of the scientific networks. While seniors are usually preoccupied with their job responsibilities and do not have enough time to engage in networking, young scholars often have to deal with a fragile sense of belonging to the workplace caused by short-term and unstable employment. Their fragile positions make them reluctant to joining the networks (as they feel out of place), but also eager to create new ones, that could assure them a sense of belonging;
- Although networking by joining formal local and international networks appears in the narratives, in most cases networks are defined as informal and discontinuous collaborations between researchers and institutions (e.g. through research grants);
- Very few women declare being a member of **women’s scientific network**, and none of the men in a role of a formal supporter - as they declare gender being unproblematic for them;
- Male researchers more often are not concerned about **scientific women’s networks** as they perceived them as solutions for gender discrimination problems rather than science development oriented. **Female scientists are more gender aware and value the importance of those networks for being able to talk about same topics, because of women’s openness when compared to men’s** (alternative for old boys club); women perceive the networks as beneficial and needed place of support and exchange of ideas.

Reasons for networking

Although networking is often considered as “a must”, different definitions of it show more nuanced vision of reasons for becoming a member of the networks. For some physicists being part of the network has in fact **very instrumental character** as it provides them with access to journals, information about conferences and scientific events, new publications and funding possibilities etc.

It helps me to progress in career, give some allowance to participate at important conferences and access to journals. 77_F

The most common reason for creating, developing and belonging to the networks, sheds some light on the essence of the scientific work. For the majority of the interviewees **networking has rather informal character** and is related, at least to some extent, to **the core of physics** – a necessity of building teams comprised of researchers with different skills, knowledge, approaches and access to equipment requires collaboration with various research centres and laboratories around the world. In other words, physics as a discipline due to its basic principles (e.g. experimental work) implies participation and involvement of diversified specialists, researchers and theoreticians (see also section on "Work conditions and environment").

Belonging to a network was fundamental for the development of my career in this field. 44_M

Research according to me is international. Small experiment does not work anymore. What we need is strengths from different countries. 46_F

Such collaboration and building informal **networking is often facilitated and intensified by research funding programs** which imply close, often international, cooperation between teams. In order to receive funding for an inquiry, it is necessary to build an international consortium. Important here is that participation in one program or project triggers a possibility of collaboration in the future, that is why being part of any network, even informal, is so essential for the researchers.

I consider the collaboration as a network: we are all working in the same project, of course, but not only, so we are implied in other projects. We can exchange a lot about different subjects and it's very interesting. 33_M

Being an expert in evaluating programs from [abbreviations of research founding organizations], it certainly helped, because the appearance of such an expert implies that people associate that there are people coming from such country, and perhaps it is worthwhile to reach for these resources that are different from ours, and sometimes it directs people to other groups that can decide on developments or directions. 58_F_L

Other research conducted among physicists almost three decades ago shows that informal networks operate according to several crucial characteristics. Firstly, such networks imply regular contacts and sharing information of research progress. Secondly, being part of the network provides, creates and sustains a professional identity. Thirdly, "they [networks] provide contacts with people 'at the cutting edge', and so indirectly enhance one's own reputation and career prospects". These aspects are as well visible in the GENERA study which reveals another important facet of networking – it shows that **participation in physicists' networks intensifies mobility** opportunities and strongly supports research exchange.

The Xxx network is mainly about solving certain problems, there is always a scientific problem to study within this network, but its primary goal is about contacts, about meetings, exchange programs between laboratories, from time to time there are some bigger events. So fore and foremost it aims at mobility. 72_M

As mentioned above, the research participants value primarily **informal networks** - non-institutionalized collaboration between researchers and/or institutions (including external laboratories) is seen as most valuable for knowledge and research(ers) exchange. Such

understanding of networks sheds some light on a possibility of scientific exchange regarding research methods and approaches or of joint publications.

You must belong to different research groups, have different professional contacts and collaborate with many people. 24_F

I enjoy getting to collaborate with different people across the world. 03_M

As member of a big collaboration, I had the impression I had enough contacts with a lot of researchers and didn't feel the need to connect with other ones. 34_F

What is important here is that collaboration is also seen as a **significant career pusher** in terms of gaining prospect future job contacts. For young physicists their belonging to such structures often depends on the contacts of their supervisors, as they usually introduce their mentees to the research world (see section on Mentorship).

[Prompted about whether networking is more commonly done informally] Yes, exactly. Those are actually. With the network, that is rather with your PhD supervisor. (...) when your supervisor has a lot of collaborations during your PhD and he sends you to conferences frequently or on work trips or something, then you simply get to know a lot of people. And then the probability, that one of these people—when you do good work—gives you a job, are really high. 07_F

For women (including those performing research in emerging fields³) formal networks are important in developing one's career. Some of them declare their willingness to join women's networks for achieving gender equality, but also perceive them as “**career pushers**”. It's not always valued positively by them as it is sometimes perceived in terms of special treatment.

I've never been part of this kind of pushing career network, because that's the point isn't it? I don't think I want special treatment. 37_F.

It is very important having a real and wide network because you should have much more opportunities, but I don't know if I have it. 43_F.

I would say that cooperation and conferences promotes, there you meet people and when you talk with them then... and you keep in touch with them, then it promotes you. 22_F

Networks positively influence individual recognition and help to **develop and sustain a professional identity**. The latter means that it helps to unfold an individual identity as a physicist and strengthen existing bonds with a discipline and research organization.

The first network didn't play any important role [in my career], but the second organization, although it didn't help me in my scientific development, undoubtedly contributed to my recognition [as a scientist]. 70_F

Finally, physicists join networks because of a possibility of getting **external funding support** and coverage of access to different sources of information.

In this network, to which I made our institute join, there is a special program for women, in which a female researcher can get 1000 euro to go to selected laboratory, present herself there, so she has a presentation, talks about her research, about her scientific

³ By emerging subfields we understand e.g. combining physics with biology, medicine and technology.

plans. And that's something I will try to introduce next year, I mean I would like to organize it this way that each year one woman from our institute could go. 65_F

It is helpful because it gives you access to mobility, publications and other resources. 75_F

Challenges related to becoming a member of formal networks

Physicists sometimes decide not to participate in any formal networks or belong only to very few structures during their entire career. Such attitude can be caused by several different circumstances. For some of our respondents, **informal contacts** are more fundamental in their work than formal membership in a research institution responsible for associating researchers. In other words, the fact of a lack of any formal network membership does not mean being isolated from the scientific community. Other reasons for rejecting individual engagement in the nets are related to:

a) significant lack of time

It is underlined that such networks are important for young researchers, but senior physicists and those in leading positions perceive these support structures in terms of additional tasks to be fulfilled and do not want to be part of it due to lack of time.

I'm already part of the [name of physics formal organisation in a given country] and from international collaboration, so I don't really need to have other opportunities to meet people... And I don't have the time! 35_M

No, basically I didn't have enough time or opportunities to develop myself in this direction. I've never been active in this. 68_M_L

It was useful when I was a student, it opens doors. No, I do not have time anymore. 79_M

b) lack of funds (e.g. for fees)

Another visible circumstance that hampers becoming a formal member of scientific networks concerns **a lack of funds** for paying fees or ensuring participation in the networking meetings. This problem is particularly visible in Polish context where universities or research institutions rarely guarantee financial resources for such activities. Paying fees from one's own salary is not always an attractive alternative for academics.

Well, unfortunately, all my ideas always have this question in the background: what is the price? How much I have to pay? Well, [I'm wondering] how much I can contribute from my own salary, really, my wallet is not made of rubber. 65_F

However, it is very important because you can meet people, so it was probably the first association I signed up for, and then I signed up for many other international ones, but also because these fees are quite expensive, I gave up. 60_F

c) feeling of instability resulting in feeling of lack of belonging

Another challenge related to becoming a member of scientific networks concerns **precariousness of the employment**. Young researchers, who do not experience **a sense of belonging** to their research institution as they are hired only on temporary contracts, find it difficult to become part of any network. Such temporary employment and uncertainty

connected with it can significantly hinder developing of a sense of commitment to the scientific networks. On the other hand, informal contacts are often used for overcoming precariousness and finding a permanent position.

And now, for example, when I go back to Xxx [name of the country], I do not know anyone. That means the chance, so the probability, that I find a job is practically zero. Because everything works with like insider relationships [Old Boys Networks, but it is not clear from the interview that this is what was meant exactly]. So you will never get in if you do not know the professors, if you do not know the group, if you did not study there. Everyone knows that. So that means if I want to go back [there], I even have a disadvantage, because I did my PhD abroad. 07_F

d) lack of scientific network culture and language skills (cultural differences)

Not being a member to any formal network also relates to **cultural differences**. This issue is visible in the interviews conducted with researchers having migration experience from countries, in which formal networks are not perceived as important for a career or scientific development. These culture differences can be also reinforced by difficulties related to language and communication processes.

“[I: Are you a member of any formal network?] No. (...) [I: How come? Why are you not a member?] So, I think there is not so big culture of this membership in Xxx [name of the country] and then, when I moved here I also didn't feel any obligations to be a member of this. And I am also not so - so one point of this membership is that you get that kind of [unintelligible], but I am not so good in Xxx [language that is used here], so it is not so useful for me. For their meetings you can go without being a member also. 11_M

e) lack of knowledge of their existence

When it comes to women-only networks, the majority of the research participants do not have enough knowledge about them to become a member. This suggests that such networks are still not recognized among physicists in various regional contexts.

I don't know a network specially for women scientists. But if there was one with interesting actions, I could join it. 36_F

Frankly speaking, I've never met with such networks [for women in science] before. I have not received any information. 64_F

f) gender stereotypes/discrimination

A direct experience of sexist culture, gender stereotypes and discrimination may result in developing a distant attitude towards scientific networks, which are sometimes depicted as sexist, exclusionary and based on internal hierarchies.

It is just simply the case, that when one of those old professors, maybe in his mid-50s, it is pretty okay, but you cannot go to young group leaders or something like this. So, it is really quite weird. When you approach group leaders as a women, who are already, who are successful and you are still young and have no idea and then you just go them and want to introduce yourself, so to say. Except when you have a really good question and then the guy thinks, oh, you are smart or something like that. But, I mean, if you just generally want to talk to him or just like that, it is super difficult. [Prompt: Why? Why weird? What happens?] Either they think “Oh, what does she want from me?” or

they think “Yes, what does that bimbo there want? She is not able to do anything anyways” or they just look at how you are dressed. 07_F

Women-only networks

As mentioned in the previous section, one of the challenges related to women-only networks concerns their recognition among physicists. Organizations and structures supporting female researchers often remain unknown and unfamiliar to the researchers.

However, knowing such organizations facilitates supporting their development. The majority of women having experience of being a member of such structures, **evaluate them positively**. The networks for women in their accounts are supposed to:

- promote gender equality;
- create safe spaces for women (outside of sexist culture);
- help to gain visibility;
- enable to share similar experiences.

I was member of Xxx [name of a women-only organization], at Xxx [name of the institution]. I'd like that once a month women get together and spoke about their issues. 77_F

I think it's very important, it's a crucial point for the gender equality, to promote the presence of women in science. I would support this kind of activities if there was one in the laboratory. 36_F

And that, so this Xxx [name of a women-only organization] I think is a good thing, because you can just, so you can, the approaching is simply way easier, much more normal, more professional, so I don't know how to say it. Because there are no weird sexual or misogynist ulterior motives. 07_F

In few cases an **individual attitude towards women-only networks is shifted due to personal experience of e.g. becoming a mother**. While before such experience female researchers did not include gender sensitive perspective to their work, having a family helped to frame their experiences through lens of a need for systemic actions and solutions for gender equality.

Before I was more in an individual approach, where the sex of people was erased and where I was concerned only with skills. Since I had my daughter, I have begun to ask myself a lot more questions about the professional world in which I want her to evolve later. So I think this kind of networks to promote gender balance is really important. 34_F

Not every female and male interviewee underscores a need for such networks. For some interlocutors, creating a network or an organization only for women could introduce an additional **"unnecessary division"** among physicists. Most often such opinion is supported by the conviction that in physics there is no inequality between men and women, and the disproportions in their number result from certain objective premises. The idea of supporting “talents, regardless of their sex” is also mentioned in this context.

For me it [the networks for women] is about showing unnecessary divisions. I see that in physics we have more equal treatment in various behaviours, on different levels, than in

other disciplines. I guess that such [equal] approach could be caused by a small number of women. 66_F

I haven't heard of them, but I don't think I would like [to belong to them], because I think, that it is necessary to support talented persons and not necessary women, I mean, regardless of their sex, (...) I think it is necessary to support talents generally, but not aim at women only (...). 53_F_L

Female researchers underline as well an importance of informal women's networks, which they build using their contacts with other female physicists. Such networks help them to develop social spaces in which they could feel comfortable.

So for instance I have a very good female acquaintance, who is in a similar position like me and, exactly. I have as well met her at a conference and so on. So, and that is actually really nice, to always meet her again and exchange with her. Especially because we are both women and, yes, I find that somehow you have more things in common and you have completely different topics somehow, that you talk about, as compared to male colleagues or so (laughs). So it is a little different. 06_F

However, some of the female respondents present a very distant attitude and underline that they do not feel comfortable in such female networks as it is about "sticking together [in a pejorative sense] and general building of such a narrative that »we are better here than the others who do not have children at this age and those who do not take care of children because it is well known that guys they do not take care of children, of course«" [66_F].

5. Mentorship – importance, forms and gender dimensions

Introduction

While talking about important figures for their career developments, some of the physicists mention “private mentors” – teachers, parents or kin, who strongly influenced their life choices, especially in childhood and young age periods. This informal support has at least two different meanings. The first one shows an importance of having a role model to pursue an individual career, and to develop competences, knowledge and skills.

My parents and two extremely good teachers that cultivate my skills [were very important in my career development]. 82_M

One important factor [for the fact that I became a physicist] was my uncle who was a physicist, and he was much appreciated, he travelled around the world, he surfed, well, he was a very cool person, who was always around, he was my kin I mean, and he was a positive example of such career, he was very interested in physics. 62_M

The second understanding of “personal mentors” sheds some light on significance of the support provided by close family members. The GENERA study reveals that encouragement for choosing a scientific career and approval of individual choices, expressed by “significant others” may play a crucial or at least relevant role in aspiring to become a scientist.

Beside my husband, no one had a big influence in my career. 76_F

My father was a key figure in this choice, he always supported me in choosing science career. 41_F

Underlying the importance of the private sources of support is sometimes accompanied with demonstrating a lack of professional mentoring or assistance in pursuing one’s career. In such narratives scientific achievements are presented as a result of individual efforts and hard work, and rarely related to a team exertion. In this context, physicists often indicate that they are more likely to consult important decisions about their scientific career with close relatives, kin or friends rather than with a supervisor. This may be due to the lack of certain institutional solutions that would enable creating of a space for such discussions and guiding in the workplace. But for some of them it was their sense of independence and autonomy that guided them through the course of their careers – few interviewees explicitly demonstrated a lack of interest in being mentored by somebody else.

No, quite the opposite. Everything I have done so far is my own doing, except for the mutual support between my wife and I. 52_M

No, actually not. It is always an interaction between different people. So, I wouldn’t say that there has been a specific person. So, during our experiments, during my master thesis, of course I had my boss whom I could always ask questions like how things work and what to do next. And I found him... So, he is a choleric person and strenuous but if you needed help, experimental, he really helped you very fast and good. (...) I believe he tried to support me but somehow (...) yes, experimental, when it had something to do with work then he could support me very much but with other decisions. I believe I mostly decided for myself. There I have consulted myself rather with my boyfriend. 22_F

I have always been quite independent, I have never had a reference boss. During my PhD I had two professors which led me and with whom I have continued working together

years later. They were the responsible of the funds that's why they were our bosses. But there was not a baron who told you what you had to do and what not. Never was it a woman. 39_F

Sometimes while being asked about role models or important figures for their career, physicists draw our attention to more abstract vision of a role model and stress their idealistic vision of what they want to achieve. For example, the idea of “changing the world”, a certain “curiosity”, knowing that “we still search for something, (...) that there are still great things to be done” were mentioned by some of the participants at the first place while answering the question about role models guiding their research and academic career.

I didn't have any role model in my career, I just followed what I wanted to became. 43_F

When I was young, I wanted to change the world by being a scientist. 42_M

Furthermore, it's worth noting that a significant role of school socialization to science seems to be of high relevance to individual choices regarding future careers. For some of the research participants, their teachers from primary or secondary schools were the first ones who inspired them to follow the scientific path⁴.

And when I went to middle school (...) I participated in a competition in mathematics and physics, I had a lot of support, as I went to private school, we were a small class (18 people), and there was this physics club for pupils and it initiated my involvement in science. Then I went to public high school and I had a great mathematician but a bad teacher in physics, but despite that I was following physics path. 62_M

When I was in high school, I went like one week to this academic discovery program. People from different schools and universities. I choose the physics course, but the course was not only the teacher teaching, he told us “Ok we have a problem to solve, you're in a room full of books and instruments, how do you want to work?” It made me really happy because I was afraid it could be very boring, but finally it really makes me have the decision to go on in physics. That man was not the most brilliant physicist of the world, but he convinced me it was the job I wanted to do. 37_F

Math teacher was from Moon, a lady who came to us only for a year, in 4th year of elementary school and she did such a revolution that I felt in love with math (...). And later I found myself in this fantastic class and at the beginning it was math and nobody told me that I am a girl and couldn't make it, and later [it was] physics and this teacher who told us that we could make it (...). 56_F

The research shows as well in what way more institutionalized and professional forms of support, mentorship and guidance impact individual careers in physics. The following part of the report gives center stage to definitions of the mentorship and its importance for the career development. It also discusses the main forms of scientific guidance and gender dimensions of being a female supervisor or leader, and managing male or female young scholars.

Importance and forms of mentorship

In addition to the above-described narratives focused on an individualistic description of own achievements, the majority of the research participants indicate that mentoring has a great

⁴ Thus, gender equality plans for science should include actions addressed to both teachers and pupils with special attention given to girls.

significance for the scientific development. This attitude is rooted in the experiences of being both a mentee guided by more experienced scholars and a mentor to younger physicists. Many of the respondents demonstrate an **instrumental character of mentorship** by showing that having a good, well-organized, well-known and well networked supervisor is a key to the scientific world. In such perspective a mentor plays a role of a gatekeeper and a necessary link between his or her mentees and academic labour market, cooperation proposals, and grant programs. A supervisor in these descriptions ensures funds for the team research, helps his or her younger colleagues to apply for a job position, builds wide networks between researchers and includes to them those who are mentored. In this perspective mentors are the gateway to the academic success.

I think thesis supervisors are important; not only in terms of good or bad thesis supervision, but also professional contacts and research subfield. 31_F

She was the boss of my research team and she encouraged me to apply for a prestigious post-doc grant. I am very grateful. 26_F

Besides the fact he [his mentor] is recognized in science, and he has a lot of contacts, which I made a use of, he is also a smart and funny person. 62_M

More specifically, the instrumental aspects of mentorship are sometimes narrowed down primarily to **help in finding a job** by young researchers. The research shows that informal support by giving a positive opinion or a recommendation about a candidate is often crucial for the employment process of a given person.

Yes, definitively. Definitively. Because if no one continues to support someone it is in turn difficult to find a new position, because there are many good people and it is not enough to do good work. There needs to be someone too who, so to speak, would vouch for someone or tell someone "I know someone, who I would advise you to hire them." 09_M

This facet of the mentorship is also visible in some stories told by physicists who did not experience such support and who compare their situation with colleagues having this kind of backing in their professional life. Such observation of different mentors' attitudes, resources and various levels of their involvement may lead to a growing feeling of dissatisfaction and injustice experienced in the academic world.

Yes, you really have to... if you have a boss who is a well-known and well-organized person, well, [then] these young people [under their supervision] get grants, yes, you see, they develop very nicely, get promoted, and I am happy [for them. On the one hand, I am sorry that I do not have such a possibility, I have to build my own position, which probably will take me more years, but I think that in time I will get some research funds and then I will really spread my wings. 65_F

Apart from this instrumental dimension of mentoring, a lot of space in the interviews was also devoted to the **substantive aspect of scientific cooperation with supervisors**. It is worth noting that a mentor often performs a **variety of roles**, providing younger researchers with not only strictly scientific skills, but also organizational, social or related to public speeches. Such a broad definition of mentoring translates, in turn, into strategies of using it. This means that young researchers derive diversified skills from their tutors.

I always had such an attitude that I tried to pull out some positive things [from cooperation with each supervisor], so as to learn as much as possible, and each of them

had certain skills, from a certain area. One was, let's say, a good organizer, I do not know, the other was better in science. You could rely on their approaches to certain issues, so I tried to take these positive things into account and take advantage of them, (...) so that I tried to follow good things, and leave the rest [of them] somewhere to the side, so this is a question ..., so each of these people would be, as I say, important, each significantly influenced me, because I learned from each important things so I cannot say that ... I mean I liked some of them less or more, but I took something from each one, whether it some skill or a certain philosophy. 68_M_L

These gentlemen had a huge impact on the fact that I was never coerced into anything, I was not told that I could not do another step because a certain experiment or development path was planned. On the contrary, I was encouraged to try using all the weirdest ideas. And that resulted in the fact that I was firstly in this group of the Nobel Prize winner and then I was in Xxx [name of the country]. 58_F_L

The cooperation between a mentor and a mentee influences sometimes explicitly career decisions of young researchers, when for example they decide to follow their supervisors and move from one research center to another, also to a foreign country like in the quotation below.

[Going back to home country] was basically only a coincidence. So I didn't make the conscious decision. It was the case that I worked for the director Xx, who used to work at the University and I was there with her as a post-doc and then she was appointed as a director and then I just followed. 08_F

This different dimensions of the mentorship' significance is from time to time accompanied with more specific expectations addressed towards scientific guides. In Polish context for example in two different institutions an additional character of mentorship, related to the **personality of mentors**, was underscored. In such understanding a mentor is not only responsible for scientific development of his or her mentees, but introduces them to broader social and cultural worlds, by showing e.g. how to behave or act in a cultural and ethical ways. Such vision of mentors was also expressed in French realm. The perception of mentors through the prism of their outstanding personality was present above all among senior researchers.

