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Multiple Masculinities and Gendered Research Personas: Between experiments, career choice and family

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ABSTRACT

The aim of this study is to analyze multiple masculinity identities among experimental plasma physicists. It is based on ethnographic fieldwork with long term observations in a laboratory and in-depth interviews. The point of departure is that different identities exist side by side and are co constructed among physicists in the laboratory. They are defined and challenged at the same time in everyday work, and are therefore central to those attracted to experimental physics. In this study, masculine identity work is analyzed as boundary work for both masculinity and experimental physics. Physics and identity work can be understood as a process where the performance and daily work is also a way of defining gender. I argue that perspectives from masculinity studies are crucial in order to advance an understanding of gender dynamics within physics communities and enrich the current understanding of the lack of women in physics. Both senior and junior physicists emphasized the importance of a strong scientist identity. The plasma physicists represent a type of double hegemonic masculinity front stage. The scientific ideal is in itself strongly gendered with the ideal image of the scientist.

KEYWORDS

Masculinity, physics, career choice, life expectations, research persona

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INTRODUCTION AND AIM OF THE STUDY

Gendered aspects of science education is an important topic to understand leaking pipelines of, for example, women in the material sciences and thus the context where science is produced at an everyday level within a university context. Women not only leave the STEM (science, technology, engineering, mathematics) areas during undergraduate and graduate education, but also while working as faculty members. The inflexibility of work hours and gender role expectations have been suggested as reasons why women leave STEM. Homosociality and men supporting men within the field are also considered as reasons (Mavriplis et. al., 2010; De Velde & Laursen, 2011; Sheltzer & Smith, 2014), and thus a possible foundation for masculinized laboratory contexts.

In current and previous research, such as the EU-funded Genera-project, an organizational structure is created to overcome 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' (https://genera-project.com/index.php). In order to further understand why certain teaching and scientific research environments continue to attract more men than women from undergraduate student to senior level, we also need to problematize how masculinity is produced within these environments (compare with Nyström, 2007; Danielsson, 2009).

The aim with this study is to analyze multiple masculinity identities among experimental plasma physicists. My point of departure is that different identities exist side by side and are co constructed among physicists in the laboratory. They are defined and challenged at the same time in everyday work, and are therefore central to those attracted to experimental physics. I argue that perspectives from masculinity studies are crucial in order to advance an understanding of gender dynamics within physics communities and enrich the current understanding of the lack of women in physics. In this study, I analyze masculine identity work among the physicists as boundary work, for both masculinity and physics. In relation to boundary work, physics can be understood as a process where performance and daily work is also a way of defining gender.

It does not seem controversial to say that masculinity identity work is integral to the sciences. The relationship between masculinity and science and technology can thus be problematized and negotiated, both within the context of the making of science and scientists' private life and life quality outside of the laboratory. To understand how the academy attracts people to science education and to stay in the academy to teach and conduct research, we need to understand the demands of science – in this case experimental physics – but also how scientists reflect on professional work and their private life.

Data collected during long term field work among experimental plasma physicists in the United States allowed me to develop an in-depth understanding of multiple masculinities that exist in parallel, and challenge each other. The analysis is based on the physicists' understanding of what defines experimental plasma physics, their daily work with the machines and experimental devices, as well as their career ideals and expected career trajectories.

From the data, I found a close relationship between the making of masculinity in the laboratory and the building of devices and daily workshop practices. The physicists' identities were constructed through negotiations and interplay between masculinities performed at the work place and masculinities informed by career and personal life related expectations. How then were ideals regarding the experimental physicists and masculinity defined in relation to ideals regarding (contested) career choice and family life? Were these ideals converging or were they challenging one another?

In higher education and among faculty in science in the United States, men still outnumber women. In relation to the life sciences, computer science and chemistry, physics is a discipline where the proportion of women continues to be low (Hill, Corbett & St. Rose, 2010; also see Stewart, Malley & La Vaque-Manty, 2007). Even so, given the high representation of men in the sciences, men, masculinities and identity work in physics is a field that has not yet been analyzed.

Although I analyze narrations by men and women doing physics in experimental physics in this study, it is the *practice* of conducting physics in the laboratory that is the focus, as graduate students as well as researchers spend considerable time in the laboratory and are required to develop competence in a range of experimental skills. Laboratory work is related to conceptual knowledge construction in physics, and it also provides a means by which graduate students and junior physicists are apprenticed into the community of experimental physicists. Laboratory work also involves a process of gender making into the community.

Analyzing Masculinity

Analysis of men and masculinities is a study of men's identity work. According to Ashe, there is a "new politics of masculinity", challenging and renegotiating power relations and its social, political and economic conditions. In late modernity, traditional roles, values and identities are tested. This includes gender in general. However, regardless of the definition of gender, the understanding and interpretation of gender has changed. Gender can now be understood as a non-fixed identity, depending on cultural and social context (Ashe, 2000).

Academic institutions represent arenas of practices with "bodily experience, personality and culture" (Connell & Messerschmidt, 2005). My interpretation of masculinity – as with femininity – does not carry any predetermined or pre-essential aspects. Neither masculinity nor femininity can arise independent of other gender dynamics and interactions. Masculinity is affected by emancipation processes of women as well the re-organization of patriarchal powers. These

powers, which have been mechanisms of subordination and supremacy in the so called industrialized world, are related to a form of masculinity that "embodies, organizes, and legitimates men's domination in the world" (Connell 1995: 82).

Given that gender is dependent on fluid social and cultural contexts, then masculinity too is a fluid culturally determined concept rather than a fixed biological trait. Hegemonic masculinity has been the concept with which to think through and understand social and cultural contexts inhabited by men - and women, and has dominated debate in recent decades about men and masculinity. Since the introduction of hegemonic masculinity, it is almost impossible to think about masculinities outside the concept (Connell, Lee & Carrigan, 1985).

Yet different types of masculinities exist side by side. The discourse of hegemonic masculinity has been criticized on the grounds that it only focuses on "a" single masculinity (Wetherell & Edley, 1999 p.337). In their work, R.W. Connell and James Messerschmidt (2005) established an understanding of multiple masculinities, and defined masculinity in relation to a larger system of cultural and social gender dynamics. Lusher and Robbins (2010) argue that "hegemonic masculinity controls a hierarchy of masculinities". The control is made in relation to subordination of women or other systems or orders of gender.

Neither gender orders nor masculinities are created equal. There are hierarchies between individual men as well as between different groups of men (Kimmel, 1997). Unlike what the theory of hegemonic masculinity initially suggested, there is a hierarchy among masculinities, which is defined both in relation to men as individuals and as members of a group. It is thus important to avoid generalized statements and to be sensitive to a diversity of identities (Coles, 2008).

Different types of masculinities do not inevitably relate to dominant forms of masculinity. It might be possible to talk about leading types of masculinity, like the image of the male global corporate business leader, but also a masculinity performed by criminal gang members. Different types of masculinity are articulated depending on context, topic or performance. One must bear in mind that dominant or leading types of masculinity also exist side by side with other values (Howson 2006), and are thus not isolated or unchangeable.

Beasley's (2008) criticism of the concept of hegemonic masculinity concerns the lack of a social critique of the relationship between different masculinities. Ideal forms of masculinity, Beasley writes, are not necessarily the same as those that work to guarantee men's authority over women. Beasley has a critical argument regarding the relationship between dominant forms of masculinity or hegemonic masculinities and power. Specifically, dominant forms of masculinity are not necessarily linked with hierarchical and economical power (Beasley, 2008).

As Beasley problematizes, there are many stereotypes of masculinity that do not hold any power or influence. On the contrary, she provides examples where strong ideals of masculinity are maintained, despite a lack of relationship between hegemonic masculinity and power. One example might be the cowboy or a master

in martial arts. Both of them are stereotypes of men, masculinity and the male body and they are both hegemonic masculinities. But as Beasley writes, it is important to remember that ideal images of masculinity are not necessarily equivalent with power or access to economic resources (Beasley, 2008).

Different masculinities contest each other, and sometimes in the same social and cultural environment. They also carry dynamics of hierarchies and power relations. Taking Beasley's point of departure, even a group like physicists must be understood as producers of parallel identities in relation to masculinity. As different masculinities are negotiated, there are also other parallel variants of masculinities contesting hegemonic masculinity. In an environment such as the academy, and in experimental physics, the production of identities performed through the daily scientific practice is challenged by private life expectations.

Beasley also suggested "a de-massification" of the concept of hegemonic masculinity. With the concepts "supra" and "sub", she created a taxonomical expansion to permit a "discussion of hegemonic masculinities in vertical as well as horizontal systems" to provide for an analysis that takes global and local interaction into consideration. Therefore, Beasley suggests that social aspects should be taken into consideration when analyzing the different layers of masculinity (Beasley, 2008).