Undoubtedly, when I came to this institute, professor [name] was such an authority in a scientific sense, but also in [the other sense] ... He was not, after all, old ... With some sadness I have to say that this group of professors, who were the most outstanding group in our institute, at the moment, mostly do not work. There is the next generation now, and the older group, not in scientific terms, but in terms of behavior, representation, acting, I think was "better", and undoubtedly, this professor [name] was such a personality. We did not always agree (...) there were some disagreements, but it's normal for people to happen, but for me he was somebody important and different, different from among all the others and that's why I ask myself whether there is such a person in our work environment right now. 70_F

It means that these are the people who influence other through their behavior, often ethical behavior and such people used to be and still are here (...) and this is very important that there are such people not only for me, but they had an impact also on colleagues. 54_M_L

So, they are this kind of academic people of very high level, with a personality very highlighting for their colleagues. I mean, you can be very clever and specialized in your

domain but be totally stupid in real life, I consider it's not an intelligent person. This people had the whole package, they were really a source of inspiration. 35_M

Mentoring in the collected narratives was often equated with formal and informal supervising, informal and personal support or even support received through collaboration in a team. For example, in some definitions given by the interviewees mentoring means simply **close and productive collaboration with a team**. In other interviews, the interlocutors expressed their appreciation of working with younger generation of physicists, who can provide new ideas, theories and tools to the research.

My team colleague is a role model to me. My team colleague is always encouraging my work in a very supportive way. 83_F

I still have support from my mentor, he is almost retired but he still supports me. He tries to get grants for the team, teaches cooperation with other people, centers. This is important. As for strictly scientific support, I try to cooperate primarily with young people, because they have a more fresh perspective, they bring a new perspective. They come to me with questions, present their perspective, but I also often ask them about various things. I feel that there is a discussion between us, a live debate. And older employees are often discouraged. 74_F

Such a perspective clearly shows that mentoring is still more often understood as informal support received from colleagues and supervisors. Institutionalized mentoring programs are rarely invoked.

Critical evaluations of mentorship

Although the majority of respondents positively commented on cooperation with mentors, there are also very critical evaluations regarding such cooperation and assistance received. A good illustration of such reflections could be the following statements: “it was a clinch in which I found myself for a very long time and which also caused a lot of burnout”, “I was left alone”, “I did not receive any support”. Among situations indicated as the reasons for difficulties in obtaining support appeared: distance mentoring, personality conflicts and conflicts in the team.

I had no mentors at Xxx [name of institution], at the contrary I must say I had there a mentor “at negative”, people that provide negative examples and I would not became as they are. 42_M

As I was doing a PhD programme, I was writing my articles and I was very happy [at that time]. Unfortunately, the next two bosses, whom I chose, or maybe I had no other choice, claimed that in principle only they are able to write good articles. And this exhausted me. 65_F

I had no mentor for my career. 76_F

On the other hand, critical evaluations came from mentors as well. Some of them indicate several difficulties in supervising young scholars, showing e.g. that mentees should be “released” at some point of their career path to gain their independence, autonomy and capacity of making decision. Basically “giving somebody a free rain” is seen as something positive when it comes to guiding young scholars.

When it comes to my boss for instance – he is very self-reliable person and he was like that from the beginning. At some point this mentoring is very helpful and I try to introduce

my students to the lab, show them what and how, so they don't feel like being on their own, but at some point they should be "released" and be taught some self-reliance in work. Mentoring yes but not introduced by force and not for too long – just like raising the children. 55_F

I mean, I do not think I have a plan [regarding being a mentor] here, I do not know. Well, it depends of course on a person you cooperate with. In the case of my doctoral student, during the PhD program there were consultations, I suggested her what to do, now after the program [is finished] our cooperation is based on an idea she can do what she wants, but I clearly said to her that "if you want to consult something that is unclear, something to be explained, you can always come to me". Yes, I think that after the doctoral thesis, you have to give this independence too. 72_M

Gender dimensions

Female role models

While talking about gender dimensions of mentorship, physicists underline relatively **visible lack of female role models**. Some of them indicate that it's hard to find any contemporary famous female scientist with whom young researchers could identify. On the other hand, it was revealed that sometimes the scientific world does not provide positive examples of female reconciliation of professional and personal life – **a dominant discourse promotes a total devotion to science and does not advocate for more balanced vision of career path** (see also chapter "Career paths...).

When you think about it, the only female model people know in physics is Marie Curie. She died a very long time ago, of course she was brilliant but how do you want young women of today identify with her? 34_F

There were not so many female role models which I met during my career. 01_F

[Interviewer in referring to her current supervisor: Was it important for you to have such a role model, a female role model in physics so that you can see that it works?] Yes, of course. Yes. Whereas, that is always funny. There are many things that should work on paper, and then you don't find a woman in real life that embodies that. So I do not know a famous female physicist, for starters. And I do not know a female professor with kids. Full stop. And then you are always told 'Yes, of course you can have a career with children; that's all possible'. Yes, show me where. Go on. Please. And then you think to yourself, oh great that works. And either you try to be the first and then good luck to you or you say, yes, I am not going to do that to myself and you leave. 07_F

In my Institute there are a number of female researchers that I always considered as peers. No one on those was a role model or boss. 41_F

In the context of role models, **the need to create (informal) support networks between women** is also pointed out, so that at different stages of their career they could exchange their experiences and feel comfortable in the workplace (see more in the section on networks).

The support measures are different at different stages, but it is essential that women support each other, for example in faculties, I do not see why it should be institutionalized, but I think we should have tutors for both women and men so that young people who go

to college with any problems do not feel embarrassed or feel bad about trying to tell their problems. 58_F_L

Gender and leadership

One of the topics discussed during the interviews connecting gender dimensions and mentoring is related to differences between male and female bosses. Most of the interviewees **did not experience having a female boss during their entire career**. A general belief that women in leading positions are evaluated differently than men is expressed by physicists.

I did not have so many, but a female boss suffers more negative judgments than a man. 49_F

Those who had such experience underscore two important aspects related to female leadership. The first one indicates that there are in fact no differences between male and female leadership styles. In such perspective the attention is shifted to **individual personality rather than gender**.

My boss is a woman, [there] is no difference between a man and a woman in leading a group. 75_F

No, I think there are differences, but they exist because everyone is a different personality, not because of sex. It is known that new authorities mean new directions, new way of thinking, this is natural, but I don't think it is related to being a male or a female. 53_F_L

The second facet of female leadership reveals primarily positive evaluations of female leaders by describing their **constructive engagement in chief roles**. It is indicated that women contribute better than men to organizational aspects of work, that they are more “stable”, “empathetic”. Management style linked with female bosses is based on multitasking skills, good organization of time and stability.

I'd like to have a female boss, because I think women are more organized and more stable. 83_F

A female boss seems to be a better administrator that gives a proper balance between personal life and profession. 82_M

Different leadership than men's meaning that women are more empathic and are good at group formations. 32_F

But it's also worth noting that other studies on female leadership in academic world shows that female leaders not only meet with critical judgments from colleagues (both male and female), but also in some cases do not necessarily support each other. For example Redmond et al on the basis of literature review demonstrate that “emerging leaders regularly report having had negative experiences with female co-workers and supervisors within the workplace. In addition, senior women who have not had support from their female colleagues are frequently unaware of how best to support other women aspiring to assume leadership positions and often consider aspiring leaders as a threat to their own advancement”. **A lack of support from female leaders** is also experienced by some of the respondents, although it is **quite rare**.

Yes, I really appreciated the fact that she was a woman, because she was very reliable, although she said ...because she was there to write an opinion about me, she told me that

the opinion would be good, but she had two excellent (male) doctoral students to whom I did not hold a stick, she told me so. It was unpleasant at the end. 64_F

In the realm of female leadership, it is also pointed out that the presence of women in the role of bosses may favor **the emergence of female researchers** in a given department. Presence of women in leading positions acts as encouragement for other female researchers to enter the scientific world.

No, but that is not the case with us at all. However, coincidentally we are three women and two men in this group. [...] But we are the only women in the entire department too. But I think that this was a coincidence, because my supervisor is a women and then. 07_F

Supporting female and male young physicists

Another important topic discussed with the research participants covers a problem of the **intersection of gender and mentoring** – namely **supporting young female scholars**. The majority of the respondents did not participate in any formal and institutionalized mentoring programs for women in science. But the collected interviews reveal various aspects and ways of thinking about the need of supporting women in physics. The main noticeable experiences in this regard are:

a) no experience in mentoring

Some of the interviewees, both senior and young researchers have not been mentors due to the character of the work. The support they gave during the professional career is perceived through the prism of collaboration and team work.

I had no occasion to be a mentor. 41_F

b) gender neutral mentoring

Not having any “special rules” regarding female mentees appears in the realm of gender neutral mentoring. Although the respondents mention working with and supporting younger researchers, they also underscore that they try to treat everybody in an equal way and support every talented person regardless their gender. Such attitudes are often accompanied with a critical assessment on the needs for special programs addressed to female scholars.

I prefer to judge not on whether female or male but on what they are worth. I prefer not to promote one or the other gender. 05_F

If someone wanted to meet me more often and came to me and said that he wanted to talk to me, of course I would do it, but I do not recall the situation to do it on special rules, except when I was in a scientific center where my female PhD student also worked, then self-evidently we met more often and talked more. 58_F_L

I don't see any differences between men and women because it's all about science, and not about being a male or female. If you work hard, you can achieve something [in academia] regardless your sex. I believe in a human mind. 63_F

But when they are in the team, they are all treated equally: I support the students, I give them missions, I encourage them to speak publicly, for both, women and men. 34_F

c) informal mentoring for female physicists

The most common model of mentoring present in the narratives involves **building an informal network of support** between more experienced researchers and younger colleagues and students.

Of course there are a couple of students, which I support, but like not in this direct mentor - mentee relation 14_F

In this approach mentoring often goes beyond clearly scientific collaboration and enables female scientists to share with each other broad experiences and reflections. Such vision of mentoring programs is in compliance with a need for having role models who could be used as “real examples” of how to reconcile professional work with personal and family life.

(...) not entirely, but for instance during my first post-doc, the university had a program, which was called “Women mentoring women”, where they connected post-docs to students and where you would then, so it was just informal, meet and, yes, talked about everything that was important at the time. So that was the one thing. And the other thing was only in projects in which you would work with students and needed to pay attention that they (laughs), yes, that they are students and not post-docs. 08_F

The lack of defined rules with regard to informal mentoring may, however, lead to potential conflict situations or lack of recognition of the mentor's work.

[...] Two years later one lady appeared, also a MA student and situation was similar, meaning part of the research was designed for her MA research and it was tragic. (...) I have to say that I felt exploited, I wasn't her supervisor, I was helping her a lot with experimental work and thus with data analysis and later I devoted a lot of time, (...) and it was like that I was applying for additional scientific attractions, then we were going to do our research to synchrotron centres so I helped her to find funds so she could go with us and fully participate and when it came to process finalization and writing a thesis, I don't know how much I helped her, but I helped her with editing this MA thesis, she went with grudges to promoter [saying] that she actually complains about our collaboration because I never had time for her and [that] I didn't talk to her (...).57_F

d) mentoring addressed to students in high school

Those physicists with teaching experience underline the importance of starting mentoring activities as early as possible in order to meet the needs of students and pupils.

Experience with the upper classes to inspire and mentor. It is fundamental that people are involved and aware. People aged 17 ask me how to manage to balance research and family. 46_F

e) differences between male and female mentees

The majority of interviewees underline that they do not see any evident differences between male and female mentees and their needs. If they are any, it is related with **individual approach to science, personality and experiences**. Some of the mentors, however, indicate that girls are socialized in a different way than boys what may result in various styles and approaches towards career path. Female mentees are perceived as more conscientious, dutiful and well-organized than male.

Female PhD students are asked more to do things because they say yes where boys are more likely to say no. At some point I realized it. 01_F

I would say that the girls are trying harder. Gentlemen are relaxed about everything. Usually girls, when there are some deadlines, they try to fit in these dates, they also try to work on better grades. Gentlemen are who they are and do not necessarily want to change, which sometimes is deplorable in its consequences. 65_F

f) personal experience triggering a need for being a mentor

Becoming sensitive to gender-related issues in mentoring can be associated with own experience of discrimination and sexism. This applies to both women and men.

It's a personal experience, I don't know if it's useful for you. My wife is a physician; she has been treated very badly in her first hospital in Xxx [name of the country]. She was pregnant and when she announced that to her chief of service, he became crazy. He told her: "You fucked up all my planning. Go away, I don't want a dead weight in my team." This personal experience made me very sensitive to problems and what is more difficult for women. So yes, I helped a little bit more my female students than the guys. 35_M

6. Reasons for domination of men in physics and existing barriers to women's success

The awareness of the gender discrimination and the knowledge on its determinants is considered as an important step towards gender equality change. In our study we asked physicists about the causes of men's domination in physics as well about the barriers that women may face in their career. It is important to underline that the concept of “domination” relates for some respondents not only to quantitative overrepresentation of men in the field, nor to their dominant presence in the governing or decision-making bodies. It is understood as a symbolic domination of which we will write below – the symbolic figure of a scientist being a man, and the masculine culture of physics within which some women feel isolated or unwelcome. Also important to add, that for a few respondents the numeric gender imbalance was not striking or not existing – Romania is an example of the post-socialist country where percentage of women is noticed to relatively high, similarly some fields witness more women presence:

At Xxx [name of an institution] gender situation is not so unbalanced, we have 43% women researchers. 81_M_L

I don't think there is a male domination in physics research because I've always worked with women since 15 – 16 years. That's not my opinion. I think difficulties are not link to gender, theoretically you succeed if you are competent. In practice it doesn't happen because there are a lot of variables which are not linked to gender. In Italy, it depends from the power of your boss, or other factors. 39_F

Growing awareness of gender imbalance in physics

Among the processes that have been indicated most frequently as causing gender imbalance are: firstly, cultural stereotypes around abilities of women and men to pursue scientific career and secondly the difficulty of reconciling family and work and social expectations towards women's roles in family. These processes are not specific to physics, nor even to STEM.

We observe rather perfunctory attention paid to the topic by many interviewees, but also difficulty to disentangle the actual causes of this situation. There is a share of the respondents that admitted that they never gave a theme much attention, and that simply they do not have a ready answer as this is not their field of expertise:

I do not know why this happens. Maybe the priorities are different. I do not know, I have no idea. 24_F

Declared lack of knowledge about the causes of gender imbalance in physics did not necessarily paired with assumption that topic is not important to deal with – in some cases respondents sounded rather hopeless that the issue still pervade scientific world:

I don't have a clue about why it's like that. I have two girls, they are very brilliant in mathematics or physics, they are really interested in science. I don't know where the break comes from, why so few women go for physics. It was already like this in my time, when I did my studies, we didn't have more than 2 or 3 women in PhD level. I'm still asking myself why, and why it didn't change. 35_M

On the other end are located those who have gone through much reflection concerning their own trajectories in physics (particularly females) and the situation of female researchers. Moreover, they attempt to undertake actions (individual or systemic) in order to tackle the witnessed gender inequality or discrimination. These attitudes will be presented in this chapter.

These diverse positions nevertheless illustrate the important switch within discussion around the gender imbalance in physics from “the problem of women with physics” to the “problem of

physics with women” (Götschel 2011)– thus, the community starts to express the concern over female low representation or even absence⁵. Particular activity is seen in Gender Equality Plan, and in around 36% of research performing organizations existed gender equality plans (EC 2015: 6; see as well chapter “Evaluation of institutions in fostering gender equality”).

Nevertheless, the voice that this topic is not of immediate worry for physics as a field, or that this is just how it is, is also present. Below there are three positions which assume a rather passive or negative attitude towards the implementation of measures to tackle gender imbalance:

Argument 1: Science is gender neutral with objective evaluation procedures. The respondents, more often men, stress the importance of rational evaluation and the ultimate importance of competence, knowledge, achievements and excellence on the career development and advancement. Gender is not considered an important criterion for evaluation and not seen as an important characteristic conditioning success.

I'm not sure it's really pertinent. My theory is that when you have your PhD, at least in this laboratory, you don't have to prove your value and you don't have problem because of your gender. It's a proof of excellence, you don't need something else.

33_M

In the physics I'm doing, high energy physics, it's really competence which counts, even not character. Of course you can have competition, but in a big collaboration it's very bad seen if you try to show misbehavior. The fight is only on scientific topics.

35_M

Sure men and women show different attitudes in carrying out duties, but that does not affect personal knowledge; what really matters is to have a high level of knowledge to solve your duties.

41_F

Argument 2: This is not a problem, as in other field there is dominance as well (of men or women). The passive approach to the problem is based on the observation of a general tendency for men to dominate in academia (e.g. in Italy), or through juxtaposing physics to fields that face opposite situation – this “justifies” the dominance as a phenomenon.

[In physics men dominate when it comes to numbers. What are the causes of this?] I would turn around this question, does it have to be equal? For example, the situation where you have dominance of women in sociology, and then dominance of men in physics, should this bother us?

72_M

It is a general problem that concerns all fields, not only physics

48_F

Argument 3: Women just do not want to be physicists. The position assumes that each person makes a free choice on their profession, according to one's predispositions or interests, and that simply female students choose other fields. The lack of willingness to study physics is also witnessed by numbers of those who apply to study this discipline. A simple fact of students being more often male is causing the imbalance within staff.

[Gender imbalance] results from the fact that (...) there are different predispositions to some activities, there are more preschool female teachers and more female nurses. (...) If a woman feels that she wants to be a physicist there is no problem to be one.

⁵ We have to stress here that the interviewees were volunteers who expressed interest in the study participation, so possibly they are more interested in the theme as such.

(...) this comes from the specificity of the profession. This is in the whole worlds and I am not sure if you can artificially change it, as it is deep in a person what they want to do in life. I just think fewer women want to have this profession. 69_M

From my point of view, when you look in the master studies, the percentage is probably 80% men? When you see the university is distributed like that, it's propagated after in all careers. The first question is "why are there so many men in the physics studies?". I'm not sure of my theory, but the asymmetry in women/men presence in laboratories is a direct consequence of the studies imbalance. 33_M

External determinants: Impact of the socio-cultural context

The most commonly mentioned **reasons for male domination in physics are located outside the field** as such – there are embedded in cultural and historical context and relate to cultural norms and values. First of all, the respondents relate gender imbalance to the **processes of socialization and reproduction of gender stereotypes** in youth – these concern perception of girls' and boys' talents and predispositions to scientific work. Girls in their early years are "communicated" that science is not for them, and that boys are those who have "natural" talent for mathematics and "innate" technical skills. As our respondents indicate, these processes are mostly perpetuated through educational system (schools) and family, and they result in girls' low self-esteem in relation to mathematics, potentially and in practice, impacting their educational choices. Sometimes those cultural norms are so strong that they are treated as an objective difference, nevertheless most of the interviewees underlined the meaning of socialization, learning and internalizing stereotypes by children:

The problem comes from an idea that is implemented in children's brains very soon. Science is a boy's thing, not a girl's thing. It's terribly wrong, but it's a very common idea. 38_F_L

We see that our society has certain expectations for girls and boys, that they're different. 13_F_L

From the very beginning, from preschool education girls are rather perceived as beautiful than smart.(...) I know there are some occupations that are perceived as male or female, but I think that if a girl has a need to become a scientist, like it was in my case, then why not? No, it is not unnatural. If this need exists then it is natural. Every girl in the world should know that she can be smart and that it is not something unnatural. 55_F

It's an ancient mentality that if you're a boy you might be smarter and had better technical skills than a girl does. 82_M

The [...] society looks at women as not so talented to get important roles in institutions, that's not true. This is because [our] culture. 45_M_L

In the early years when a young girl decides to be a student of physics, or even to engage more deeply in the subject in school, the **missing female role models** are a problem. This lack leads young girls to questioning their vocation to be a physicist (on positive impact of role models see chapter "Mentorship"):

When I was in high school, I hesitated between physics and history of art. The fact there was no famous female physicists made me think for a long time it was not a career for me. It is a vicious circle: since there are no examples of women known for

this field, especially in leading positions, women imagine that it is a very masculine or even macho environment and refrain from engaging in it. 38_F_L

If I have had a more tangible direct role model back at school that would have helped me making the decision maybe earlier, than I did. 15_F

Secondly, the **cultural expectations towards women's role within family** are of critical importance – many respondents underlined the constraints resulting from the social expectations towards women engagement in family life, with her professional career being of secondary importance. These social expectations have further serious implications. One of the most often mentioned consequences is **a priority of a male partner career** over female partner's one.

You can see that some of the bias sets in at very young ages in terms of what girls expect of themselves and what others expect of them. That might be a longer term problem. Overall historically physics is seen as a male career and society expects women to be home to take care of the kids which are an overall problem for women balancing a career and a personal life. 04_F_L

At some point you have to choose between personal career or keeping your relationship, your family life. Maybe girls are more willing to decide for the relationship and the guys for their career. If a guy pursues his career and his girl follows him, the society accepts it completely, he doesn't have any questions. In the other hand, you have a lot of people surprised and even shocked. It's not considered like normal. 37_F

I actually think it mostly has to do with how we all have prejudices about what men and women should do and how they should lead their life's, who should be responsible for family. I think it's both that men have prejudices but also women hold back themselves and decide not to follow a career in natural sciences. 16_F_L

The internalization of existing stereotypes of both women's lower capacities to pursue scientific career or concerning their primarily role as a mother can have diverse implications, which have been observed by the interviewees. First of all it may impact a choice of the career, but even if already in the field it may result in low self-esteem and doubts about one's capacities to pursue the career in physics, which can even cause women give up on the career in natural sciences. This was witnessed also in our study, as described in the part "Career path...", women more often voiced doubts about their talents and predispositions (this phenomenon is also known as impostor syndrome).

The older the previous generations were less likely to be welcoming to women and see them as peers. Since I have been here I've seen less of it but in high school my physics teacher was convinced women couldn't do physics. Perhaps its [the effect comes from] internalized ideas that women have on their own abilities fed to them by society. 04_F_L

Eh, well. Maybe it's a, well, there are multi-culture reasons probably and most of them are probably obvious but eh, obvious probably for many of us. But it's not clear how to fix this. So, well, you should probably start at schools. Because we need to give women already since there are very little, so very young, the confidence with the topics which are related to physics. So, they have to feel that they are also competent or that they can be competitor on this field. They have to find the confidence with themselves

on this topic and these, I think, can be really done by bringing simple experiments to school. 21_F_L

Men and women are equally motivated, the problem is more social. Sometimes women put them self-limits and obstacles believing to be minus than a man in terms motivation, capacity, skills. 41_F

As showed above the “responsibility” for the imbalance is assigned to cultural context and early processes of socialization outside academic world, and many respondents indicated that the **barriers for women to realize their careers are not within institution**. This statement matched with the assurance on the fairness of the represented institution or even science as such, non-existence of discrimination, and the existence of adequate laws and regulations to prohibit that to happen.

Men are not privileged, more than women, by any laws or regulations. 81_M_L

[Do you think that women encounter problems in realization of their career in physics?] We would need to analyze specific issues, as in general I do not see such problems. In our institution this is really an open profession, here we actually look at the potential of one's abilities. If someone is able to organize one's research work and has some successes. The matters of gender are of secondary importance. [What about women having children?] So, my statement was of general character, but if we look into specific themes, there might be problems. What you have just mentioned, can it fact pushed women from a normal path, stop her or even push away from the path. 69_M

I don't think that there is an institution barrier which is higher for women. 16_F_L

I don't think really that there is an active discrimination anymore nowadays. (...) Maybe self-esteem it was hinders you but not the research job or the administrative. 15_F

While, most of the respondents hold the opinions about the socio-cultural context impact on the situation, some pinpointed **objective differences between genders, their preferences or predispositions** – they mention abstract or logical thinking that is easier for men, level of aggression, level of sociality, nonetheless they are not necessarily innate. Interestingly, even if sometimes admitting to some differences they could not be sure that they would have an impact on the career in physics.

Apparently men think more logically, I don't know if it is so, I'm not knowledgeable about this, and women are more 'dispersed', but does it cause troubles in physics? I don't know. 53_F_L

I would say that usually a woman is less stimulated in doing such kind of things, she is less competitive for nature. 40_F

And you can see that, for example when you give them the kit with components, it's typically male, ehm, immediately touching all the components, starting to build things, do the experiment. While the typical attitude of a female is to, I mean, to do more careful, she has to realized and believe, she can do something and she, eh, she has to find the confidence to start with. But at the end the results they achieve and the experience, are better for the female comparison they made themselves, precision (laughs) and the way they decided to do the experiment and so. 21_F_L

Internal determinants: Androcentric vision of a scientist and growing importance of structural conditions

Second block of determinants of gender imbalance is related to the functioning of the field and its specificity. These arguments were less often mentioned by our respondents and included reflection over the specific features of the field that could potentially deter women from entering it. Some respondents listed the features of very style of working, stressing lonely character of theoretical work, the need to sacrifice for science or the necessity of enormous dedication to it. This vision of a scientist who is fully dedicated to science is androcentric thus not allowing for other engagements than scientific work – in this context family is a deterrent factor, that coincides with main duty of a scientist and the effects of such collision should be eliminated. This tale about “sacrifice to science” is seen in the interviews of both women and men, who underline the strenuous, often lonely, constant 24-hour brain work (see also chapter on “Work conditions...”):

This works like that, that a women is really ambitious and she can manage life in a way that her work is on the first place. 66_F

At the same time, the **recent developments in the field** (or in academia in general), linked to work organization and structural conditions grow in importance. Three traits of the today’s physicist career were underlined as potentially causing more challenges to women: precariousness, competitiveness, and demand for mobility. These challenges are believed to deter women from undertaking this career path – they are related though mostly to the experience of younger generation of physicists. These aspects of the scientific career are also challenging to the image of a scientist present in the above-described narrative of a person fully absorbed by the scientific problem – today the management of the career becomes additional duty of the scientist (see chapter on “Work conditions and environment”).

While these new demands are faced by both men and women, it is believed by respondents that women are less willing to work in these new conditions. Nonetheless, the analysis of other parts of interviews shows, they are in fact negatively evaluated by both genders. Here, when asking specifically for the obstacles to women career, they are believed to be more difficult to be tackled by women. In fact, these determinants appear even more as a challenge where matched with gender stereotypes concerning role of a wife or mother – **precariousness or mobility appear most problematic when gender and family norms hold as actual.**

Precariousness: Due to existing gender roles related to motherhood women seek more often than men stability in the career. As the period of family formation coincides with the time of unstable employment (usually, multiple post-docs with temporary contracts), this may be deterrent to women who would like to establish a family or already have one:

We, as women, have been taught we have to take care, to be cautious about future. Men are more taught to be adventurous, to take risk to succeed. I think it reflects in the career path: men are less stressed to have several temporary jobs when we concentrate on security. 37_F

The second thing is - I already spoke about this, but I’ll stress this – the process of obtaining a permanent position, especially in the West it is very difficult and it is associated with doing a number of post-docs, and this sometimes lasts, we are talking about 2, 3 post-docs three years each, this makes almost ten years. 10 years of very hard work before one can receive tenure. (...) there is also a strong competitiveness – 10 or 20 enter a race and at the end there is one. This is how this community looks like. 54_M_L

Long precariousness that is why women choose university paths that lead to less remunerated jobs, but stable and with less mobility (one of my colleagues has chosen to be a teacher). 47_M

Demand for mobility: Intensive mobility is more difficult for women who have children or who are caregivers in more general sense. (See more in the chapter on mobility)

The method of working in physics may sometimes pose problems, for instance these multi-week measurement campaigns make it necessary to leave for four weeks and not see home. In our culture it will be much easier for a man than for a woman, because – if there is a choice – a woman more often looks after a child and a man goes hunting. 59_M_L

You have to be competing and moving constantly in the period when people normally think about forming a family. In this phase many people give up, but they are mostly women 30_M

You have to consider that in the chosen academic career you will be asked to travel a lot. To go to conferences, to workshops, to be in committees, and this is already something that normally men can do without issues for all his life. While a woman, for a woman is for a few years can be an issue. 21_F_L

Competitiveness was mentioned as possibly deterring females from participation in the field. In fact, many female physicists in our study stressed the competitiveness as a part that they dislike about their work. On the other hand, there were critical voices underlining that competitiveness is not specific to physics and that it bothers both men and women.

(...) apart from cooperation there must be competition and (...) not a power struggle, but a fight for influence, to which men are believed to be foreordained and which is more (...) attractive for men than for women – maybe this is the reason and it activates more strongly in physics. 59_M_L

I would not say that it was more difficult because I have lots of colleagues which succeed without discrimination, I would say that usually a woman is less stimulated in doing such kind of things, she is less competitive for nature. 40_F

But I think physics in general is exhausting. Also for men as well. This constant competition. 07_F

There were also few comments concerning **female preference of scientific field where the knowledge is more easily applicable** to the external world over those fields that concentrate on basic research and theory. Some indicated as well that women like didactics and contact with students, which may deter them from undertaking work in research institutes that do not imply teaching duties. In the quote below it is interesting that the male respondents link the lack of choice of physics to the difficulties women may face in finding work - this is very symptomatic as the respondent immediately disclaims the possibility of scientific career of female graduates.

Physics is a bit for persons “with their heads in clouds”. Women are more practical. For example, my wife is a chemist, there are plenty of women in chemistry, they like didactics (...) and also chemistry gives wider opportunities, (...) you can deal with cosmetics, set up a business, this is a more pragmatic choice that allows to sustain a family. (...) so women are more grounded to the earth, they choose faculties more promising from such point of view... 68_M_L

Between external and internal determinants – areas of challenges for women

The clash between cultural norms and internal organizational issues create difficult conditions for women's career – cultural norms that work in favour of men when matched with new principles for work organization can have even more deterrent effect for women's career. For example, although reconciling work and private life was already difficult in a linear and predictable model of career due to career breaks, now it become even more difficult to pursue a career when having children with a demand to leave for a post doc to another country.

“Male club” – experiences of being in minority

The domination of men in physics has important consequences for the work environment and the women's well-being at work. Women who enter the field, have to face the fact that they will be among the few of their gender. Our respondents describe different moments when they realized that they are in minority e.g. they noticed that the committee is only consisting of old men, or that they are the only female members of the research team. Some of them feel that being in minority may be uncomfortable – “*you ask yourself if you are in the right place*”, some underline that it may cause fear or discouragement. In one case the female researcher noticed that this even caused to her the crisis with her womanhood –women want to adjust so much to the field culture that they cease to wear dresses or make up (see chapter on “Female experiences of microaggressions”):

Women feel frightened because of the surplus of males. 23_F

I'd always have the impression the male club had this feeling of: we do understand [ourselves] better among us boys. 42_M

When such a potential female professor of physics sees that she's one in 50, and there is no other female professor of physics, discouragement appears. 59_M_L

It is difficult to be the first or among few ones. 49_F

As our study shows the masculine model of scientist is reproduced in different ways, from the androcentric model of work, to organization of space, ways of joking or communicating. This causes as well the lack of understanding of the different challenges that women may face in their career e.g. linked to parenthood. This may have consequences for institutional change as most governing bodies are consisted of men.

Male model is not questioned, in trivial aspects, too. For example, at Xxx [one of the European physics institute] toilets are not divided according to gender. This is disturbing in such an international environment.) 49_F

The community in physics consists mostly out of men and they are missing the female perspective and don't understand the different needs and challenges from/for women in their career. 21_F_L

Some of the male physicists were aware that the way they behave may be a cause of unconscious discrimination as the style of communicating between men or symbols they use may be obsolete to females. Others are more critical and underline misogyny and lack of respect of the male colleagues towards the female researchers.

I have never come across conscious discrimination, however there might happen unconscious discrimination, which comes from some habits and from the fact that physics has been for long dominated by men, and the fact alone that women constitute 10% in physics and men – 90%, this alone creates unbalance, because the men's world can be a bit different, is based on bit different rules (...), codes. 54_M_L

When I speak to male colleagues I feel that they have low estimation of female colleagues. 42_M

Female researchers in our study often talked about the consequences of being in a male dominated environment. The first group of consequences relates to discrimination, sexism and microaggressions – these are discussed in a separate chapter “Physicists experiencing different treatment”. The second is linked to the notion of **gender bias**. It was noticed by the interviewees that women in physics need to **women need to “prove double” to receive similar evaluation** - there were voices in our sample indicating that for a women physicist to achieve success she must be much better than her male colleagues. Additionally, being a physicist means a contact process of proving that you are worth to be in the field.

I say it loudly, and definitely in physics, at least in our institution, but I think in the whole country, women needs to know much more than her male colleague to get a certain position or work. This is really true, I can say it from my experience. 70_F

As a woman in physics you have to be really, really good to get the same status as a man. 29_M

[Interviewer: Do you think you need to work harder...] Yes, yes. [...to counter these prejudices?] Yes, of course. Definitely, but that is always the point. As a woman you always need to prove that you deserve it, you know. And a lot more than a man. 07_F

Additional important consequence related to gender role and gender relations is the **delegation of low prestige (and time-consuming) tasks to women** e.g. taking notes during meetings, administrative tasks. Women are also often seen as teachers, and their engagement in didactics may cause lack of time to do research work.

I found Xxx [name of a scholarship] quite helpful. It really helped women to be one semester off teaching which they could concentrate on research towards the end of their PhD which can be useful. Female PhD students are asked more because they usually say yes. To have something specific which say you are not teaching that term helps counter act that. I realized at some point I had to protect my students because they are always asked. They are all small things but they take away from research. 01_F

And this is the barrier that me, but also my female colleagues, we were delegated to different tasks, like assisting, and the male colleagues were progressing. And then I was burden with all the small things to do so my time at work was full and I had not time to sit and reflect on some physics theories. Even if you notice it, it is difficult to liberate yourself. 65_F

Reconciliation of private life and work engagement

When the respondents are asked about the barriers to women success in physics, at the first place they underline the challenges women face with **reconciliation of family and work**. As noticed above the field is perceived as the one which demands sacrifice and presence in a workplace, mobility and dedication to publication, which can be difficult to realize when having care duties. On one hand respondents noticed how their careers or careers of their peers slowed down due to fact of having a child, on the other hand there is a realization that within the field there is a high number of those women who resigned from childbearing as it was difficult to reconcile with their career. While having family can have an impact also on male career (and as described e.g. in chapter on mobility it sometimes has), it is women who face social expectations linked to fulfillment of mother role. While respondents indicate that some

institutional solutions can help in the management of family duties in the context of work (which will be further discussed in the chapter on Institutional aspects of gender equality), but they rather stressed the meaning of cultural expectations towards women and men in family, which are hard to change.

They are in a disadvantaged position with regard to their curriculum because of the career breaks. A woman's career is slower because of family duties. Mobility is more difficult. 46_F

Physics loses its women after the PhD. Many female scientists decide to leave science at this point of the career. The women rather concentrate on the career of the (male) partner and/or become mothers. 19_M_L

I think there are social barriers. If your mother or your mother-in-law gets ill, who cares of her? You or your husband? We still suffer – even young women – from these social mandates 28_F

I think the difficulty that comes up in case of women is to create a family and face difficulties that on the one hand are to be goals that we want to achieve in a professional life, and on the other hand, a compromise between that purpose and the fact that we feel obliged to perform other functions and they are undoubtedly very important, (...). I think this collision is always very difficult and I am afraid that it is more difficult in the case of women than in the case of men. What it comes from? From the fact that on the one hand we have enormous demands for development in the profession, in science they are - I would say - exorbitant, especially when you are young, because that acceleration must be dynamic enough to reach as soon as possible until this independence, building your own team is already possible. And usually it is also related to the period when the ladies decide to have children, for example, would like to spend some time with their children, especially in the early years of their lives. So it affects the slowdown in a completely obvious way. This is completely natural. And it is undisputed. 58_F_L

Interestingly even if the last respondent mentioned for a slowdown due to being mother to be “natural” and “undisputed”, in many cases the slowdown was not welcome and also not considered within evaluation, for example in a case of a Spanish institution, career breaks are not considered in the selection boards that have to evaluate the scientific production of the candidates. So, on one hand, most physicists praise the role of mother, or even “privilege to give life”, on the other hand the discipline does not accommodate it within its functioning – in fact also men are treated as they are family-less (also in the narrative around the career men rarely mentioned any private life events that had impact on their career, while many women did). On the contrary, in the new model of career most of the achievement should be gathered in the period of post-doc positions (after PhD), which coincides with time for family formation and reproduction – as described in the quote above, the expectation is for a dynamic and rapid advancement up to the moment of building independent research team. As stressed in the chapter on “Mobility...”, these new positions are often linked with the demand for settling in a new country or even multiple countries – in a situation when a partner/husband does not want to migrate this becomes practically impossible to realize. The importance of after-PhD phase for retaining women in science is stressed by many respondents:

The crucial point for me was always the Post-Doc-Phase, always. So, there was no woman, no female doctoral candidate in my group who stayed in science after her PhD. [...] I had really, really good female doctoral candidates and I really intensely

supported them to stay because they were really excellent. [...] On the one hand the reasons were always that the partner got a really good job in a well-respected institution. And they said I go with the partner, but I don't believe that I could get a job in the same institution. Then they check out if they become mothers or get a job somewhere else. 19_M_L

Priority to male career in a double career couples

The cultural norms linked with family roles are playing an important role in the dual career couples experiences. It is admitted by the physicists that the priority for men career exists also in physics, and in the couples when both woman and man are scientists, it is a man who is more likely to continue.

I know in physics there are a lot of couples, and often the man is continuing academic career. I do not think stay at home with family it's a wish which came up from woman spontaneously, it is not her choice, I think it's always a man's choice. 43_F

It's impossible for both of us to pursue our career. It's not fair, because one of us has to sacrifice for the other. 37_F

The demand for mobility without accommodating the needs of double career couples causes a lot of challenges and results in long distant relationships. While such situation is not perceived as welcomed by the researchers, it usually forces one of the partners to resign from a career. Even in our interviews there was feeling of resignation by some of the respondents, they do not believe they can avoid this sacrifice:

It's the other side of the coin when you are working on the same subject. It's quite difficult because we are working in the same field, and to find two positions in the same place, quite in the same research field is really a problem. 33_M

We will finish our PhD in few months and then we will have to decide what to do after. Of course the main problem will be to find a place to go together. In a logistic point of view, it's difficult to plan. What if we both find very interesting jobs, but not in the same place, not even in the same country? Currently, I still don't know how we will personally and professionally manage this problem. 36_F

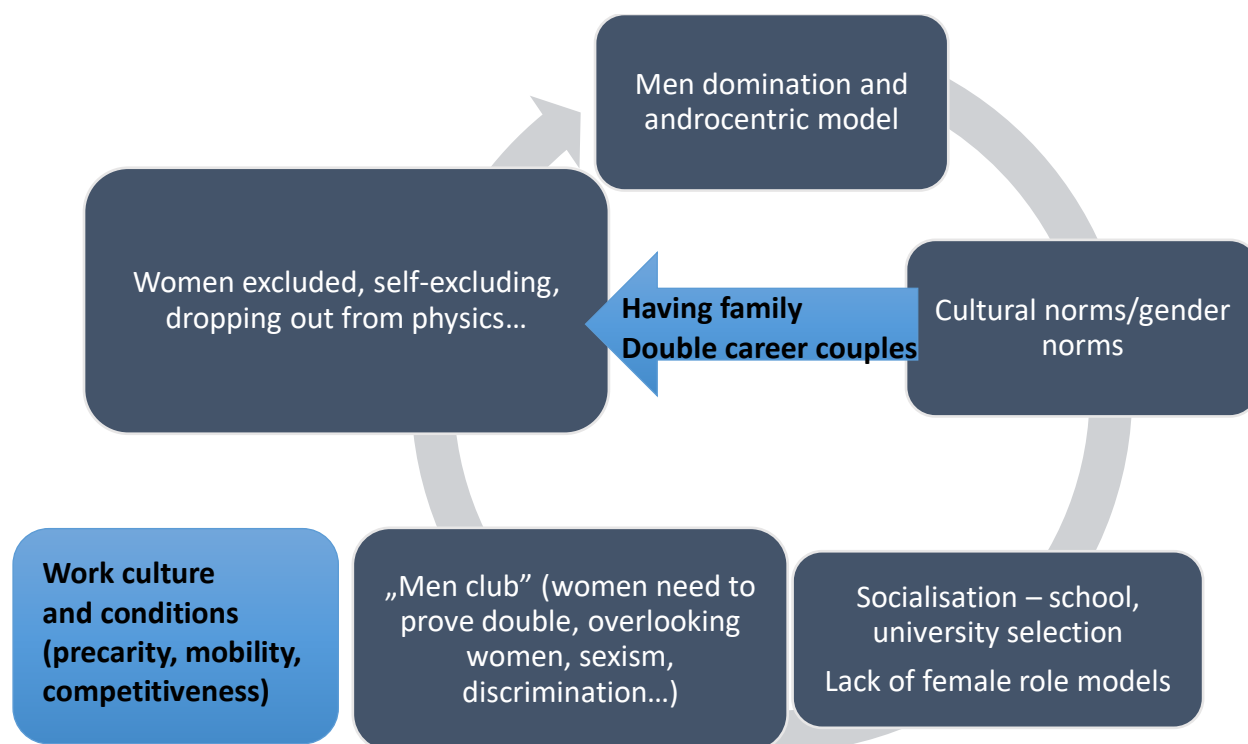
But at the moment I don't know what the next step is for me and he is very clear, so I mean. I also had a chance, I did a post-doc already, I chose where to go, we were long-distance for a year and maybe now it's his turn to get the chance to choose where we go. [I: Or you don't go together.] It's an option, but one we don't really want to have. From a sustainable relationship point of view living long-distance is not something we want to have. [I: How likely is it that you both find something that you want to do at the same location?] Both of us doing academia is almost impossible. Going into industry is possibly more likely, but that really depends on the cities. And the country. 10_F

Summary: The vicious circle of male domination in physics

We summarize the arguments discussed in this chapter in the illustration X. The vicious circle of male domination in physics starts from the simple numerical domination of men in the discipline resulting from the historical processes. The establishment of the androcentric model in physics is further strengthened by the cultural norms towards women and men roles in the family, as well as the stereotypes linked to the predispositions of girls and boys towards science

and research. These processes most strongly impact early socialization as well as educational choices of girls and boys. This is also reinforced by the lack of female role models.

Picture X. The vicious circle of male domination in physics



Source: Authors' elaboration.

When women enter the field (or university studies) they have to face the fact that they will be in minority and this bears certain consequences. The culture of physics is marked by the dominance of man, and the masculine model of scientist is reproduced in the androcentric model of work, to organization of space, ways of joking or communicating. This may result in experiences of overlooking women and other experiences of microaggressions, sexism or even discrimination, as well as in gender bias. Additional set of factors) is linked to the organization of the field – work culture and conditions. Three factors are most relevant here: precariousness, competitiveness and demand of mobility. External and internal factors when clashing may create a difficult experience for women in physics – raising difficulties in reconciliation of private life with work, giving priority to male career, and necessity to deal with male dominance. All these may result in leaving science.

7. Physicists experiencing different treatment

Introductory remarks

There is much evidence that women are systematically treated differently in academia and science disciplines, including physics (for an overview of findings see: Sekuła, Pustulka 2016). While blatant sexism – including sexual harassment – is argued to be on decline, covert discrimination - based on subtle, often unconscious gender bias – has been proved to be prevalent. The accumulation of covert discrimination makes the climate for women ‘chilly’ and sends them the message that science is a man’s world (Whitelegg et.al 2002; Ivie, Ray 2005; Ceci, Williams 2010; Shen 2013; Hughes 2014; Britton 2017). It manifests itself in a number of various ‘microaggressions’, understood as “brief and commonplace daily verbal, behavioral or environmental indignities, whether intentional or unintentional, which communicate hostile, derogatory, or negative slights, invalidations, and insults to an individual or group because of their marginalized status in society” (Sue 2010: 5).