There are no lack of studies of scientific work that include men as scientists. There is an abundance of literature, for example in the history of science or bibliographies of scientists, that target and highlight men as scientists (De Meis et. al., 1993; Schummer & Spector, 2007, p.224). Most work about scientists is indeed about men (Hearn, 1998 p.786). The relationship between the use of machines in the work space and the construction of masculine identities is a well-studied phenomenon. Ulf Mellström has for example studied machines and homosociality (Mellström, 2003). As an extension of the homosociality of men and machines, David Nye discussed the meaning of the articulation of homosocial bonds as a way of signaling an affinity (Nye, 2005; also see Sheffield, 2004).

Gender and masculinity should be understood as performative and identities staged in the daily work among my informants, the physicists. As Anna Danielsson discussed in her study of physics students' identity construction and laboratory work, the making of gender is intertwined with the everyday practices within scientific communities. Masculinity does not necessarily need to be tied to biologically defined men and women, but is tied to acts of gender, sexuality and a performed sexual identity (Danielsson, 2009). In both Danielsson's and my studies, the informants' identities can be understood as identities formed through practice; which in my case concerns experimental work (Gonsalves, Danielsson & Pettersson, 2016).

In this study, I would like to highlight how physicists negotiate their identity work in relation to their professional work and their professional lives in relation to their experimental work. This analysis is based on the idea that masculinity is not only related to science and the way it is performed, but that, within the scientific

community, a relationship between masculinity, scientific culture and its practices are intertwined with career systems, private life and family. Given my background in ethnology, I interpret physics and the making of masculinity as a social and cultural process. Cultural contexts such as the laboratory and physicists can thus be understood as a process where masculinity is produced but also contested.

Ethnographic Fieldwork and Data

As an ethnologist I study cultural practices and meaning creating processes. The advantage of ethnographic fieldwork is that it produces a comprehensive understanding of the scientific environment under investigation. Laboratories are complex environments in their combination of humans and machines (Barad, 2003;2007; Lynch, 1985; Suchman, 1987). The ethnographer performs a translational act when analyzing the lab as a cultural phenomenon. There is a balance between an insider and an outsider perspective where the ethnographer becomes "the professional stranger" (Agar, 1980). Estrangement or de-familiarization remains the distinctive trigger of ethnographic work, providing a sense that there is something to be figured out or discovered during fieldwork (Marcus, 1998).

Through observations I can study how the laboratory and experimental practices are interlinked with physicists' identity work and the making of physics. The reason I chose following/descriptive observations instead of participant observation was my lack of training in physics. I conducted ethnographic fieldwork among the physicists during 2007 to 2009 at a university campus. A university laboratory is smaller than Big Science laboratories but may still maintain large experimental facilities like tokamaks and accelerators. Central for this case, was a building with devices and rooms for plasma processing, laser experiments and a huge hall with a workshop and machines and experimental devices.

The field work consisted of long term following observations and interviews with fifteen lab members in a specific laboratory. Two of them were women and thirteen were men. Four men were senior physicists, two men junior faculty. One of the women was a junior physicist about to complete her Ph.D. and already admitted to a post-doctoral position at another university, the other was a Ph.D. student. The other six interviewees were male Ph.D. students. I also interacted with members of another laboratory and with incoming guests who used the experimental facility at my specific field site, and conducted short interviews with eight physicists while at workshops and conferences that my informants attended.

During the first one and a half years of fieldwork I was present during ordinary working days in the lab and at the office on a regular basis. The physicists granted me access by giving me a magnet card and key to their buildings. I was also given office space with a desk, chair and internet connection. Beside the laboratory fieldwork, I sat in on seminars, conferences and research presentations at the local campus. During the last six months of fieldwork, I did follow up observations and interviews.

The observations I conducted can be defined as following observations. I did not consider myself to be a member of the physics community. Neither could I perform any advanced work in the lab. My only participation in the daily practices were, for example, helping physicists clean the lab, holding antennas to be stored, or sorting nuts and screws into their right cases. But while following the physicists, I observed them while they were building antennas and measuring tools, when they ran experiments, worked manually in their workshops, processed data and discussed research results. From the observations I took field notes. Due to my workspace among the physicists, I could sit down and read through the data on site.