The problem of different treatment in the place of work was raised in the semi-structured interviews conducted among male and female physicists. The categorization of their experiences is based on their answers to a specific question (“Do you think you were discriminated against or treated worse than men/women in some situations because you are a woman/man? Please, give me some examples”), as well as on other parts of the interviews, which included or referred to gender and discrimination. Additionally, experience of gender discrimination was discussed in the expert interviews with physicists in leading positions conducted in the Polish institutes. The analysis is therefore based on the results of overall 72 interviews.

Sometimes female scientists described their experiences in a very general way of undergoing sexism, discrimination, worse treatment, or having a misogynist boss. While use of these vague characterizations may suggest difficulties with sharing unwanted experience with an interviewer, they do not allow for any further interpretations. However, most of the narratives were elaborated and allowed for classification of own experiences of different treatment:

- lack of experience of gender discrimination
- females’ experience of overt sexism
- females’ experience of microaggressions
- males’ experience of discrimination

Additionally, regardless of individual experiences some of the interviewees simultaneously:

- either declare knowledge of gender discrimination in their scientific institutions
- or deny the existence of gender inequality or diminished its’ importance.

Lack of own experience of discrimination

When directly asked about being discriminated, about one-third of the interviewees (26), both men and women employed in most of the institutions represented in the research, deny they had ever been treated differently because of their gender. A few of them further elaborate on the circumstances of not being discriminated. For some physicists, mostly in senior positions, the absence of episodes of being unequally treated in their professional life is linked with the nature of physics, which operates with objective, external criteria of merit. At the same time

rationality and comparability of achievements are seen to be the features, which are not necessary present outside science:

I have never felt to be discriminated neither because I was a man nor because of any other feature. I have impression, that most of choices were based on merit, it is because substantially it is possible to relatively well rate the value of a candidate through his achievements. In physics there is comparison to the whole world, this is not a closed group, which does something in one place, locally and doesn't move beyond this, because in such a situation it is difficult to compare. Therefore, there is external way of evaluation and there are certain indices which are independent of what we do here. 54_M_L

I emphasize that - at least in the faculty that I represent at the moment, I never felt that I was treated worse, differently, that was not the case. (... In addition, it seems to me that in science it is easier than anywhere else, that the effects of work are extremely rational. It is much more difficult to compare successful people or to compare their results in other areas. 58_F_L

For some female physicists the concluding proof of not being discriminated in the workplace seems to be the way how they were treated by their supervisors and colleagues at the time when they became mothers. The fact that they had caring duties did not caused undermining their credibility as scientists:

(...) nobody thought of me, that I have two children and already don't fit for anything and won't do anything 53_F_L

However, lack of own experience of different treatment is sometimes perceived by the female interviewees to be unusual as they declare – directly or indirectly - awareness of the presence of gender discrimination in their environments. While one of the physicists explicitly defines her situation being exceptional, the other links her advantage of not being discriminated to the qualifications of her (male) colleagues:

The question is asked to me very often, so it really forced me to think about it and remember. I happily never had this feeling. I want to say it's probably an exception; I have many friends who experienced this kind of discriminations in personal or professional areas. 36_F

My enlightened colleagues never had problems with the fact that I am a woman and I have never felt any problem connected with this. (...) but I know there are women (...) who feel that [way] 56_F

The suggestion of existence of gender discrimination is also implicitly present in the narratives of other physicists, who – when asked whether they had ever experienced different treatment in physics – declare either “being lucky” not to have such an experience or not to have it “personally”. Moreover, a few of the female interviewees who negatively answer the question about being discriminated, in other parts of the interviews recall being in situations that can easily be interpreted as various forms of microaggressions, which will be discussed below.

Female experiences of overt discrimination

While there are different classifications of discrimination we use the category of ‘overt discrimination’ for explicit, direct, intentional and often unlawful forms of negative demeanor and/or treatment toward the members of social minority on the basis of their minority status membership (Jones et al. 2016: 1591). The analysis of the interviews with physicists reveals rare, isolated incidents of overt discrimination and all of them are reported by female physicists. They include instances of mobbing, sexual harassment, discrimination in access to resources as well as unequal pay.

A few interviewees’ declarations of being bullied, intimidated, being the subject of verbal aggression as well as being in long term conflict with a supervisor, which prevented them from personal advancement can be qualified as the examples of workplace **mobbing** (comp. Duffy, Sperry 2007):

It is a man with who I had personal conflicts, so sometimes I have a feeling that [these conflicts occurred] only because I am a woman and it was sad and this mister for some time was head of the department. (...) and then it was very unpleasant and this held my development down, because mentally I was blocked, even to propose something, because when I am treated as ... It is hard to say in what way [I was treated], if I was shouted at by somebody [who] says that I am bad person without having basis for this
57_F

Two of the interviewees talk about being **sexually harassed** in the past, experiencing unwanted touching and fondling, being blackmailed to “be good to” their boss, otherwise they won’t get promotion. At least one of them revealed the problem to the management of the institute. She asked to be moved to another research group which limited her direct contact with the oppressor. However, it seems that the wrongdoer was treated leniently, which might suggest both lack of anti-harassment procedures at that time and unspoken support to male dominance:

I went to the director with a written request to be relocated with description of some of the situations that I had been going through. The director read it, blenched, his hands started to shake (...), he summoned my boss and told him to sign it. And he said: ‘Here you sign the approval of Ms X’s transfer to this and this department with own office, computer, and everything’⁶

One of the respondents complains about being **discriminated in the access to laboratory and other resources**, which she reports to be directly related to her gender, rather than her junior-level position at the institute. Another female physicist declares being a subject of **pay discrimination**, which she unsuccessfully tried to solve:

(...) I don’t have the key to the laboratory. When I applied for it, because my two male colleagues have it, I was told: ‘we won’t give you the key, otherwise other women would like to have it too’ (...). I was forbidden to go for other departments’ seminars, when my male colleagues were allowed to go. I was also forbidden to take part in various grant workshops, and I know my male colleagues were not. 65_F

I feel discriminated because I get a less salary compared with others male colleagues. When I’ve asked I get no explanation for it. 83_F

⁶ This citations has been intentionally fully anonymized.

Female experiences of microaggression

Most of the narratives of being treated worse delivered by female physicists dealt with the instances of more or less covered forms of discrimination based on gender bias, which here will be analyzed through the lenses of the concept of microaggressions. As it was signaled in the introduction of this chapter, microaggressions are brief and commonplace daily verbal, behavioral or environmental indignities, whether intentional or unintentional, which communicate hostile, derogatory, or negative slights, invalidations, and insults to an individual or group because of their marginalized status in society (Sue 2010:5). They have also been described as subtle insults delivered through dismissive looks, gestures and tones (verbal, nonverbal, and/or visual) toward people of color, ethnic and religious minorities, women or LGBT persons often automatically or unconsciously.

The scholars analyzing gender microaggressions identify a few of their dominating themes or forms, including: 'sexual objectification', 'second-class citizenship', 'use of sexist language', 'assumption of inferiority', 'restrictive gender roles', 'invisibility' and 'sexist jokes' as well as 'denial of the reality of sexism' (Sue 2010; see also Barthelemy et.al. 2016). It is argued that they “act upon women in several ways, by reiterating the social view that men are more valued than women, by reinforcing traditional stereotypes about proper gender roles, and by contributing to violence toward women by objectifying and sexualizing them” (Barthelemy et.al. 2016: 4). Therefore, the consequences of microaggressions may be as severe as these of overt sexism. As they often result in lower evaluation of female applicants for posts, grants or awards than their male counterparts’, less often citing women’s research than men’s, and less often inviting female researchers as speakers for important conferences, they can hinder women’s recruitment to academic positions, their advancement and promotion as well as have impact on their decisions to leave science (Roos, Gatta 2009).

Most of the themes of microaggression can be identified in the narratives of female physicists. They are discussed in the order of frequency of occurrence.

1. Assumption of inferiority/ second-class citizenship

In the original categorization of themes of gender microaggressions assumption of inferiority and second-class citizenship are treated separately (see Sue 2010, Barthelemy et. al. 2016). Whereas assumption of inferiority implies expression of conviction that women inherently are unable to do certain tasks, due to their physical or intellectual inferiority, particularly in comparison to men; second-class citizenship refers to treating women as lesser persons or group or/and believing that women should not have same access to resources and opportunities as men (cit. after Barthelemy et.al. 2016). While there might be analytical distinction between these two categories, empirically they are difficult to differentiate, as they interrelate and both explicitly refer to cases when women are told through words and/or actions that they are inferior to men. Therefore, these two themes are analyzed here together.

The theme of assumption of inferiority/second-class citizenship appears in the narratives of 11 female physicists. They recall situations taking place during their studies or at work when they were ‘informed’ with words or gestures by their male supervisors, directors or colleagues of their inabilities, including “*not having spatial imagination*”, “*not being able to worthily represent the department*”, “*being second-class researchers*”, “*being of a second, third or C category*”, “*having again stuffed something up*” or “*being stupid*”. According to one of the respondents this kind of discrediting one's abilities does not happen among female scientists:

And for example with women, something like this does not happen. So, it never happened to me, that I tried to talk to a woman and she immediately said, immediately looked at me strangely or immediately said 'Ugh, what are you doing here?' or 'Why are you coming to me? You are not able to do anything' or something. 07_F.

Some of the women described situations when their profession or a research field evoked the reactions of astonishment and disbelief. They interpret comments like *'oh, really math and physics?'* or receiving emails addressed to them as if they were men as the effect of the domination of an opinion that a physics is a manly thing (*"A genius has to be a man"*) and that from women should not be expected too much.

I felt that he [IT Programming course coordinator] didn't know how to address the fact that I was a woman doing such an abstract thing [theoretical physics]. 51_F

Female physicists recall also other particular actions directed towards them throughout their career which either informed them that expectation towards them are lower or were aimed at showing them their proper place in the hierarchy. These actions include undermining their abilities and competence to make accurate measurements, fix laboratory equipment, or write good articles:

we had this experiment and there were very vulnerable electronic modules, they were very capricious and had to be monitored all the time. It was my experiment, so I asked my male colleagues "If something happens to it, let me know, please?" and then they asked me a question "And what will you do? To which expert we should call? What will you do?" and I said what I would come and repair it because I knew how. But for them it was impossible to imagine that a girl could do such things. Although they are educated men and probably have seen many women doing different things, yet still the environment is strongly dominated by men, and they couldn't imagine me doing such things. All in all, they are not against women, but they have in their minds these clichés that we [women] don't do such things. 61_F

The assumption of inferiority also emerges in some women's experiences of not being accepted in leadership positions, be it a chairperson of a students' association or a head of a department. As one of the interviewees notes it was because *"guys didn't want to be ruled by a babe"*:

I was the best among them, as far as scientific output, the level of engagement and the number of promoted doctors are concerned. Still, men thought that it was one of them who should be the head of the department, which is why they moved to another department when I took over this position. 70_F

Female having different experience than men in physics manifested further in mocking their (unconventional) career path and research themes as well as discouraging them from applying for promotion, which *"wouldn't surely happen to a man, who would rather be told 'why haven't you yet applied for a professorship?'"*.

2. Restrictive gender roles

The theme of restrictive gender roles refers to the belief that women must uphold traditional gender roles. The message which is communicated with this microaggression is that women either do not belong in the field of physics, as their presence there is in direct conflict with their gender roles as females (Barthelemy et.al. 2016), mainly as mothers or that, since they are physicists, they should take tasks which are 'appropriate' for them as women e.g. teaching,

note-taking. At least 11 female respondents discuss cases of being the object of this kind of microaggression.

Women are informed through words and action that as mothers they should give up or at least limit their engagement in science.

When my child was born, I received an email saying that my invited talk had been replaced by a poster. And I said “no, you cannot do this” and finally I was allowed to give the talk by Skype. 26_F

Being a physicist having children becomes a heavily gendered experience since men are not expected to sacrifice their career when they become parents:

the organizer heard I gave good seminars so he invited me but he told me 'I know that you have a kid so I was very hesitant to invite you. I didn't want to put you in a difficult situation'. You would never say that to a guy that has a kid, right? (05_F)

The clash between social expectations about proper gender roles on one hand and the image of physics as requiring full-time engagement on the other becomes a dead-end trap for some women. They are both expected to limit their professional activity when having babies and, at the same time, they are told that they “do not have good qualifications for being a physicist, because they are too much distracted by home, by children (..)” (65_F)

By stressing their roles as mothers and wives women are reminded that they belong to the private sphere rather than the public one. Other ways of informing females about this “natural” order is posing questions like “why women should be at the institute, [as they] are just meant to play with dolls” (07_F) and whether they do not “have any beds to make” (05_F) or not recognizing them as physicists:

I have been confused for a secretary before. When I told people: “Well, that a person is not here, you can get a coffee in the kitchen”, they thought I was gonna go and make them a coffee, because I was a woman. They thought I was a secretary and not a scientist. 10_F

Apart from being subtly discouraged to or displaced from physics, once they enter the world of physics women are expected to play their “natural”, socially acceptable roles. One of them is assisting males. Female physicists share their experience of being automatically assigned to service duties like taking notes at committee’ meetings, making copies of documents, making coffee before and washing dishes after the scientific group’s meetings. Similarly, administrative tasks are sometimes ascribed by default to women:

If there were any administrative duties my director at my previous institute wanted us, as women, to do these things. I have always refused doing this kind of things. I don’t know why women must always do administrative tasks. 40_F

Some female respondents also recon that their role as physicists is reduced to didactics:

I heard it already twice that they like me as a teaching assistant. That is nice, but I heard my supervisor never say that. She knows that there is always more work than that to be done. 51_F

3. Sexist jokes and comments

Sexist jokes include derogatory, crude jokes about women, rape, domestic violence (Sue 2010, Barthelemy et. al. 2016). Nine female respondents (and one male) refer in different parts of their interviews and rather generally to sexist jokes or comments that were told in their presence by their male superiors and colleagues. Mostly without citing them, the interviewees call these jokes “inappropriate”, “stupid”, “insinuating”, “boorish”, “chauvinist”, “distasteful” or “obscene”. Some of the women suggest that sexist jokes become an outdated problem, as they used to be told mainly by elderly professors, and it happened rather in the past than nowadays:

Mainly elderly people, (...)older than 50 years, used such sexual overtones or jokes, but it slowly, it somehow slowly changes, however there used to be such distasteful comments
64_F

Additionally, the remarks like: “(...) but to say that we were shocked shows it was not typical.” (05_F) and “he said it as a great joke, but nobody laughed actually” (61_F) may imply that telling sexist jokes or making sexist remarks ceases to be an accepted social norm in science and academia. However, narratives of other respondents suggest that, at least in some surroundings, it remains a problem that physicists are still faced with on a regular basis:

A few times my boss did some insinuating jokes about the fact that I share the office with a male colleague. 83_F

4. Invisibility

Invisibility refers to the cases of not including or recognizing women within and outside their institution, not being heard or listened to by their peers due to their gender (Sue 2010, Barthelemy et.al. 2016). This theme fits well into the category of non-events that have been recognized in science and academia. “Non-events are about not being seen, heard, supported, encouraged, taken into account, validated, invited, included, welcomed, greeted or simply asked along” (Scientists of the World 2013: 38). In our interviews 9 female physicists reported instances of being invisible.

Invisibility of women in the workplace manifests itself in being ignored, overlooked and not being asked at conferences or meetings, which in the opinions of our respondents happens to them just because of their gender and because “male colleagues (...) have low estimation of female colleagues” (42_M) and makes them feel that they “don’t belong to the community” (06_F):

So how often did we go to fair or to, to, what is the word?, the supplier. And then we were with two people. And then a man comes over and we say ‘Yes, hello, we are blah and blah’ and this guy, this guy, he only greets the man and I don’t matter at all. Just straight up ignored, from beginning to end. Completely. Despite the fact that my colleagues sometimes said ‘Yes, she is well versed, maybe she can say something about it’ or something, they always went back to the other man (...). 07_F

Not only women experience not being included in conversations but also their ideas are sometimes underestimated, they “are not taken seriously at all” (07_F) or are not given “the value they deserved” (26_F):

There were things which happened to me where I thought, ‘that’s because I’m a woman’, but I was never sure. Like when I was a post doc, I had an idea and nobody was interested. It was another post-doc but this time a male and people were interested. It made me think if I had been a man they might have listened. 01_F

Another way of making women invisible is ignoring their performance by attributing merit and success to their male colleagues. This kind of behavior can be seen as an aspect of a wider, well identified phenomenon of systemic under-recognition of women's scientific efforts and achievements, labeled as the Matilda effect (Rossiter 1993; Wennerås and Wold's 1997; Benschop, Brouns 2003; Hill et.al. 2010):

I was then, how to say it, an organic adaptor, who could insert a screw in such a way that it was possible to take measurements. So I sat there whole time and was doing it. No one else was able to regulate gas flow in such a way that the temperature stayed static. And then it was my male colleague who got all the praise, he wrote a paper, because he analyzed the measurements. So, what that he tried five times to take measurements by his own, but he couldn't? 65_F

Women also report cases of their superiors staying silent when it comes to career support, including financing participation in an expensive scientific summit or assigning a project:

yesterday I talked to the other women and then it came out that we are both sort of isolated. So we are not allowed to now, we both do not have a project anymore, so no defined project and they [the men] are getting all the new projects, even though one of them is leaving in two months. 07_F

5. Sexual objectification

Sexual objectification means treating women as sexual objects, reducing them to their physical appearance or assuming their bodies should be controlled and commodified by men (Barthelemy et.al. 2016). Experiences described by 6 female researchers can be classified as sexual objectification. These women report being treated by their superiors and male colleagues as physical, sexual objects:

It happened once, as I am very sensitive to this kind of things, so maybe it was because of my sensitiveness. Once, it was at the first year of studies, we came to one professor and I carelessly, I never wear short skirts, had a dress long to the knee, and he was watching me carefully, evidently, like three times (...). 56_F

Female physicists also evoke cases of being flirted with at work or during conferences and – as one of the interviewee put it – approached “with weird sexual (...) ulterior motives” (07_F), which are difficult to resist, especially when they remain in power relation with the offenders:

So there have been situations where I wish I had stood up for myself more, but it is difficult when it is a person in a higher position, when you know there is some kind of ... 'I am organizing a meeting dinner, they'll go, if you'll be going, I'll join'. It's not really harassment, but it is uncomfortable. [...] And I wish I could say something against it, but you know it's that moment where you wish you'd have said something back, but you have to be careful. These are the people giving you jobs. 10_F

Perceiving women as sexual objects means at the same time not treating them seriously as scientists, which our respondents are aware of. Therefore they consciously manage their presentation of themselves as well as their behaviour in order to be perceived as professionals. This management amounts to mimicking men:

I wear trousers with determination, as men. It might seem stupid and pointless, but I do not want them to treat me differently because I have for instance a short skirt (...), I do not want even any subliminal or subconscious signals. 56_F

I had a feeling that if I wanted to be treated equally with my male colleagues I had to be perceived as a man and that I have to become a man. 55_F.

6. Other themes of microaggression

In the original conceptualization of the gender microaggression two other themes were identified. These were sexist language and denial of the reality of sexism (Sue 2010). Sexist language refers to using terms that infer superiority of men, e.g. as in the phrase: “lady physics” (Barthelemy et. al. 2016). However, in our material this problem did not come out as an independent factor, rather women occasionally cited sexist terms when they discussed other cases of microaggression, including assumption of inferiority or sexual subjectification (“*sweet blonde*”, “*bimbo*”, “*neither fish nor fowl*”). Denial of the reality of sexism means not believing that sexism exists and refers to situations when individuals are persuaded on different occasions that gender inequality is not an important problem, its scale is minimal or is being sometimes instrumentalized to conceal professional failures of women (Barthelemy et.al. 2016). None of our respondents raised the problem of being faced with this kind of microaggression. However, some of them, both males and females, themselves formulated opinions challenging the existence of gender inequality in physics, which will be discussed beneath.

7. Effects of microaggressions

There is some overlap between discussed categories or themes of microaggression, which has been already discussed in an earlier study on gender discrimination in science (Barthelemy et. al. 2016). For example, sexist jokes most often denote sexual objectification of women and sometimes also imply the assumption of their inferiority. Similarly, restrictive gender norms and assumption of inferiority often merge with each other as the belief that women should limit their activity to their traditional gender roles might be supported by the conviction that they are inherently unable to perform “manly” tasks.

While overlapping of themes is a certain limitation of the use of the framework of microaggressions, it does not demand giving up the whole concept, “since it has great power in terms of explaining how small, often unconscious, behaviors can work to convey sexist messages to women. Instead, we may posit that sexist messages are often very complex and may contain multiple messages for women” (Barthelemy et. al. 2016: 10). Together with overt sexism they create a hostile and invalidating climate for female physicists and may have detrimental consequences for their comfort and work productivity (comp. Sue 2011) and, therefore, their professional development and advancement. Our respondents who reported cases of different microaggressions find them “*frustrating*” (37_F) and “*exhausting*” (07_F). Potentially, accumulation of microaggression may also contribute to leaving science and academia. This potentiality seems evident in case of one of the female interviewees who may have been subjected to certain microaggressions during her career in physics quite frequently and appeared doubtful about continuing her career in science:

*(...) for 10 years I am working so much, so that I can do what I like, but at a certain point you are done with that. So, it is sort of **on the verge** right now. Because eventually you realize that the entire world is against you somehow. And that is exhausting. 07_F*

At the same time it is argued that “due to the subtlety and often ambiguous nature of microaggressions, the perceived targets often question themselves about whether or not the incident was motivated by gender bias” (Barthelemy et.al. 2016: 4). This kind of doubts was also formulated by our respondents who for example asked themselves, whether they are “*too sensitive*” to pay attention to men looking at them as sexual objects (56_F). It is also difficult to discuss or to respond to microaggression as it is often perceived as part of the masculine culture of physics (as might be in the case of sexist jokes), incidental and not being harmful:

*And you, you can, so you can convince yourself that it's all just **small things** and that this is not necessarily because you are women (...)* 07_F

Last but not least, the perpetrators remain often in the relation of formal power or informal domination with women experiencing discrimination, which makes responding to the perceived microaggression difficult as it may have an unintended impact in the form of retaliation:

And I wish I could say something against it, but you know it's that moment were you wish you'd have said something back, but you have to be careful. These are the people giving you jobs. 10_F

These characteristics of microaggressions make them, as compared to overt discrimination, “particularly difficult to isolate, confront, and resolve” (Barthelemy 2016: 4).

Men's experiences of discrimination

The problem of being discriminated in professional life is raised in the interviews with both female and male physicists. However, most of the males who are directly asked the question deny they have ever experienced discrimination. However, four men recall situations, when they felt being unequally treated because of their gender. Two of these were concerned with preferential treatment of female physicists when it comes to recruitment and grants:

I felt uncomfortable with reading documents stating that with equal qualifications – in was in Xxx [another European country] – they will choose a woman 67_M

Another example describes situation when a man felt discriminated by national quotas practiced in one of the European physics research institute:

When I was in a competition at Xxxx [research institute outside France] for a permanent position, I was ranked second after a woman because she was from a minority needed in the program. (...) It was clearly told to me that I was the most brilliant but that she was selected because of quotas. Of course at this moment I was very angry against all Portuguese women (...) 35_M

The last instance of men being unequally treated concerns interviewee's past experience of informal rules of marking of undergraduate students:

Well, not, not really in [country of interviewee's current residence], but in [interviewee's home country] I think, during my undergraduate years, somehow it seemed - maybe that was also just perspective - but somehow it seemed that, for example, sometimes for girls it was a bit easier to get the same grades in some exams. 11_M

Knowledge of gender discrimination in physics

Irrespective of own experience, 19 physicists, both women and men, admit that gender discrimination remains a living problem both in their institutions and in wider environment of physics. Some of them only signal a problem by talking about “*existing discrimination*” (46_F), or “*misogynous men*” (40_F), women being “*little excluded*” (06_F) or “*institutional sexism in subtle or less subtle ways depending on the institution*” (04_F_L). Others, more precisely, talk about the climate of physics, which includes believing “*that physics is more technical than other research fields and can be difficult for a woman to handle with*” (83_F), looking down on young females, sexualizing them and overburdening them with teaching duties. Additionally, a few admit being aware of past or recent cases of mobbing, bullying and sexual harassment, which resulted in women’s “*being victims of men’s waging wars*” (66_F) and leaving science.

Denial of the existence of gender inequality

Apart from a question whether the interviewees experienced any instances of different treatment, a more general issues were raised of whether gender equality was an issue both in physics and respondents’ institutions. These problems were addressed both in the semi-structures interviews with female and male physicists and in the expert interviews with the leaders within institutions. While the awareness of gender inequalities in physics seems to prevail, some interviewees express belief of the lack of discriminatory practices in their institutions and generally in physics.

The respondents who are confident about inexistence of gender inequality base their belief mainly on own perception, arguing that they have never met with conscious or unconscious discrimination, formal or unconscious barriers, never had experienced it as an important problem in their institution or in physics in general:

I haven’t heard of a case that the career of a great female physicist was buried only because she was a woman. 58_F_L

These interviewees also assert that generally gender discrimination is no longer a systemic problem. Even if it happens, it is not omnipresent but rather rare and diminishing. However, few of the interviewees represent the attitude of ‘discrimination happening elsewhere’, either outside physics in other areas of social and professional life (“*here is better than in corporations*”, 55_F), or in other countries:

There is not much discrimination in Spain. Except for specific cases, in Spain we think that a man can be so good as scientist as a woman. I have not perceived problems with women working in my research groups. However, I have heard comments that discriminate against women scientists in other countries. 30_M

To validate lack of discrimination in physics they claim that there is no prejudice and everyone is treated similarly, “*fair and equal*” (22_F), there is “*no difference in salaries or preference for someone*” (71_M) as well as “*women are occupying more leading positions, [which] means there is no difference in achieving good positions*” (80_F_L). Moreover, it is asserted that the exceptionally lower number of women in physics may be advantageous for them, because as a tiny minority they do not threaten the dominant status of men and may even be treated preferentially.

A few of the interviewees, mostly from Polish institutes, link lack of gender discrimination in physics with the nature of the science itself, which includes openness (“*if you feel called to be*

a physicist, there is no problem to be a physicist, I think”, 69_M), using “objective, external criteria of achievement evaluation (54_M_L), and immunity to sex differences:

*physics as science does not distinguish between a man and a woman, a scientist is a scientist and we don't have to add **him** a masculine or a feminine ending, if someone works in science and is suitable, **his** sex doesn't matter 59_M_L.*

8. Institutional aspects of gender equality in physics

Among the themes raised in the interviews, institutional aspects of gender equality in physics were thoroughly discussed, including opinions about the desired role of research institutions in fostering gender equality, attitudes towards actions and measures taken by own institutions to enhance gender equality as well as stance on introducing special measures in research organizations. While these problems were included in the scenarios of both semi-structured and expert interviews, in 10 particular interviews (8 from Spain and 2 from Switzerland) they were not discussed. Therefore the following analyses are based on the results of overall 73 interviews. The findings concerning these issues are discussed in three consecutive chapters.

Roles of institutions in fostering gender equality

One of the aims of the conducted interviews was to recognize the physicists' understanding of their role and the role of their institutions in enabling gender equality in science. The respondents were asked whether there are any solutions to raise women's participation in physics and whether research institutions should support women by implementing them.

From the narratives of female and male physicists and leaders it comes out that most emphasis is put on changing the wider cultural environment of science through interventions in the school curricula and fostering recognition of gender differences and gender inequalities among scientists.

Modifying the wider cultural environment of science

While the need to act towards fostering gender equality is quite widely recognized, it does not automatically mean support for introducing gender equality measures within the research institutions. As inequality in physics is mainly perceived by the respondents as a result of wide social processes, including socialization (see the chapter on "Reasons of dominance men in physics and barriers to women's success"), the respondents emphasize the need for changing the wider cultural environment of science. The dominant attitude is that transformations have to start somewhere there, including the whole society and its' particular institutions such as families, schools and governments. The way many physicists talk about these transformations may suggest that they themselves do not clearly see own role in initiating and developing these changes. Either "the others" are responsible for changes or this responsibility seems undefined. Most generally, the interviewees argue that to change the situation in physics institutes, **social mentality has to be somehow modified** to make women's career in science more acceptable and, therefore, more accessible. This should start early with the social practices of upbringing children, mainly by teaching both boys and girls to trust in themselves and ensure that both believe in themselves, with no fields in which they feel ill-suited:

None of action taken at the University will be as effective and powerful as change of social mentality and the way girls are treated, and boys, because it works both ways. 55_F

You have to change the society at this point where little boys and little girls separate themselves from each other and the girls are cooking with the mother and boys go fishing with their fathers. 20_M_L

I think that one should change that you somehow, well, provide girls and boys with the same belief regarding what they believe they can do. 06_F

There should be a change in the society, that make women able to emerge in this field. The problem is not just about physics, you should be able to choose the physics without feeling the need to be helped as a woman. 36_F

The change of social mentality and everyday practices together with an active role of educational system may result in raising the number of female physics students, which for some respondents is a precondition of any efforts towards gender equality in physics:

Everything starts somewhere there at the phase of primary school, right. So if one would like to, it's simply necessary to have better physics teachers, who can encourage wider circles. I think that generally in this moment there is a tendency, that not only in Xxx [interviewee's home country] the youth reluctantly engage in science, right? 73_M

First and foremost, it is necessary to raise the number of female students, this is the first thing (...) and this is the key. (...) I have no doubts, that this is the role of schools, maybe there is also something to be changed in academia (...), but if I have two females within a group of 40 undergraduate students, what on earth can I terribly change? So, I don't think that there is something we could have changed here, to change the proportions [of female physicists], they won't change. 54_M_L

Power relations in families and traditional division of gender roles are other aspects of cultural environment of physics that – according to our interviewees – need to be transformed. Given that child care is perceived as one of the factors challenging women's professional advancement (see the paragraph on “Reconciliation of private life and work engagement” in the chapter “Reasons for domination of men in physics and barriers to women's success”), changing social norms concerning parents' engagement in upbringing children seems especially inevitable:

Culturally, the idea should be provided that both a man and a woman have the same rights within the family; it should be foreseen that also the father, and not only the mother, take time off. 46_F

At least males must take the parental leave. Only if males are obliged to take the parental leave, then the way of counting publications and success will be done with the same measure and then equality can be reached much faster. But if you go on in having even males or your partner that does not take the parental leave, because this is something for women, then you don't, you don't move on. So, you really have to, not giving more opportunity to females, but try to remove the differences. 12_F_L

One of the female physicists directly expressed a belief that to understand current gender inequalities in physics it is necessary to look at wide cultural – and institutional – factors which are determined by deep historical processes. According to her factors seemingly unrelated to physics sustain the prevalence of patriarchal culture which is unsupportive for women pursuing career in science:

Culturally it is a big problem in Xxx [interviewee's home country]. Women here got the vote not so long ago and the culture of school which is closed on Wednesday is predicated on

someone looking after the children. If both members of a child bearing couple work they have to find alternative child care. This is not how to encourage women to have active careers. You really see that it is a country that hasn't dealt with many equality issues properly. For example if a man and a woman marry and want to keep their own names there is a lot more paperwork and the default option which requires no paper work is when the woman takes the husband's name... So I recommend: don't make such assumptions about women staying at home looking after the children...there are many ideas left over which reflect a culture where women were second class citizens. 04_F_L

In this context the decisive role of public authority and especially – legal regulations – in changing both mentality and social practices is discussed by some of the respondents. They indirectly express a conviction that social transformation towards gender equality is not possible without adapting law, which – together with financial incentives - makes changes obligatory and, therefore, effective:

In my opinion in order to balance the participation of women and men in physics it is necessary to introduce some measures, some legal regulations. Surely much depends on an individual person, but if there are some regulations, the mindset of many people might have changed and they would have respect competent individuals. Because for example my female colleagues from my grade were clever and skilled, but still they dropped out. It is also necessary for these regulations to be followed by concrete material resources for the realization of given tasks. This is an important choice – either we want to live in an egalitarian society or in a primitive one. 74_F

(...) make mandatory that men have to take the parental leave in order to have some financial support. And so from one side it should be the government that makes this obliged - obliging people to do it. 12_F_L

While many interviewees concentrate on others actors' impact on changing cultural environment of physics, others clearly recognize their role as scientists and the role of their institutions in facilitating gender equality in science. For some of them public research institutions are the ones that have a vocation for initiating gender equality changes in social mentality and practices:

We work in a public institution, so if the state really wants things to change at the level of society, we have to start with us. It is by being exemplary that we can bring about a collective change. 33_M

According to the respondents the function of research institutes in bringing general social change should manifest in making interventions in the education of young generations as well as in fostering recognition of gender differences and inequalities among the scientists. **Scientists' interventions in schools** should be firstly and most importantly aimed at counteracting gender stereotypes, demonstrating role models to girls and, through these actions, attracting young women to physics. Visiting schools and giving talks to pupils by physicists, especially by female physicists, should challenge the prevailing idea that it is rather men who is suited to be a scientist:

Xxx [the name of the research organization] should point girls in high school to tell them it's possible to have a career in physics, whatever is your gender. This is not only a men's career. But it's not only for physics: it should be made for scientific area in general: mathematics, chemistry, engineering, all this jobs which have the reputation to be for men only. 33_M

I don't know if we can change some teachers' mentality but we can do our own actions as university, e.g. by inviting students from schools, and showing them that physics is not only for men. 61_F

My goal is to show the girls that doing physics is normal for a woman. I want to destroy stereotypes that science is not made for women. This communication is really important. 36_F

For our respondents the female physicists, including these who have reached high positions in science, evidently should act as role models for girls and young women. In correspondence with the findings on the role models and mentors in reaching gender equality in science (see e.g. Bonetta 2010), the interviewees see it inevitable to actively eradicate a well-established stereotype that career in physics is not a realistic option for females. In this context it is argued that interventions in high schools – and in universities – are crucial to target young women who are about to take decisions regarding continuation of education, the choice of the subject of studies and whether to take up a career in science:

So one of the initiatives that I would personally like is to have our females to give more talks at schools about our job, in order to make children from school having us as models. 12_F_L

I think it's very important that for example women in high school or university can see or talk to women in top positions. Because communication with us could help them to understand that they can make it because eh, if they see there are a lot of males in top positions eh, maybe they see the professors are all male or they use to talk with males they don't see a future (...). Either in high school or the university they say okay, I would rather go for something else, I would rather go for teaching at the high school or whatever because there are no opportunities for me at the university or in the research field. So, if they do talk with women in top positions they are encouraged for sure to, because they can see models, so they can see that somebody managed it. So, I think for them it's important to have this, let say, this encouraging point of view in the discussion. So, this could be another, another thing, I believe it's important. It's something we should keep in mind to try to have meetings with them. (...) we have to keep them on track somehow to balance the numbers. 21_F_L

The ultimate goal of the discussed interventions in schools is to raise the numbers of women deciding to pursue careers in physics, which would be a necessary condition for further enhancing gender equality:

That's I think that we should really have an effort in having us going to schools to speak. Because then you even enlarge the pot from which new generations come up. Because at the end what you want to have is really a large quantity of females, because the more they are, statistically, more good people you will have and statistically would be easier to

compete with males. If there are not many, then it is difficult to justify that among the few they are all super cool, super great. 12_F_L

In the context of scientists' interventions in the educational system some of the interviewees refer to initiatives taking place in their institutions as examples of projects aiming at changing the social image of physics as difficult, unpractical, male dominated and not suiting women. These are Girls Days in the German context or PhysiScope in Switzerland, which bring practicalities of being a (female) physicist closer to the outsiders:

Something like 'Girls day', actions like 'Open Day', to see real people who are female scientists, who are female physicists. 17_F

Get more [girls] in by going to school and try to recruit in a subtle way. For example half the PhysiScope presenters are young women.(...) Some students have no idea what science looks like so suddenly they see people like them and they believe they can do it too. Otherwise the image of a physicist is someone not like them at all. 04_F_L

Another way of influencing the change of social mentality and social practices that has been recognized by the interviewees is to **foster recognition of gender differences and gender inequalities among the scientists** themselves. It has been noticed that recognizing gendered aspects of a scientific career and gender inequalities in science is not universal, as it means contesting the existing social order that is posited as natural. It can be especially difficult from the perspective of the members of the dominant – and privileged – group in physics, the men:

It is the role of the institution to encourage a change in professional practices, and in mentalities. Changing mentality is not natural. You do not question an idea that has always been obvious. 38_F_L

This is very important, that the community itself has to understand and except that there are differences and it does affect the career of the woman and this is very important to be accepted and of course if the community is mostly composed by men that's less probably because they don't understand, I mean it's difficult to understand for them. 21_F_L

Recognizing gendered aspects of being a physicist demands a social skill acquired through deliberate, systematic, and sustained effort. Therefore, the interviewees recognize the role of their institutions – including their specialist bodies – in acquiring this ability by the scientists. Especially the usefulness of gender trainings, including compulsory training for people in leading positions and in scientific committees, workshops, thematic talks and conferences is discussed:

If there are gender specific elements in career development it would help if Xxx [gender equality office in respondents' institution] does something there but also for us to be aware that there are elements that are not the same for men and women. 18_M_L

Xxx [respondent's institution] should raise awareness on researchers, because the problem exists and women struggle to be considered as men. 45_M_L

Trainings and conferences might raise the local awareness on this topic. 81_M_L

While the need to raise gender awareness of both rank-and-file scientists and leaders is recognized, the details of such activities need to be well thought out as at the same time some of the physicists who already underwent gender trainings perceive them ineffective and wasting their time (see the next chapter on the Evaluation of institutions in fostering gender equality).

Necessary measures in reconciliation of work and private life

Apart from direct and deliberate influencing social mentality outside and inside research institutes, the interviewees see the need of taking measures for better reconciliation of work and private life, which is predominantly understood as enabling female (and male) physicists to balance their professional duties with the role of a mother (and a father):

Women professional and personal challenges should be reflected in the support the institution gave for all employees. 82_M

One of the worst problem women can encounter is having no support when they have children, and have to stop their work for childcare. I hope I will have support of my employer if I have children one day. 36_F

In this context it is worth reminding that some respondents suggest that parental leaves for fathers should be obligatory in order to modify the social perception of and social practices in gendered division of child care. Moreover, according to the respondents, the physicists who are parents should be entitled to **additional time for advancement**. While it is acknowledged that this measure could be available to both male and female physicists, it is women who are believed to benefit from it most:

At all stages where it comes to evaluation, this would be a very good thing, just give parents more time, target parents, but women will use it because they need it. 13_F_L

It's really considered for example that if you had a pregnancy or something that you get additional years. That you can use to try for example to achieve some grants or, or somehow to give more time to women to achieve the same CV of men. So maybe when you compare the CV of a man to the woman's one you don't really compare that they are at the same age, you compare them by giving the woman more time because she needs more time. She will have the same results. This way would be a little bit more relaxed. So, this doesn't mean that you are up to create fix quota or to advantage the women, but it sights just to give her more time to consider that she would require maybe three, four years more compared to man to achieve the same CV or the same level. Maybe it won't fix completely the issue but sometime, I mean, maybe somehow to relax the parameters in the evaluation in case you are a woman and (...) for example you have children or you are pregnant or whatever. 21_F_L

Another measure for life-work reconciliation, this time explicitly dedicated to female scientists, would be **easing their return to science after maternity leave**, which sometimes might be problematic. According to the interviewees special programmes dedicated to returning scientists as well as enabling work flexibility would facilitate the decision to continue scientific career after a woman becomes encumbered with new caring responsibilities:

When a child appears in a family then it is a woman who takes most of it on herself. Women very often choose here to stay at home with a child instead of continuing the career, because

- let's face it - scientific career do not foster stabilization and having life outside the lab. (...) I think it would help women a lot if there was a facilitation of the return after a maternal leave, some kind of measure would be needed. Possibly, there are already some in place, I heard about grants called 'Returns'. 55_F

Probably, measures for family can always be improved. There's the obvious things that you can do like home office 18_M_L

However, the most often recognized measure of work-private life reconciliation is **providing facilities for children**, including nurseries and kindergartens. Available child care facilitates reconciliation of work and private life of both females and males, however it is mainly understood as a direct way of fostering women's retention in science, as "*it is typically the woman who will stay at home*" (02_M_L) in case of inaccessibility of day care. In this context few respondents talk about the necessity of resolving the general problem of the availability of nurseries stemming from the shortage, expensiveness and lack of compatibility between opening hours of these child care facilities and physicists' working hours, as in the case of *crèches* in Switzerland. However, most of the interviewees discuss the advantages of setting up child-care facilities within research institutes. Thanks to them, female (and male) scientists can better manage their time and therefore work more effectively:

If there was some kind of institute's kindergarten, for sure mothers would be encouraged to stay longer in the workplace for instance, because when I come to work and I know that my child is two buildings away then I know I can go and see it for an hour, it is not a problem, right? This would be a good solution but I don't know if it's possible to formalize it. 55_F

The ideal solution would be to have a nursery integrated in the laboratory, such as some big companies have integrated nursery. This would make possible to drop the children the morning just before to go in your office, and to be present if there is any worry. I guess it must be very expensive and we cannot afford it, but it would relieve the parents of an enormous weight. 35_M

Apart from nurseries and kindergartens in the workplace – or in cases when the respondents do not see the possibility of setting up these institutions (a returning theme is the expensiveness of such an endeavor) – they talk about part-time solutions, such as after school care or ad hoc care when a parent takes measures at a laboratory or goes for a business trip:

(...) and also for older children – sometimes they finish school at 1 pm and you have to do something with them, so maybe a day-room for children could be useful, so I could go back to work and children could play with each other. Such solutions will be amazing, because now when we go home it's hard to do anything with children. 61_F

A solution alternative to establishing a nursery or a kindergarten in the place of work, would be subsidizing by the employer the outside child care, which sometimes is unaffordable for young scientists or granting financial support for employees' self-help groups:

(...) strengthening of self-organization of women who, for example, live near the university, all have children of certain age and would like to have, I do not know, a social kindergarten. 58_F_L

Solutions in hiring, retention and promotion

Another field of gender equality interventions recognized by our respondents concerns measures in hiring, retention and promotion. On one hand, the interviewees emphasize the role of merit, qualifications and productivity as the necessary sole and gender-neutral criteria for employment or advancement of the scientists. On the other hand, they notice that if these parameters were really in force, it was “*a little odd that there are so few women*” among successful physicists (08_F). Therefore they infer that recruitment and promotion processes are burdened with gender bias and unclear selection criteria and need intervention:

The local recruitment process need to be very much improved, also the leaders mentality.
83_F

According to the respondents, the **criteria and processes of evaluation** of candidates to positions, grants and awards should be genuinely made **objective** and **transparent**, so that there would be no doubts about the verdicts of various decisive bodies:

*(...) my observation shows that it would be good if it was an **impartial person**, who would] for example set the conditions of employment. So there must be an objective look, because the issues of the interests of various individuals play a very important role.* 74_F

*I would like to see more transparency for **who** has what position **and why** they have that position. Why some people get long-term positions, other people don't. All sorts of things.*
10_F

Moreover, the selection and evaluation criteria should be made universal and long-lasting, which would make them predictable and would enable scientists to accommodate to them:

*During the competition they should select objective standards valid **everywhere** and **every time** when evaluating competence.* 39_F

*Obviously there should be transparent selection criteria. I would like that there are clear guidelines for the evaluation process and that they remain **the same for long period** because researchers can adapt their work to what is requested as evaluation criteria.* 40_F

Interestingly, only one respondent, and moreover a male senior physicist, talked about the necessity of eliminating considerations of private matters of the candidates in the selection processes. It might suggest that either this practice is rare in the scientific community due to legal constraints, or its' inappropriateness is not well recognized:

During the selection process I'd like to eliminate all these questions referring to the intimate sphere of the person, such as 'what do you want to do with your family' and so on. Those are really tendentious questions. 45_M_L

Another important way of intervening in the selection and promotion processes in physics is **acting against precariousness** of physicists, understood as insecurity and instability of work due to the dominant pattern of employment through multiple temporary contracts. While the instability of employment in science hits both women and men, the interviewees notice that it is especially detrimental to the female scientists, as it hinders their decisions about family formation (for details see the chapter on “Career paths...”). Therefore, implementing permanent

employment in science is desirable, as it will enable female scientists to “*make projectable career paths*” and to be given “*realistic perspectives*” (13_F_L). However, this would require a systemic solution rather than an effort of a single institute:

One very easy step: to stop the precariousness of the profession of researcher, because it turns immediately against women. When you have to do 5 post-docs, at 40 years old you have lost all the women. The few of them we have, who are courageous enough to come in our domain, will be disgusted. You cannot settle for a short term contract if you want to create your family. 34_F

What I would really like is having more female permanent positions, so you need to have more permanent positions, uh, openings. But we know that this is not happening at Xx [respondent's home institution] in general, because there are no permanent positions anymore. 12_F_L

To facilitate the work, under normal conditions so people do not think that ‘in three years my contract will end and what then’, to think about these young people, especially when it comes to young people, there are also girls in this, ugly speaking, reproductive age. 57_F

Mobility is a frequent experience of physicists and is seen as an indispensable element of their careers (see the chapter on "Mobility, migration and internationalization of science"). At the same time, it is a challenge in terms of their professional and private lives. Therefore, any **facilitation of mobility** is needed, but it seems that the most expected measure is institutional support in settling partners of the relocating scientists, namely in their seeking employment. In case of dual career couples, it simply means offering a job for the partner of an admitted physicist:

And Xxx [respondent's institution] is a big institution therefore I think that it could be done more, also for the first time, offer limited jobs but also long-term perspectives for the partner. 17_F

When a physicist's partner works outside the field, the assistance in looking for a job in an institutionally and culturally unfamiliar setting seems to the bare minimum, however support can be based on a systemic solution of formal agreements with the representatives of other economic branches on time-limited employment. While these measures would be applicable both to male and female physicists, they can be crucial for women's decisions on moving or migrating as it is them, who are more often objectively and culturally constrained with the demands of their partner's professional career.