A methodological challenge during the interviews was to make my informants reflect on gender. The interviews were conducted in a small conference room or in the informants' offices at the field site and lasted around 3-5 hours with semi-structured interview questions. Most interviews were conducted in one long sweep, including small breaks. However, for some people, it was hard to find several hours for an interview, so they were conducted on two or three different occasions, though not far apart. The list of questions included details about their work and practices but also about gender.

Beforehand, I informed the informants about the interview process and the style of an in-depth interview; while I had a set of questions, interviewees would be welcome to start or develop a thread they considered important in the interview context. The list of questions included biographical data, why the informant chose to enter physics, the informant's work in the laboratory, their view on careers, mobility and private life.

A question I wanted to raise was the lack of women in physics in general and within plasma physics in particular. To make gender visible became a challenge. A spontaneous reaction by the informants when asked "Why are there so few women in plasma physics?" was "I don't know. But I would love to know why", but they offered no reflection or explanation about why that was the case.

Thinking through the interview questions, I realized they needed to be altered, and instead asked the informants why there were so many men attracted to plasma physics. By changing the question, the informants started to make reflections on how boys and girls are treated throughout the school system, about experimental physics, men and machines and career trajectories and the daily experimental work. Instead of trying to understand gender and the lack of women in physics, I came to the conclusion that the data could be analyzed through masculinity as an analytical lens. The informant's reflection on why men are attracted to experimental plasma physics provided me with an explanation of why there were so few women within the field.

The fieldnotes and the interviews were compared through thematic analysis of the data (Riessman, 2007; c.f. Gray, 2000) and three interrelated themes emerged: gender, masculinity and the practice of physics. This specific group of physicists conducted basic plasma experiments in an almost 20 metre linear plasma device. A few of them also conducted fusion physics experiments.[1] The physicists worked at a

large university campus in the United States. Their daily activities took place mainly in two buildings. One consisted of offices and a few smaller experimental devices, the other housed the linear plasma device, from now on called The Device. It was located in a large hall in the cellar. Adjacent to The Device were rooms with a laser, and a data processing room. A smaller workshop was also nearby. At ground floor level a huge workshop took most of the space. There was an area for building smaller electronic components and circuit cards. A space for cutting tools, drills, saw machines, drill presses, sanders, measuring tools and more was frequently used. A large doughnut shaped tokamak[2] was located in a corner. It was not running at the beginning of my fieldwork, but was restored and used as time went by.

This specific lab is situated in an urban area with heavy traffic and close to a highway. Most people in the lab commuted to work by car. Some of the informants sometimes rode bicycles to the lab, despite the heavy traffic. Even though many of the informants lived in areas that were 30-60 minutes away by car, they were in the lab during the week and also during part of the weekend even though they were not running an experiment.

As the American anthropologist Laura Nader writes, an ethnographer can contribute to the literature by "studying up", conducting research on powerful institutions and among groups in our culture that enjoy influence, money, space and voice or are defined as influential in the economy, politics and the development of society (Nader, 1974 p.284). These groups are represented in many sectors of society and include the research community, both in the academy and in research and development in the private sector.

The number of "studying up" studies has increased during the last twenty years, e.g. in the expanding field of studies of science and technology. Researchers from anthropology and sociology have taken on the challenge of observing and interviewing people who are members of the research elite or enjoy elevated status in the academy in general (See Johnson, 2004; Krauss, 2005; Knorr Cetina, 1999). This is also the case with my own study, and added to that, also an aspect of men and masculinity among scientists.

MASCULINITY AND PHYSICS AS BOUNDARY WORK

Embodied Masculinity through Machines

Boundary work is a well-used concept when analyzing scientific contexts. As defined in Star and Griesemer (1989), the concept can be used to analyze social worlds where people interact and share a common goal. In their analysis of collecting and classifying vertebrates for a private collection in the US they show how different participants with standardized methods are able to carry out similar scientific task through shared methods.

Identity work can be described as a process where different gendered identities are under constant negotiation in relation to practices in science (Gonsalves, 2011). As it is hard to define a clear boundary between a person's professional and private life, negotiations between these spheres is interesting to analyze. As discussed

above, machines are not merely a material representation or a tool for scientists when conducting experiments. Machines are also carriers of gendered values and symbolic meaning. During fieldwork, I observed a close relationship between masculinity, machines and experimental physics based on the physicist's definition of what a "good physicist" represents.