When you move in a new country and your partner follows you, he could receive information and help in his research for a job (...) Ok, you are, whatever, mathematician or florist, we know this company or this one in Xxx [respondent's host country], we can help you to adapt your CV (...). It could be just one person in the university, but that could make a huge difference. 37_F

For every time that we got a "No, thank you" when we offered the job to a female, I think that if there was a better coordination among us, or a better link with the industry, so that the partner of the person that we wanted to hire will have had a possibility, then it would have been easier to hire the females. So, having like an agreement with some, eh, I don't

know, Xxx [name of a company] or any other big company, that for, eh, 5 years can have, eh, host an engineer that is normally working somewhere else in the world and having this, eh, double career help support. That is the thing, that, that, you need. Because only in this way, the women when she got the offer, she can say 'yes, I come, but I need a job also for my husband'. 12_F_L

Some of the interviewees discuss introducing **direct measures** for enhancing the presence and advancement of female physicists. These include special hiring programs offering female physicists high-profile positions:

Xxx [interviewee's home country] has special job offers, positions dedicated to women, also special scholarships, very prestigious. It's not easy to get it, but women have additional motivation to be productive, to apply for such prestigious position, because it's of course time-limited, but after that you can get a permanent position if everything will be ok. I think that something like this could be here at our university, maybe every department (...) but I guess that physics is this discipline where women are the most underrepresented so it's worth thinking of such a solution. 61_F

I think, the only thing would be to offer specific programs for women. Something like 'excellent women in physics' or so, hm. So as temporary measure. That they are systematically searching for excellent women. (...) So yes, I think, the only thing would be to offer specific programs for women 19_M_L

Another method of increasing the proportion of female physicists discussed by one of the respondent would be openness to interdisciplinary projects and hiring women from other disciplines, which are more gender-balanced:

Something like my transfer could be a good solution. I came to physics although I'm not a physicist, so science should be treated in more interdisciplinary way. Because there is no harm if somebody without physics background comes, if we want to have more women, we could invite them from chemistry, medicine, biology, why not? There are plenty of them there, they can come here. 60_F

Enhancing the presence of female physicists in the research institutes further requires deep structural changes warranting gender balance in leadership positions and in the decision-making bodies through introducing new positions in the structure of the institutions and changing existing procedures:

I think that some sort of intermediate positions could be created, like 'the leader position'. Because there is plenty of areas that could be covered. We don't have this leader position, only the supervisor [who, according to the procedures, needs to be a senior, a scientist with habilitation]. (...) this could have helped women to prove themselves. 65_F

Additionally, in the context of structural integration of gender equality a few interviewees from one of the institutes talk about the possibility of establishing a gender equality office, which could work on raising gender awareness among the physicists and preventing acts of gender discrimination. However, while they emphasize that existence of such a body is a norm in research centers around the world, it remains unclear to what extent they perceive it as an effective solution fostering gender equality:

In most of the places I've worked there were or gender equality networks or offices. We can take the example. 79_M

Few of the respondents who admit that research institutes – as well as other social actors – could and should take active steps to foster gender equality in physics at the same time admit that they are lacking competence necessary to identify effective measures for resolving existing problems:

I really do not know how this could be solved, but we are not moving in the right direction. 29_M

(...) any actions directed outside, to attract women to physics are thinkable, we have to only identify this problem, because I don't know what I should do, now I walk through mist. 54_M_L

I have no ideas what could be done. 06_F

Conditions for success in implementing gender equality measures

In some of the interview narratives the problem of effectiveness of various gender equality solutions is raised. Among the conditions of success in fostering gender equality in physics the respondents point at the necessity of transforming gender equality **ideas and regulations into actions**:

We don't only have to speak about this, we must act. 79_M

This opinion might sound obvious and not requiring further discussion. However, the accounts of a few interviewees imply that in some cases gender equality procedures and measures remain 'on the books' and organizations fail in "making staff aware of specific measures and creating opportunities to discuss any questions or issues they may have" (Lee, Faulkner, Alemany 2010: 9). Apart from adequate publicity and promotion of gender equality solutions, it is also necessary to monitor their effectiveness in improving female physicists' everyday life, which might be problematic:

I have the impression that the first problem is that no one knows the actions implemented. You tell me there are some of them in the Xxx [interviewee's institution], but I never heard anything about this. The first point could be to communicate better about the existing measures. 36_F

I have the impression that there are records and announcements at the high management level, but it is never followed by concrete effects in everyday life in the laboratories. 34_F

In this context it is worth noticing that the analyses of various equality initiatives in the workplace demonstrate that their effectiveness depends on establishing clear leadership and responsibility for organizational change (see for example Kalev et.al. 2006; Vinkenburg 2017). It is argued that it "will guarantee the long-lasting effect of a gender policy since this proximity to 'power' prevents a gender policy from becoming just another policy paper (...)" (European Commission 2012a: 27). Our respondents also point out the role of the **management engagement** in the gender equality initiatives:

I think GEPs are a good solution but a real commitment is needed from management. 42_M

Talking about it is a fine thing and it works well if important persons talk about it. 49_F

Similarly, some respondents emphasize that the establishment of gender equality aims and solutions should be a result of **multi-actor engagement**, which means cooperation between the actors from all levels of institutional hierarchy and equally engaging female and male scientists: At the same time, there should be agreement between the institution's leadership and associated departments or institutes (Lipinski 2014; Morimoto et. al. 2013).

This requires persuasion and not forceful imposing, if this came from the central authorities it would be nonsense, if this came from the faculty authorities it would be nonsense too. If this came through a talk within a faculty and well formulated questions, and then this group formulates conclusions, it might work. 59_M_L

Solutions must be found together, women and men. 46_F

Few of the interviewees discuss the positive aspects of having gender equality targets imposed by other actors, including the state and international institutions. **Pressure from outside** mobilizes to action, especially when financial incentives are introduced:

In my point of view, you need pressure from outside, from any institution. Somebody has to say: If you don't do this, you will not get the money. 19_M_L

Or we can imagine that the Ministry [for Science] creates a programme that would award universities for accepting women for the post of assistant professor or offer an allowance for those universities. In our system financial incentives are activators of change. 59_M_L

Last but not least, one of the respondents argues for the necessity of tailoring gender equality measures by taking account of the **cultural and institutional specificity** of research organizations and monitoring the results of the undertaken actions:

Keep listening to ideas. Pro-actively look for solutions for advice, not everything will work. Cultures are different and institutions are different. A program that works somewhere else may not be successful here, but you have to keep pushing and looking. There is lots of inertia and it is tiring. It can be discouraging. 04_F_L

Only few interviewees present negative attitudes toward any institutional and systematic interventions in the field of gender equality in physics. Their doubts concerning the effectiveness and worthiness of institutional measures for gender equality in science stem from a belief that they are not targeted at the roots of inequalities, which are primary socialization and women's attitudes:

The role of institution is limited. Any mechanisms introduced in academia could be even counterproductive. Inequalities are made and strengthened at the phase of upbringing and families are the ones that are solely responsible for a low number of women in physics. (...) I think that laws regulating such issues when people are already shaped/determined, would be a loss for everyone, and especially for science. 53_F_L

I think it's not an institutional problem after all. I think it's more about what women think that society expects from them. It's more about their values and their believes. 14_F

Evaluation of institutions in fostering gender equality

Both semi-structured and expert interviews addressed the problem of the respondents' perception of work done by their own institutions for enhancing gender equality. The interviewees were asked whether their institutions are taking any actions to support women in physics and, if yes, how they assess these activities. Additionally the persons being in leading positions were prompted to talk about their own engagement in fostering gender equality.

When directly asked about any solutions that their institutions have implemented to enhance gender equality a considerable group of interviewees (representing 7 out of 11 institutions) either blankly deny there are any, as in the case of the respondents from the Polish and Romanian institutes, or admit **they have never heard of any special programs** or “*extra affirmative action*” (22_F). In this context one of the respondents metaphorically describes perceived underdevelopment of his institution in dealing with gender inequality:

I do not see any particular effort on this topic at Xxx [interviewee's institution]. I think Xxx's gender policy is like a delayed train that already departed late from the original station and will arrive late anyway at destination. 42_M

A few of the respondents admit that while there are some institutional frameworks in their institutions, including a gender equality office, their **knowledge about the existing procedures and solutions and their effectiveness is limited**:

So, I know we have a gender equality officer, but what is done exactly, I would not know. 08_F

I know Xx [equality office in one's institution], but there is little popularity of the existing measures, very little is known. 46_F

It is necessary to notice that these are mainly early career physicists who admit that their knowledge about gender equality measures introduced in their institutions is either lacking or limited, however a few of the senior scientists and leaders also signalize this problem and simultaneously provide possible causes of their being ill-informed. Some of the interviewees complain that their insufficient knowledge is the result of **poor dissemination of the information on the activities and measures** taken by the bodies responsible for gender equality in their institutions. In some cases gender equality policies are argued to be boiled down to a **sheer formality** known to a limited number of people rather than real actions engaging all stakeholders:

I know that it exist but I haven't ever been in contact with it. I see it as a formal thing and I perceived it as far away from me and I am a research director so, I should have noticed that. But I haven't ever received communication or something similar. 45_M_L

I've heard we have rules to enhance equality in selection committees or to make human resources aware of the gender equality problem, but I'm not very familiar with these actions. I have to confess I heard there is a committee working in woman/man equality issues. But I don't know exactly what they are doing concretely. It's like they are checking

a box, 'we made an equality plan', but the staff working in the laboratories is not concerned afterwards. 38_F_L

When talking about inefficiency of gender equality actions in engaging all employees, two female physicists notice that it happens that male employees are either not being informed about some initiatives or do not feel being involved or interested in them:

Two professors forwarded the announcement of the Gender in Physics Day, but only to the female PhD students, so no one of my male colleagues went to the event. It should be broader announced. 51_F

Well, most male colleagues have simply not felt addressed from the invitation [to an event introducing gender equality work and GENERA], there they said to themselves, 'well, I do not have anything to do with this, it does not interest me' (...) 06_F

The opinions of some of the interviewees suggest that the undertaken measures and actions towards gender equality are perceived as misguided as they either **do not have an impact** on everyday relations in the institutions or their positive **effects are limited** to a small group of recipients rather than to a broader population of physicists:

There are some measures, for example the Xxx [equality office in one's institution], but I believe that in everyday life they don't affect so much. 50_M

Yes, so I believe that (...) [own institution's gender equality] programmes are already very good (...) but they reach relatively few women and not the broader population. That is rather targeted towards excellent women, so few excellent women. 06_F

I would give Xxx [respondent's institution] high marks for awareness and motivation, but medium on concreteness, on real world issues. 04_F_L

Some interlocutors point that inefficacy of some of the measures is the result of their **poor design** and **lack of comprehensiveness**. Therefore, instead of resulting in far-reaching positive consequences, these solutions generate negative responses of the physicists who feel that their engagement in such activities as role-model talks and gender equality trainings was only a waste of their precious time:

When I was in Xxx [a city where a respondent did her PhD], there were these talks where women from industry would come to speak with us of career stuff. The problem was that these talks were completely not adapted to the audience. There was this lady telling us that her biggest success with her husband is that they both pay 50% of the cleaning lady at their home? How is it a success? It was a completely loss of time and they forced us to go to these useless talks which had no relation to research. 37_F

How long it has no far-reaching consequences? It is hard. So, only to give an obligation seminar? And we (as group leaders/scientists) just hear for one day how important gender equality is in the scientific career. You go there, you leave and you are angry because you've lost a day. 19_M_L

As far as knowledge and opinions about specific activities taken in home institutions to foster gender equality are concerned, the respondents identify interventions targeted at pupils,

measures concerning recruitment and promotion as well as solutions for enabling reconciliation of work and private life. A few of the institutes take up activities aiming at **attracting pupils to physics**. These initiatives are seldom addressed exclusively to schoolgirls, as in the case of the Girls' Days in two of the German institutions:

What comes to my mind and what I think is a good initiative is that they have, like here, Girl's Day at this institute and, also, I think at Xxx [another physics institute in the same city]. And then they try to show good examples of successful female scientists (...). 11_M

More often these projects aim at explaining the rules of physics, popularizing physics to schoolchildren or encouraging high school students regardless of their sex to study physics and mathematics at a university level. While none of these programs is explicitly addressed to girls or young women, one of them is argued to be inspired by the willingness of raising the number of female students in the institution. The respondent being directly involved in this initiative finds it an important part of his duties and evaluates it as useful and effective in winning the interest of young women:

I am very proud of the Xxx program I am responsible for which has been a huge success. (...) It is a project encouraging students in their final year of college to follow a first year University Physics course. (...) They have a tutor and they take the exam and if they pass the exam they get a credit... This was inspired by the idea that we suspect at college the interest is 50/50 girls and boys but there is something that breaks the girls. (...) The girls were almost always in a group where the tutor was a young woman chosen to be a role model. Already in the first year [of this program] 50% were girls. 02_M_L

Some physicists discuss the gender equality **interventions in recruiting, retention and advancement process** that are applied in their institutions. These measures include active looking for female candidates, formal or informal rules of giving preference to females when the skills of candidates are equally rated and founding special grants for female scientists.

When we open a position we have to search for a minimum number of female candidates. There must be roughly 4 out of 10 otherwise the rector doesn't allow us to proceed unless we justify our shortlist. 02_M_L

I was discussing just with the personal office when they explained me the rules for hiring somebody in my group and they said: It's not that you are forced to fixed quotas but somehow you are encouraged to consider a bit the gender balance. 21_F_L

Now we have the Xxx [a name of scholarship] which is only for women in budding professorial positions. 04_F_L

Additionally, the respondents from Poland talk about the routinely practiced statutory requirement of considering career breaks caused by caring duties when deciding about recruiting, retention and promotion. The interviewees who talk about the gender equality interventions in the recruitment, retention and promotion generally find them both legitimate and carefully observed.

I believe inherently that it is already established [in selection procedure] that women, if it is 50/50, are preferred. This is, I do believe, already clear. It is also established that

interviews cannot not be conducted without an equal opportunity commissioner, ehm, and I find this good. 20_M_L

(...) institutions do it in this way, that they all decide that for example there is, let's say, 8 years for the post of an adjunct professorship, but if there is maternity leave, this time is not included. This is an additional time. Or parental leave ... And everyone is scrupulously observing this rule. 71_M

While not many respondents in leading positions declare being active in working out any gender equality measures, a few of them admit they initiated or conducted career workshops for both female students and employees. Moreover, some of the respondents recognize that senior physicists and the institutional leaders demonstrate attitudes of strong support for or authentic engagement in setting up measures for raising the number of female physicists:

For professors in my group it is crystal clear that there should be more women in the field. And they say that without any reservation. 51_F

On the faculty level, the last deans have more actively participated with the Equality Office. They have thought about and promoted policies that the Dean's Office as whole put together to raise number of women faculty. There is a conscious effort to carry out actions, which I find positive. 04_F_L

Negative assessments appear when interviewees talk about measures for enhancing women's visibility and power through establishing gender quotas in various scientific collective bodies. While from the perspective of female physicists enrolled to a number of such committees, this requirement becomes a time-consuming burden, for the heads of the institutes it might breed difficulties in finding the sufficient number of female candidates:

I've been in so many commissions only because I was the only women and this disrupt much of my research time. But often a presence of a woman is required by law and this ends up to be very requesting task for the few women in certain disciplines. 41_F

[In the EU grants or awards] there is sometimes this requirement that there should be an adequate number of women in various commissions, and this is truly a problem for us. We forcefully try to have any women in our council, any female doctoral student, etc. (...) 68_M_L

Additionally, one of the physicists reports a situation in which the employer demonstrated serious insensitivity to the difficult situation of own female employee, who due to changes in the national legislation on parental leave lost her position at the institute:

(...) they changed the parental leave laws, (...) before you were extended for the period of time you took leave (...). So when you went on parental leave and if your contract would have still been running for a year or something like that, then you got that year plus the time you were on leave. And now it is the case that, when the parental leave is longer than the remaining time of your contract, then you come back from parental leave and your position is simply gone. They changed that at the beginning of the year and apparently there was a post-doc here who had a child. And then the law changed while she was on leave. And then she came and found out that she did not have a position anymore when she comes

back and asked whether they could make an exception so that her contract could be extended. And the directors said 'no'. No one cares. 07_F

When asked about available solutions for fostering gender equality, some physicists point at **measures for reconciling work and private life**. Besides, the respondents had the possibility to separately discuss this issue, as they were directly asked whether they were offered any solutions to balance their family life and career and how they evaluate those solutions. Most of the physicists point at **childcare support**, including the existence of nurseries and kindergartens, but also day-care facilities, after-school facilities and summer daycare. In most cases these childcare facilities are located outside the workplace and are run either by local authorities or private actors. However, a few interviewees declare using or at least having knowledge about childcare support provided by their employers. This support consists rarely in regular day-care centres, which – according to the respondents – exist in two institutions, however in one of them the facilities are outside the physicists' site, which makes their location inconvenient. Some of the interviewees report the existence of spaces at their institutes, when they can leave their children in the afterhours, in the emergency situations or during school breaks. In this context one of the female physicists talks about informal rule of tolerating the practice of bringing children to the workplace during vacation:

We have an office where people, men and women, can come to work with their child if their child is sick and they have a problem with the, uh, baby sitting or such. So we have this place, we have an online booking and people can, eh, book the room for a day or two and it is having a computer space and a game space, so that they can stay there with their children. 12_F_L

(...) very often you can see children during vacation season running in the hallways. Under supervision, of course! No one here gives you a dirty look when you come here for a while to work with a child. So I don't think that there is some kind of impediment from the Institute or Faculty in this topic. And this is all informal, but it's cool that this is not repressed. 55_F

Among other measures of childcare support the respondents talk about institutional help in finding appropriate facilities outside workplace and receiving funding for childcare. These solutions are generally very well evaluated by the interviewees who appreciate that their institutes are “very child-friendly” and “help a lot” the researchers who have children. However, some of the female physicists talk about weaknesses of the existing measures. One of the respondents notices that the child care facility in her institute does not allow to satisfy all parents' needs. Other comments on the expensiveness of the kindergartens offered by the employers, lack of (breast)feeding rooms, and conditionality of financial assistance for childcare:

(...) the university, that it opened a kindergarten for children, I would not say it is for employees' children, only for people who make a lot of money, as far as I am concerned this kindergarten is quite expensive. 57_F

I remember one day I read an email sent by social services of Xxx [respondent's own institution]. It offered financial assistance for childcare under conditions. I sent an application, but it was not accepted because I did not meet all the conditions. 34_F

The respondents recognize also other than direct support in childcare measures existing in their institutes that make it easier to balance their occupational and private duties. Female leaders in two German institutions talk about working out informal rules of **scheduling professional meetings at times more convenient to parents**:

(...) there is openness, openness in allowing time to go from not setting telecoms too late in the afternoon, because the mother or the father has to go home with the children, (...). Yeah, it's just that it is an agreement, saying "Let's make a meeting at 5" - "Sorry, I cannot, because I have to go pick up the child", so it's, okay, then we fix it, we do it every day, every day of the week at 3.30. And you agree with that. 12_F_L

Well we continue the discussed things like the timing of our seminars or scheduling of our seminars, not have them too late to have them on family friendly times, that's one thing. 16_F_L

A few physicists, mainly from German, Polish and Romanian institutions, point to the existence of formal or informal rules of granting parents with **flexible working hours** which helps them to better fulfill their caring duties.

We have part time employees or have a PhD student in my group who works from home every second week to combine the PhD work with their family. 16_F_L

There are situations when someone has to be relieved from teaching during one semester and is asking for such relief because he has to take care of the child or there are some special circumstances and these are things that we solve on a regular basis and we try to encourage our female and male colleagues to speak about this. 58_F_L

The Institute is permissive with work-family life (...) It's good that you don't have to stay longer hours if it's not necessary. 75_F

Few respondents discuss a specific measure, namely a special grant funded by one of the Polish research funding organizations and used for encouraging scientists with caring duties to continue their careers after longer breaks. While they generally find this program needed, one of the physicists notice that it is underfunded, which makes it not fully effective:

(...), there are grants that are dedicated to women, after a longer absence at work. Special grants. So, you know, there is a kind of balance. I can't apply for such a grant, women can. Only money that is allocated in these grants, is too little. (...) I think that these regulations could actually operate well, only if the funds were higher. 69_M

The theme of insufficient funding for balancing professional and private life returns in the narrative of another interviewee who discuss the superficiality of the measures available in her institution for dual career couples. If necessary resources were available, the institutions would be able to offer jobs to the partners of engaged scientists:

Or another example, the dual careers office has no power or money so is useless. So when they hire a man and his wife is looking for a job, they just forward the wife advice of job listings or counseling. This is not a solution. 04_F_L

Last but not least, a few respondents refer to the issue of **measures counteracting gender discrimination**, including overt sexism. Some of them demonstrate a belief that there is no need for introducing so far non-existent special solutions, either because general formal rules are sufficient or because the organizational culture of the institution is permeated by the idea of equality:

The statute of our institute and our rules are based on some general laws, which state that one must not discriminate on the basis of this and this. (...) So additionally writing it in would be ... There is no director's decree that for example that one must not discriminate on the basis of skin colour or gender, there is nothing like this. But it results from the fact that all our rules are based on the documents of higher rank, on bills, where there is this issue. And I think that the awareness of people in our institute, or the scientists in general is such, that everyone knows 69_M

Equality of possibilities is important. And here [at the Institute], I think, this equality exists. It is not a problem here 55_F

At Xxx [respondent's institute] there are no job/position restriction, or any kind of differences. 80_F_L

Other interviewees declare the necessity of better dealing with the issues of gender discrimination, which so far has been unsatisfactory. Therefore, one of the physicists reports own engagement in preliminary anti-harassment activities in her institute, and the other welcomes with hope emerging gender equality down-top initiatives:

For example, we, last year we made this work conduct declaration, where we really wanted to make clear that here we should respect each other and not having problem related to (...) harassment or such and it would be valid also for visitors or people attending our conferences or working at premises that are from our institute like there are small laboratories that are out of this building, but are connected to us. And we really worked hard in making this text, that then the directors approved and we put it on the, on the webpage and now we are trying to make other initiatives and like having somebody coming to talk about harassment and such, so we are collecting the list of actions that then the directors can, can decide, but we are gain slow. Very, very slow. So we managed to get this equality webpage only now instead of the end of March, so it takes time 12_F_L

Also the young students are more aware, including men. There have been projects dealing with gender equality, diversity and harassment that were student initiatives, some of which were proposed by young men which I find very encouraging. 04_F_L

However, statements of few respondents suggest that the problem of gender discrimination is sometimes swept under the rug rather than dealt with diligently:

when there was this one case, with the PhD student who left [because of gender discrimination], there were discussions here and it was asked what should be done and somehow commitment was demonstrated, but somehow nothing much came from it and it faded: (...) Nothing much is left now, from this dynamic, which arose there, which is actually a little bit of a pity. 06_F

Physicists on special measures

The use of special measures has been widely argued to be an adequate solution “to overcome the effect of historical discrimination and accelerate the attainment of substantive equality for women” (UNDP 2014: 33; see also CEDAW 2004; Rees 2002; Mühlenbruch, Jochimsen 2013). Special measures – named also ‘specific’ or ‘positive measures’ – refer to all actions “aimed at favouring access by members of certain categories of people, in this particular case, women, to rights which they are guaranteed, to the same extent as members of other categories, in this particular case, men” (EIGE Gender Equality Glossary and Thesaurus). They encompass a wide variety of instruments, policies and practices, including allocation and/or reallocation of resources; preferential treatment; targeted recruitment, hiring and promotion; numerical goals connected with time frames; and quota systems (CEDAW 2004). Currently, some of these measures are used to counter the underrepresentation of women in science (especially in the STEM disciplines), including individual fellowships for female researchers, legislative gender quotas applied in the decision-making of research organizations, such as scientific committees, advisory boards, expert groups, and university governing bodies and setting targets of a defined proportion of the unrepresented sex in recruitment and promotion procedures (Rees 2002; Mühlenbruch, Jochimsen 2013; Id 2014; Lipinsky 2014). However, the suitability of special measures for science, particularly quotas, is debatable. It is argued that in “academia, where merit and autonomy have a central value, sanctions and incentives” applied to quotas “could be seen as compromising either, and therefore corrupting the system” (Wallon et.al., 2015: 16). Additionally, the concern is raised that gender quotas in various scientific committees “would place greater demand on the small pool of female scientists who would serve on these panels — possibly enough to hamper their career progress” (Vernos 2013: 39). Finally, it is unsettled whether more women in various committees and boards will increase female representation in science and their promotion. The results of the studies on the impact of gender composition of decision-making bodies on hiring and promotion practices are ambiguous (Zinovyeva, Bagues 2011; Williams, Ceci 2015).

In the context of controversy over applying selected special measures to counteract gender inequality in science, recognizing physicists’ opinions about these solutions is valuable. The participants of both types of interviews had the opportunity to express their views on special measures in general and quotas in particular. The analysis of their narratives demonstrate that while the general idea of implementing solutions to foster gender equality in science is in many cases acceptable, affirmative action is preferred by a minority of respondents. Above all, regardless of the sex of the interviewees there is a lot of ambivalence about quotas as well as overt resistance to it. The respondents representing ambivalent attitudes towards quotas, while agreeing that they are effective in raising the number of female scientists, point to a number of negative side-effects of their usage and advise to use them carefully, to use them “*as a medicine*”. Those who present an uncompromising stance against quotas either see them as inadequate measures for counteracting gender inequality in science or – explicitly or implicitly – question the necessity of introducing them since there is no inequality in science:

I do not agree with affirmative action but I think it would be more useful to start encouraging women earlier to participate in physics. 03_M

It the field I came from there is no need to create special measures for enhance gender equality. 80_F_L

The women who feel good in this profession, they do not have any barriers to enter these [scientific] councils. There are just less of them. 69_M

The **negative aspects of using affirmative action** that have been perceived (or experienced) by both its' opponents and those who present ambivalent attitudes to it can be categorized in four broad themes, according to which special measures: 1. cause injustice to women, 2. challenge the idea of quality and merit, 3. are discriminatory for men, and 4. are implemented by force and therefore breeding resistance.

The most often risen argument against affirmative action towards female scientists is the belief that it is indeed **the source of treating women unequally**. Firstly and most importantly, when gender quotas or preferential treatment apply to selection procedures, there appears prejudice against female scientists who received a nomination to a scientific committee or were chosen for a position that they are not fit to perform their tasks. It is because their selection for a post is believed not to be based at all on meritocratic criteria and therefore “*they don't really deserve their nomination*” (37_F):

I'm not sure that's a good idea. It always leaves me a little puzzled. When you are there because you have forced the institution to select you for a committee or even for a position, your entourage will inevitably blame you. In any case, even if it is unconscious and not expressed, you colleagues will think you did not have the level and you are not legitimate 34_F

Bias against female scientists who were selected due to preferential treatment or quotas is not hypothetical only, but it reflects real life situations, which can be harmful for women as the experience of one of the respondents confirms:

After I got this position and I came here there were actually good friends of mine and good colleagues at my institution asking me how it feels, what does it feel like to be selected to the job only because you're a woman. So, that was really like a slap in the face. 15_F

According to another interviewee the exposition to accusations of receiving unjustified privileges impels women to constant proving that they deserve their positions. This damaging side-effect of preferential treatment together with male resistance towards over-privileging women are the sufficient reasons to their rejection:

If you start in having the position just because you are female then you start already that you need to demonstrate over and over that you actually deserve the position and it is not that it was an unfair selection, but you also deserve it. So for me this forced selecting female is only damaging us. I, I understand the good intention behind and I understand that it is a fast way to reach the higher number, but you just create enemies and you don't really change the mentality. 12_F_L

Special measures are believed to be harmful to women not only because they expose female scientists to objections to their capability, but also because they challenge their sense of personal worth based on the idea of merit and self-reliance:

I don't feel different from a man, I would complain thinking that I won the competition because there were quotas. I win competition because I am competent. I feel injured to think about quotas because it looks like a zoo, as we were in a cage, I don't feel comfortable with that. 39_F

I felt discriminated against only in Xxx [country in Europe] or in Zzz [one of the European physics institute] when they applied some special measures for women. I don't like it. I don't need a support only because of the fact that I'm a woman. I don't want to be treated special. 63_F

Moreover, the examples of a few female physicists confirm the concern that introducing gender quotas in scientific collective bodies would overburden the eligible female physicists who are few with the duty to serve on a number of committees. This in turn may impede their scientific advancement, which would mean bringing the opposite effect to the intended one of the gender equality measures:

I'm already a sort of that women who suffered from that because now I get to be part of many review panels and things like that because they need to fill a certain quota of women and then as I am one of the pure women who are there I have so much of this work that it's holding me back from doing my other things which might be more important to push my career further. 16_F_L

In every committee there has to be a woman so as a woman you are asked at least twice as many committees and it always takes time. I have learned over the years to say no. If I wouldn't say no I would do 60hrs of only committee work. 01_F

Another argument against affirmative action in science formulated mostly by the respondents working in Polish institutions states that using special measures **lowers the quality of science**, which is the consequence of enrolling/accepting women on the basis of their womanhood, not competence:

As there is nothing to choose from you will not have more women without quality loss. The fact that somebody is a woman shouldn't be an argument. 55_F

I don't like this measure [quotas in decision-making bodies], because we would choose..., this must be the representation of the best individuals (...).The statistics in physics is simply merciless, there is far less women and their choice will result in this that we won't choose the best, who truly should properly represent, no. 67_M

In this context one of the interviewees explicitly opposes using quotas in the process of allocation of grants, as they challenge physics' objective and proven to be effective methods of evaluation:

As far as grants are concerned I would be against. In my opinion allocation in physics is based on merit, some accidents can always happen, but generally the achievements are

evaluated in independent manner and introducing any mechanisms will not be welcome by anybody, women including, in my opinion. Physics has independent methods of verification of success and I would stick to this. 54_M_L

Some of the female respondents remark that preferential treatment of women, special programmes for female scientists and gender quotas may be **discriminatory for men**. It happens by refusing them access to resources and – through making competition unfair – by limiting their chances to be hired. It is perceived as a real threat and therefore makes special measures unwelcome:

I understand it is done for good intention and for helping, so there are a lot of programs also for helping women to go back in science after having pregnancy and so on. But for those males that were also sharing the responsibility of the family, they say: 'I do not have that opportunity'. 12_F_L

(...) sometimes the quota is a bit unfair against men too. Cause there are many good qualified men, who have less chances 23_F

(...) if there is a competent man he must not be hired because of quotas, that's a double discrimination. 40_F

Last but not least, according to some of the respondents special measures are undesirable or at least questionable, because they are **implemented by force**, disrupt natural processes and, therefore, **breed resistance**. Instead, as gender inequality is a sensitive issue, it needs to be tackled cautiously:

I am somewhat divided on this point. I think the intentions are good, but the effects can be very harmful. As you say (...) 'Hell is paved with good intentions'. If you force people to do something, chances are, it will have the opposite effect of what you wanted to do. 35_M.

(...) don't do this by force, because everything that is [done] by force becomes artificial and it is grist to the mill for those who are against. 56_F

It's the same like introducing special measures for race (e.g. black people). It is a sensitive field and things have to be done naturally. (...) It's also artificial. Kind of an abrupt modification of the rule. 82_M

Describing special measures for gender equality as forced and therefore risky solution recurs in a few narratives of the physicists. In this context, two of the respondents additionally identify explicitly the entity responsible for imposing special measures on the scientific community. This is the European Union as the founder of scientific projects and the HR Excellence in Research Award:

We're forced to hire a specific number of women (in European projects): I understand that's for a good aim, but to me this is counter-productive. 44_M

(...) because we try to (...) receive some privileges, also from the European Union, there is sometimes this requirement that there should be an adequate number of women in various commissions, it is truly a problem for us, we try by force to have any women in our council

(...). This EU policy, that there should be 60% of women or else and so on, personally I don't – let's say – understand this, because for me it doesn't matter. 68_M_L

As it was previously signaled, raising objections to special measures does not necessary mean rejection of any actions towards gender equality in science. According to the interviewees who question the appropriateness of their introduction, it is instead necessary to act “*at base*”, understood either as influencing the youth making decisions about thinkable career paths or facilitating work-life balance of the physicists (see the previous paragraph on the Role of institution in fostering gender equality).

Only a dozen or so respondents overtly **support special measures** as a method of fostering gender equality in science. Most of them argue that their introduction will generally **accelerate the systemic change**, understood not only as a numerical increase in proportions of female physicists in high-rank positions, but also as a change of social mentality. The respondents believe that otherwise this transformation would proceed very slowly or even would be impossible. Therefore, despite social resistance and the arguments raised by their opponents of being unjust and compromising quality, quotas and preferential treatment should be introduced. Applying these special measures, which are a complement to the criteria of excellence, rather than their contradiction, will help to “create a real change in the laboratories and institutions” and therefore “all the structure will be more balanced”:

I believe that it is helpful, to start, that real equality is possible. Otherwise it will simply only go forward very slowly. (...) there are probably always some people who will say 'Oh, she only got the position, because there is this quota'. You have to say to yourself, you just need to stand above that and say 'I am excellent regardless, even if I am a woman and, uh, fulfilling this quota'. So you are not getting the position only because of the quota, but also because of the quota. 06_F

I think that if there doesn't appear an outside factor [quotas], women won't be entering the Scientific Council for long. Mentality and the way women in physics are perceived must change. I think that this measure would meet with a negative reception by the majority of the council, but it would help us very much for a start, right? It would be a cool solution, because in our system ..., exactly how to do it, so that women would begin to appear in the council? 65_F

Of course, if you force parity in committees, or meeting's stakeholders for example, you have a risk to hire women who could not completely deserve it. There will be angry people and outcry. But, by the fact that women are present in these committees, it will create a change in the mentalities and allow hiring more young women. 38_F_L

Few of the interviewees talk about further, specific advantages of applying special measures in the scientific community. They argue for example that introducing quotas will enable to counteract the gender bias of the male nature of scientific excellence, which indeed governs the processes of evaluation. Additionally, special grants for women are seen as a method of overcoming female mental barriers to apply for top positions:

Quota would be good otherwise you would just hire a man again, not because he is better but just because he is a man. 51_F

You force male to take a look around at women candidates, to have the perception of professionals no matter what gender is. 77_F

In a way we have this freedom (...), but on the other hand there are so many blockages we have learned for the whole life, that it is difficult. Therefore, I think that a special grant program for women, so that there was this requirement that it has to be a woman, it would certainly be beneficial. 64_F

Last but not least, a few of the respondents who are in favour of introducing special measures additionally discuss their **temporary nature**. Special programmes for women as well as quotas in decision-making bodies and recruitment should not be set up as permanent solutions. Rather they are perceived as a method of overcoming long-time injustice. Once the gender balance is achieved, which should happen at some time in the future, special measures will no longer be necessary:

I don't know how many years it will takes [a special program for female physicists] and till it is normal but then they can do away with it. 19_M_L

I believe it [the quota system] is necessary to change the society first. Secondly, it is important to turn and change it back to normal after the world has changed. 20_M_L

After a transitional moment, the selection will again be based solely on excellence, but in an audience composed equally of men and women. 38_F_L

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THE INTERVIEW STUDY METHODOLOGICAL GUIDELINE – STUDY DESIGN, SCENARIO AND STRUCTURED NOTE

Prepared by the Jagiellonian University team

1 Study design

1.1 Aims of the research

The main idea standing behind this study is to provide a complex sociological portrait of gender equality policies in physics, built upon various standpoints and perspectives of both female and male physicists who have an experience of working in research organization, including universities and non-academic institutes. The main aims of this qualitative research is to:

- analyze women's and men's career paths in physics, especially structural, political, organizational and cultural barriers to and factors that enhance the success;
- determine subfields in physics that are attractive for women and analyze why;
- identify successful approaches and innovative ideas for GE measures in physics oriented research field and successful gender actions of institution and countries for strengthening women's careers in physics and leading to reaching better gender balance in their participation;
- define set of immediate implementation activities for all other partners and countries to be included in toolbox and Gender Equality Plans.

1.2 Individual Semi-Standardized Interviews and Expert Interviews – An overview

In order to gather all necessary information for answering research questions introduced in the project application, two separate methods of interviewing will be applied.

The first one – the **semi-standardized interview** – will be introduced to the interviews carried out among physicists, both female and male. This method is based on an assumption that people in general as social actors construct their “subjective theories” about their life and experiences. The notion of “subjective theory” refers to the fact that “the interviewees have a complex stock of knowledge about the topic under study” (Flick 2006: 155). Some of the information could be delivered by the respondents in an explicit way (e.g. if we ask an open question about his/her career path, the interviewee will give us a response containing all the events/processes/moments

he or she finds crucial for the career development). The other information (“implicit assumptions”) must be articulated with a support of methodological aids (e.g. several additional questions; following the example used below, we could ask about more details regarding some steps of career path or about relations between the events mentioned by the respondents). A general rule is that in every sub-section of the interview the interviewer starts with an open question (usually very general) and then ask several following more detailed questions.

You should conduct 6 semi-standardized interviews in total (see Chapter 1.3 below). In order to conduct these interviews, please see **Scenario I** as well as **Structured note from the semi-standardized interviews**.

The **expert interview technique** is usually applied in the research with a very specific and restricted area of study. It helps to exclude from the interview all unproductive topics that may occur e.g. during the narrative interviews. The expert interview is therefore centered around a very specific topic and organized by a list of questions. This method will be applied to the interviews with physicists in leading positions. The experts interviews will be focused only on measures for fostering gender equality.

You should conduct 2 experts interviews in total (see Chapter 1.3 below). In order to conduct the expert interviews, please see **Scenario II** as well as **Structured note from the expert interviews**.

1.3 Participants’ selection – research sampling

At least 8 interviews should be conducted in each partner institution, including both **male and female** academics:

- 6 interviews with physicists;
- 2 interviews with leaders / scientists in a leading position.

To ensure a diversified sample and include to the research various perspectives, experiences and standpoints, the interviews should be conducted with physicists and leaders in accordance with the following criteria:

Table 1. Interviews distribution in the sample of one institution

Semi-standardized interviews	Expert Interviews – 2 interviews in total
------------------------------	-------------------------------------------

– 6 interviews in total			
Gender	4 female and 2 male physicists	Gender	At least 2 researchers [one female, one male] who have been in a leading position in your institution for at least 2 years (e.g. administrative position or being a leader of a research project) or recently has stepped down from a leadership position (in the last 2 years)
Research experience	3 young researchers (up to five years after obtaining PhD) and 3 senior researchers (at least 10 years of experience of working in an academic / a research institution)		
Working in emerging subfields in physics	At least 2 persons (but at least 1 female) working in emerging subfields in physics (the emerging subfield may be different for different institutions)		

Semi-standardized interviews (please see Scenario I) will be conducted with 6 physicists, including:

1. 4 female and 2 male researchers;
2. 3 young and 3 senior researchers (for details, see the table 1);
3. 2 researchers [at least one of them will be female] working in emerging subfields in physics.

Expert Interviews (please see Scenario II) will be conducted with 2 physicists [one female, one male] who have been in a leading position in your institution for at least 2 years.

Additional recommendations regarding the sample (if applicable): to conduct at least one interview with a female physicist or a female leader who have been a beneficiary of GEP in the institution she works/worked for.

Please note that one interviewee may represent more than one characteristics e.g. young female researcher working in an emerging subfield.

1.4 Preparations for both types of the interviews

Before starting an interview an interviewer should make sure that he or she have all the necessary materials / equipment with him/her:

- a dictaphone;
- an interview scenario
- a consent form [in a language of the interviewee];
- a piece of paper and a pen (for making notes during the interview);
- basic information on the GENERA project in a printed form [in a language of the interviewee].

1.5 Interview plan

The meeting should be organized according to the following order (see scenario for more details):

1. Welcome
2. Presenting GENERA Project
3. Presenting the main research goals and benefits from the participation
4. Describing the course of the meeting and rules of the interview (e.g. recording, confidentiality)
5. Answering any possible questions concerning the interview from a respondent – concerning empirical material collected during the interviews, anonymization, data storage, use of the empirical material etc.
6. Obtaining written consent for participation (Annex 1) – same of both types of the interviews
7. Conducting the interview following the scenario
8. Thanking for the participation

1.6 Important information to share with an interviewee

Before starting an interview, the researcher is obliged to share with the respondents all the important information about the research in general and the interview itself.

1. The research project;
2. The goals of the research;

3. Details concerning the interview as well as information about further using of the collected empirical material and data storage;
4. A name (and email address/ phone number) of a contact person from the project team in case of any further questions [to be determined by each partner institution].

A good practice of conducting interviews is to prepare all the information before the interview and carry them in a printed form with you for the meeting. You may for example prepare a short note you will present to the research participants. The information can be also sent to participants before the interview (e.g. by email).

1.7 Interviewer's characteristics

The interviews should be conducted by researchers with an experience of conducting a qualitative study in which in-depth/semi-structured interviews (IDI) or expert interviews were applied as a core method (having participating in at least one qualitative research project, having conducted at least 5 interviews themselves).

Researchers chosen to carry out the interviews should be familiar with the subject matter of the GENERA project, the main aims of the research, as well as the actions undertaken throughout the project's duration. A basic knowledge in gender studies is also advisable. The interviewers should be able to present the project to the interviewees, as well as answer possible questions concerning the study.

1.8 Deadlines for conducting interviews and preparing notes

The interviews should be conducted before the end of **February 2017**. The structured and anonymized notes from the interviews (so called GRIDs) should be sent to JU TEAM prior to **March 30, 2017**.

Scenario I: Semi-Standardized Interviews with female and male physicists

Total time: 1 – 1,5 hours

Introductory phase

1. **Welcome** – Thank you for meeting with me today. My name is X and I am a researcher at GENERA project. I have an experience in conducting sociological research in an area of *[gender studies]*.

2. Presenting GENERA Project

3. Presenting the main research goals and benefits from the participation in the research

Your participation will help us understand the career paths in physics. This information will be used to plan the main gender equality measures and actions that could be implemented in physics departments and research centres. We also plan on implementing some of them in several research/academic institutions, *[also in your own institution – if applicable]*. The data we collect will also be used for academic publications and other forms of disseminating knowledge and promoting physics.

4. Describing the course of the meeting and rules of the interview (e.g. recording)

We will start the interview shortly, but firstly let me give you some basic information about our meeting. Our conversation will last around 1 to 1,5 hours. If you do not want to answer any of the questions, just let me know and we will move on to the next part of the interview. If you agree, our interview will be recorded, though the data will be used for research purposes only. All the identifiable information about you will be anonymized. The recordings will be stored safely at [to be determined by the consortium]. The information recorded is confidential, and no one except for [the GENERA researchers] will have access to the recordings. The recordings will be destroyed after [to be determined by the consortium].

5. Do you have any questions concerning the interview / empirical material collected during the interviews / anonymization / data storage / use of the empirical material?

6. Obtaining written consent (Annex 1: Consent form) from the interviewee.

Getting to know the interviewee

Could you tell me about your work? What is your field of research? What are your main research interests?

Where do you work (institution/department/institute/research team/project)? At what position? What are your main tasks at this position (e.g. research, teaching, administrative work)? Are you a permanent staff member or you have a limited contract (if so, until when)? Are you a full-time or a part-time employee?

The main part of the interview

Career path

Open questions:

When was the first moment you thought of becoming a physicist? How old were you?

How did your parents/peers/friends react to your choice to pursue a career in physics?

Were there any critical moments or turning points during your professional path? Can you tell me about them?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

[*studies*] What did you study for your Master/undergraduate and graduate courses? At which institutions/ where?

[*PhD programme*] What was the topic of your PhD? Which field/subfield of physics does this research belong to? When did you finish/defend your PhD? How old were you then?

[*first job*] What was your first job as a physicist? How did you get it? What was the recruitment like? Was it at the same institution where you did your PhD? What was your motivation to stay in/change the institution/department?

[*current place of work*] Please tell me about your current place of work. What do you work on? What is your expertise in? Do you work in a team or alone? Do you feel a sense of belonging to your institution or do you think you will move somewhere else eventually? What are the reasons?

[*comparison of career paths*] Do you consider your career progression slow or fast when compared to your colleagues working in physics field? Why? Does it differ between other female versus male colleagues?

Work conditions

Open questions:

How were the work conditions in places that you have been working so far?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

What were the provisions regarding the job contract, compensation, workload, and other demands?

Are you free to schedule your working hours? How do you find the opportunity for managing your own schedules? Do you find that being a scientist gives you flexibility?

Do you teach/supervise students, PhDs? How many have finished their PhD? Were they mostly men or women? Could you tell me how do you evaluate motivation of male and female PhD candidates? How do you evaluate their competences? Did you ever try to support young women physicists in any particular way?

How do you balance between different obligations at your work (research, teaching, supervision, administrative issues etc.)? Do/did you need to do any administrative work during your career?

How much do you rely on equipment/laboratory access in your work? Do you have sufficient access to the equipment/laboratories?

Do you get sufficient resources/support from your institution? Do you have your own office/office space? Do you receive sufficient funding for research, mobility, networking or conference participation? Do/did you have opportunity to build a team to support you in your research?

Work environment

Open questions:

Do you enjoy the working environment in your institution?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Could you tell me more about it. Which environment is inspiring or provides most opportunities for you?

Do you find the working environment very competitive? How do you deal with this?

Do you find the working environment stressful? For what reasons?

Mobility and migration

Open questions:

Have you always worked here in *[name of the country]*? If not, where did you go to, how long have you stayed? What were the forms of your stays abroad, e.g. change of workplace, grants, research visits? Please tell me more about these experiences.

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Is international mobility important to making a career as a physicist? Do you like this pattern?

Do you think that this mobility was important for your career development? Do you find it difficult to be mobile (foreign institutions, or challenging locations of research (e.g. desert)?

Scientific networks

Open questions:

Are you a member of any (formal/informal) networks gathering scientists/physicists? Why do you belong to such a network? Did it help you in your career to be a member of a network? Why are you not a member?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Which networks are the most important for your work? Do you feel that networks are sufficiently open in your working environment? Do these network mostly consist of women or men?

[for women] Are you a member of any associations supporting women in science or have you been in one in the past? What do you think about this kind of associations?

Mentorship and guidance

Open questions:

Were there any persons or events without whom or which you would not be able to reach the place you are now at? Have you had a teacher, a mentor or someone else who encouraged you to pursue/stay in physics/academia? What support did you get?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Did you ever have a boss that was a woman? Are there any differences between working with a female leader/boss and a male leader/boss? What are they?

Have you been a mentor to any young female physicist? What do you think was the most useful for your mentee?

Did you have a role model that you could refer to/that inspired you at different stages of your career during your career? What is the greatest inspiration for your work?

Family-work reconciliation

Open questions:

If you don't mind me asking, what is your family situation? *[if having a partner]* Is your partner supportive towards your career? In what ways?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Is your partner/wife/husband also working in research or academia? How do you evaluate the fact of you both being engaged in physics/academia in context of your and his/her career? What was the impact? What is challenging or helpful to have a partner from the same profession?

Do you have children? How many and how old? Have you taken time off to take care for the children? If yes, how long was your career break (or breaks)? How do you organize childcare for your children? How has it been when they were very young and how is it now? Has becoming a parent impacted on your career? In what ways?

Do you feel like you have enough time for both work and family life? What percentage of your time do you dedicate to your family/ work/ yourself? Do you have other family duties, e.g. those linked to caring for elderly or sick-persons?

Were there some moments when family life and career was difficult to balance? What support did you get in balancing work and family duties? From whom/where: from your colleagues/supervisors/institution/employer/state? Which solutions offered by your employer were the most useful? What in your opinion could be useful but was not offered?

Being male/female physicist

Open questions:

As data shows there are more men than women in physics – what is your opinion on this matter? Are there any particular reasons for this situation? Why do you think there are so many more men than women in physics?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Do you think it is difficult to be successful in physics if you are a woman? What are the reasons for that?

Did you feel that men are privileged in physics? Please, give me some examples. Did you feel that women have it more difficult to succeed in physics? Please, give me some examples.

Do you think you were discriminated against or treated worse than men/women in some situations because you are a woman/man? Please, give me some examples. Do you think you were privileged in some situations because you are a woman/man? Please, give me some examples.

Were you discriminated against or treated worse than others in some situations because of other reasons (e.g. age, ethnic background)?

Do you agree with the belief that women are more willing to work in the new emerging subfields of physics? Why do you think so? *[for person working in a new subfield]* How was it for you? *[if applicable]* How do you compare the conditions/atmosphere/career opportunities in the new subfield you are engaged in and the previous one?

Role of research institutions/universities

Open questions:

What would be the ideal solutions to raise women's participation in physics in your view? Who should implement those solutions? Do you think research institutions should support women in physics in particular ways?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

What do you think about women in physics being offered some special measures/affirmative action e.g. have preference for employment/quotas in grants in order to raise their participation? *[The interviewer be prepared to give an example of preferential treatment or to explain what quotas are]*

What do you think about introducing women quotas in e.g. departmental boards, to ensure more equal participation of both genders?

Evaluation of the institution work towards more gender equality

Open questions:

Do you think that gender equality is an important problem in the field of physics?

Additional questions – if an interviewee doesn't mention some of the information, please ask the following questions:

Did/do you think that gender equality is an important problem in your institution?

Is your institution taking any actions to support women in physics? Is your institution taking any actions to prevent gender discrimination? Is your institution taking any actions to assure more equal participation of women and men? Does your institution engage in any outreach or

gender-relevant activities to encourage the change in perception of women in STEM or bring more women into the field?

[if applicable] How do you find those actions? Do you think these actions bring some positive change? If not, why?

Is your institution implementing Gender Equality Plan or some programmes/projects/schemes/activities for enhancing gender equality? How do you evaluate it? If not, is it in your opinion advisable to implement one?

Is there anything that your institution could do better? Are there any solutions or actions that should be undertaken?

Closing

Is there anything that you would like to add about your experience in physics, or gender dimension in physics more broadly?

Thank you very much for your time!

Scenario II: Expert Interviews with leaders

Total time: 45 minutes – 1 hour

Introductory phase

1. Welcome – Thank you for meeting with me today. My name is X and I am a researcher at GENERA project. I have an experience in conducting sociological research in an area of *[gender studies]*.

2. Presenting GENERA Project

3. Presenting the main research goals and benefits from the participation in the research

Your participation will help us understand the career paths in physics. This information will be used to plan the main gender equality measures and actions that could be implemented in physics departments and research centres. We also plan on implementing some of them in several research/academic institutions, *[also in your own institution – if applicable]*. The data we collect will also be used for academic publications and other forms of disseminating knowledge and promoting physics.

4. Describing the course of the meeting and rules of the interview (e.g. recording)

We will start the interview shortly, but firstly let me give you some basic information about our meeting. Our conversation will last around 1 hour. If you do not want to answer any of the questions, just let me know and we will move on to the next part of the interview. If you agree, our interview will be recorded, though the data will be used for research purposes only. All the identifiable information about you will be anonymized. The recordings will be stored safely at *[to be determined by the consortium]*. The information recorded is confidential, and no one except for *[the GENERA researchers]* will have access

to the recordings. The recordings will be destroyed after [insert date – to be determined by the consortium].

5. Do you have any questions concerning the interview / empirical material collected during the interviews / anonymization / data storage / use of the empirical material?

6. Obtaining written consent (Annex 1: Consent form) from the interviewee.

Getting to know the interviewee

Could you tell me about your work? What is your field of research? What about your leading position? Could you tell me what are your work duties?

The main part of the interview

Being male/female physicist

As data shows there are more men than women in physics – what is your opinion on this matter? Are there any particular reasons for this situation? Why do you think there are so many more men than women in physics?

Do you think it is difficult to be successful in physics if you are a woman? What are the reasons for that?

Did you feel that men are privileged in physics? Please, give me some examples. Did you feel that women have it more difficult to succeed in physics? Please, give me some examples.

Do you agree with the belief that women are more willing to work in the new emerging subfields of physics? Why do you think so?

Role of research institutions/universities

What would be the ideal solutions to raise women's participation in physics your view? Who should implement those solutions? Do you think research institutions should support women in physics in particular ways?

What do you think about women in physics being offered some special measures/affirmative action e.g. have preference for employment/quotas in grants in order to raise their participation? *[The interviewer be prepared to give an example of preferential treatment or to explain what quotas are]*

What do you think about introducing women quotas in e.g. departmental boards, to ensure more equal participation of both genders?

Evaluation of the institution work towards more gender equality

Do you think that gender equality is an important problem in the field of physics?

Did/do you think that gender equality is an important problem in your institution?

Is your institution taking any actions to support women in physics? Is your institution taking any actions to prevent gender discrimination? Is your institution taking any actions to assure more equal participation of women and men? Does your institution engage in any outreach or gender-relevant activities to encourage the change in perception of women in STEM or bring more women into the field?

How do you find those actions? Do you think these actions bring some positive change? If not, why?

Is your institution implementing Gender Equality Plan or some programmes/projects/schemes/activities for enhancing gender equality? How do you evaluate it? If not, is it in your opinion advisable to implement one?

Is there anything that your institution could do better? Are there any solutions or actions that should be undertaken?

Questions about measures undertaken to fostering gender equality

When on leadership position, did/do you take any actions to support women in physics?

Did/do you believe that some actions were/are important? Which one? Did/do you take chance to implement them? If not, why? If so, did/do they work? Are/Were there any obstacles in implementation? How was the collaboration with institution bodies/scientific circles/governmental bodies/staff?

For now, do you think there are things that should be done to enhance gender equality in physics as a field? Could you suggest some pragmatic measures/programmes/ideas for doing it? What should be done on the national level (e.g. ministry) and what at the level of the institution?

For now, do you think there are things that should be done to enhance gender equality in your institution? Could you suggest some pragmatic measures/programmes/ideas for doing it?

Closing

Is there anything that you would like to add about your experience in physics, or gender dimension in physics more broadly?

Thank you very much for your time!

4. Structured note from the Semi-Standardized interviews

After conducting the interview, a researcher/interviewer on the basis of the recording will prepare a structured note from the interview. The note has to be very detailed and contain all the relevant information from the interviews. As the researchers preparing the final report from the study will not be using original recordings nor transcripts, it is critical that the notes are of highest quality – otherwise the analytical work can be hindered if notes are superficial or incomplete. Please always provide a summary in your own words (but as close as possible to words of respondent) and 1 to 3 citations for each section (if available).

Remember to always distinguish between what a respondent told during the interview (this should be included in the table e.g. “I was never privileged as a man”) and your research interpretation (this should be always additionally marked if you wish to add it as ‘researcher interpretation’ e.g. “It appears that the respondent has never reflected on the fact that he was privileged as a man in academia”).

Section 0. Interviewer and interview situation

Name of the interviewer	
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Partner institution	
Place of the interview	
Date of the interview	
Start of the interview (00:00)	
End of the interview (00:00)	
Interview situation (interruptions, atmosphere)	
Questions that were difficult for the respondent	
Comments about research tool	
Any other remarks	

Section I. Respondent's characteristics

Gender F/M	
Age	
Country of birth	
Scientific title	
Topic of the PhD	
Year of the PhD completion	
Research field/subfield	
Research interests	
Working in emerging field of physics (yes/no)	
Place of work (institution, department, research team)	
Position at work	
Country of work	
Fulltime or part time employed	
Permanent staff or time-limited contract researcher	
Leading position in institution for at least 6 months – yes/no	

Section II. Respondent's Narrative

CAREER PATH	Summary of the main results	Citations (1-3 per section)
Critical moments or turning points during respondent's professional path		
Three most important obstacles in the career		
Evaluation of the career – slow/fast compared to colleagues, female and male		
Most important support that respondent received during her/his career		
Change of subfield careers (please describe the reasons)		

PLACE OF WORK	Summary of the main results	Citations (1-3 per section)
Evaluation of work conditions: job contract, compensation, workload		
Evaluation of workplace environment: atmosphere, inspiration, stressfulness, competitiveness		
Work flexibility		
Working in a team – yes/no, please describe		
Evaluation of work in the team		
Balance research and other duties (teaching, supervision, administrative issues etc.)		
Access to equipment/laboratory		
Access to own office space, funding and other resources		

MOBILITY AND MIGRATION	Summary of the main results	Citations (1-3 per section)
Migration during the career (please describe)		
Mobility during the career		
Importance of mobility in a career in physics		
Mobility evaluation (was it difficult/helpful?)		

SCIENTIFIC NETWORKS	Summary of the main results	Citations (1-3 per section)
Scientific networks – belonging and reasons for membership/lack thereof		
<i>[for women]</i> Women's scientific network – belonging and reasons for joining		
Evaluating networks for openness and gender balance		

MENTORSHIP AND GUIDANCE	Summary of the main results	Citations (1-3 per section)
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Role model or inspiration for work		
Importance of mentors in the career		
Support received from a mentor during the career		
Female boss - evaluation		
Being a mentor to a young female physicist		

FAMILY-WORK RECONCILIATION	Summary of the main results	Citations (1-3 per section)
Support of the partner in the career		
Husband also in academia/research or physics – evaluation of the impact		
Having children, how many, how old?		
Impact of having children on the career		
How the care over small children was managed?		
Evaluation of balancing work and family duties		
Other family duties, e.g. those linked to caring for elderly or sick persons		
Support in balancing work and family duties – from whom, what types?		
Evaluation of solutions offered by employer		
What else should be offered?		

BEING MALE/FEMALE PHYSICIST	Summary of the main results	Citations (1-3 per section)
Reasons for domination of men in physics		
What makes it difficult for women to be successful in physics?		
Experience of discrimination or privilege		
Presence of women in new emerging subfields of physics – general reasons		

Experience as a women in new emerging subfields of physics		
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ROLE OF THE INSITUATION FOR ENHANCING GENDER EQUALITY	Summary of the main results	Citations (1-3 per section)
Gender equality as an issue in physics		
Gender equality as an issue in your institution		
Solutions for raising women's participation in physics/enhancing gender equality – who should do what?		
Opinion about affirmative action, special measures (general)		
Opinion about quotas (general)		
Evaluation of work of your own institution for enhancing gender equality		
Describe the actions that institution is taking		
Suggestions for what institution should do for enhancing gender equality		

5. Structured note from the expert interview

Section 0. Interviewer and interview situation

Name of the interviewer	
Partner institution	
Place of the interview	
Date of the interview	
Start of the interview (00:00)	
End of the interview (00:00)	
Interview situation (interruptions, atmosphere)	
Questions that were difficult for the respondent	
Comments about research tool	
Any other remarks	

Section I. Respondent's characteristics

Gender F/M	
Age	
Country of birth	
Scientific title	
Topic of the PhD	
Year of the PhD completion	
Research field/subfield	
Research interests	
Working in emerging field of physics (yes/no)	
Place of work (institution, department, research team)	
Position at work	
Country of work	
Fulltime or part time employed	
Permanent staff or time-limited contract researcher	
Leading position in institution for at least 6 months – yes/no	

Section II. Respondent's narrative

BEING MALE/FEMALE PHYSICIST	Summary of the main results	Citations (1-3 per section)
Reasons for domination of men in physics		
What makes it difficult for women to be successful in physics?		

ROLE OF THE INSTITUTION FOR ENHANCING GENDER EQUALITY	Summary of the main results	Citations (1-3 per section)
Gender equality as an issue in physics		
Gender equality as an issue in an institution		
Solutions for raising women's participation in physics/enhancing gender equality – who should do what?		
Opinion about affirmative action, special measures (general)		

Opinion about quotas (general)		
Evaluation of work of your own institution for enhancing gender equality		
Describe the actions that institution is taking		
Suggestions for what institution should do for enhancing gender equality		

QUESTIONS ABOUT ACTIVITIES UNDERTAKEN BY LEADERS	Summary of the main results	Citations (1-3 per section)
Evaluation of activities undertaken as a leader in an institution		
Actions undertaken to support women /to enhance gender equality in an institution		
If no activities, please state the reasons for no implementation		
Support from other institutional bodies/scientific circles/governmental bodies/staff for respondent's initiatives		
Recommendations for institution		
Recommendations for other bodies, national level, governmental bodies etc.		

Annex 1. A consent form from the respondent

<p style="text-align: center;">Consent Form GENERA Research Project</p> <p>GENERA is a new Horizon 2020 project aiming at continuing, monitoring and improving the Gender Equality Plans of Research Institutions and Organizations specifically in the physics research field. These three actions will be performed by a Consortium of 12 beneficiary partner research performing and research funding organizations and a number of associate partners and observers.</p>

The GENERA Consortium includes a considerable representation of women physicists active in their careers at different levels and will engage with further women physicists active in various Institutions to benchmark and monitor the effectiveness of already active and previously proposed measures and the ones which will be proposed by the Consortium.

The end goal is to propose and create organizational structures allowing physics research in Europe to benefit from the greater presence of talented women at all levels, and which can open up more opportunities for women to create successful careers in physics research and in related fields. While the end goal will focus on the research world, GENERA will look into the origin of the problem by creating liaisons with schools and proposing suitable programs to foster the field from early stages and to propose measures that can be adopted by middle and high schools.

Another major goal of GENERA is to contribute to overcoming the under-representation of women in physics research which is long-standing and persistent even if the prevailing cultures adopt the assumption of being 'gender neutral'. Still, these assumptions did not produce the desired effect of increasing female representation in the physics research field.

GENERA will focus on the implementation by European research organization of Gender Equality Plans customized to circumstances and needs of the physics research community. The customized Gender Equality Plans involve systematic examination of all decision-making processes to identify any possible sources of gender bias in the research organizations active in physics and related fields

Please, thick a box if you consent

I confirm that I understand the research goals and that I was given an opportunity to ask questions about the study

I confirm that I understand my participation in the interview is voluntarily

I understand that my identifiable information will be anonymized and used as empirical material for the GENERA study

I understand that anonymized material will be used for further analysis and research purposes (e.g. for presentations at conferences or publications), as well as other forms of dissemination of findings

I agree to participate in the interview

.....
Name of the interviewee

.....
Date

.....
Signature

Name of the researcher:
.....

Annex 2. Sample of invitation letter

Dear Sir/Madame/Professor/Doctor X

My name is X and I'm a researcher at the GENERA project which is co-implemented by Y University / Organization [insert a name of your institution]. GENERA is a new Horizon 2020 project aiming at continuing, monitoring and improving the Gender Equality Plans of Research Institutions and Organizations specifically in the physics research field.

As a part of the project activities we conduct a qualitative sociological research by carrying out interviews with physicists, both female and male working at each partner institution. This study aims at analyzing a specificity of male/female career paths in physics as well as exploring successful approaches and innovative ideas for gender equality measures in this discipline of knowledge. As a physicist you may provide us your valuable perspective and reflections on gender equality in physics, based on your own experience and observation.

We would like to invite you to participate in our research. An interview will last no longer than two hours and have rather informal character. You will not have to answer all of the questions if you don't want to. If you decide to participate, an interview would be arranged at a time and place of your convenience. All the identifiable information about you will be anonymized.