The informants' definition of physics and the physicist can be understood as boundary work to distinguish themselves from other fields of physics. The informants made a distinction between what they considered were a "good" and a "successful" physicist. A successful physicist was defined as a person who was able to run a large facility, write successful research grants, communicate with external actors like Department of Energy, as well as attract users to the facility and coordinate research groups, as well as designing experiments and writing articles. During the interviews, a good physicist was described as a person who had strong practical skills in building machines and constructing tools for experiments. Given the size of the experimental plasma device used in the lab, the actual work with the device could be both heavy and dangerous. From fieldwork I observed, for example, laser and beam experiments as well as heavy lifting of steel plates.

Experiences that attracted significant status within the lab were the hands-on skills in the daily work with the large plasma device. Experimental physics was defined by the informants as work similar to a shop floor; dirt, grease and heavy lifting were considered to be a part of being an experimentalist. "I love to get my hands dirty" was a sentence repeated by interviewees, regardless of gender and age.

"Theory" was described by some senior physicists as "foolish" (Pettersson, 2011). Conducting experimental physics was defined as scientific research that was different from conducting theoretical physics. The skill to build machines was also related to the ability to do physical work. The description of the lab as a shop floor did not only reflect the dirt and the grease. The definition also aimed at the physical work that was considered to be a part of experimental physics and of building machines.

Among the physicists I studied, the experimental practices were equal to the definition of real physics. Certain aspects of plasma physics were talked about with typical connotations of hegemonic masculinities; practices as heavy, dangerous and dirty, were defined as the core of physics as science. They were also heavily masculinized (Pettersson, 2011; Velbaum, 2008). What was also striking was the overall lack of counter hegemonic reaction to physics as such or how physics as science was described (Pettersson, 2014). Devotion to the idea of the experimental physicist and experimental physics was not challenged.

During an interview, a female PhD student was hesitant to define gender as an issue in physics. However, she said, she was shocked by how her colleagues dismissed the idea of women as physicists when people thought she was not listening. She felt uneasy when she overheard conversations between her male colleagues regarding the physics lab as a place where no women should be present.

Since no one would tell her to her face that women were not able to conduct physics, it was hard to argue against such claims.

To talk about women's lack of capacity to understand science was considered not politically correct. Everyone in the lab was aware of that. To be outspoken about physics as a science dedicated to men was only seldom overheard. Thus, one of the senior physicists in the lab considered the lack of women in physics uncontroversial, both regarding their scientific knowledge and their practical skills. This was not discussed among the physicists, during work or lunch, but when being interviewed in a closed room.

The emphasis on practical aspects of experimental plasma physics can be understood as a way of embodying physics which was presented by the senior researchers and most grad students as manual work and an activity where physical performance was necessary. Manual and physical work was also something the physicists repeated in their daily conversations about physics. In these stories, heavy lifts, dragging steel and lifting magnetic coils were central elements when defining physicists. The stories were also central for physics, given how physics as labor and the physicist as the manually skilled worker in the boundary work, but also to define gender (Danielsson, 2010), and thereby also making physics as labor, skill and embodied knowledge a boundary work of masculinity.

As pointed out by Wajcman (2004; 2005) and Cockburn (1983), domestic technology mirrors constructions of gender and technology; the relationship between women and domestic technology and men and workplace technology emerged with the development of the engineering profession (see also Oldenziel, 1999). As a result, Wajcman writes, "muscles, skill, strength, dexterity, rationality and labor time became the preserve of men and important power resources" (Wajcman, 2006: 780). Wajcman's notion of the relationship between muscles, skills and strength together with labor point in a central direction for my analysis: through acts of science and technology, work is embodied. The identity politics among groups such as experimental physicists is tightly related to the experiments and its practice (Traweek, 1988; 1995).

The few female informants also pointed to behavior and language associated with "frat culture", including verbal attacks, regarding their sex, and their capacity to become good physicists. The "frat culture" analogy aimed at two specific problems. It was a correlation with the fraternity clubs, gender stereotypes and sexism, but also described a brotherhood and its "natural" relationship with physics and science (Cockburn, 1983). The environment for the plasma physicists can be described as an environment that still contains aspects of hegemonic masculinity. Here, it becomes crucial to analyze the meaning of "physics" and "real work" among the plasma physicists.

Gender division could be observed for example during the lab cleaning days, when the male Ph.D. students were organizing and cleaning measuring tools, taking the devices apart, cleaning the cathode, and thus learning how the device was constructed, while the female physicists brushed the floor and whisked the dust

away. This gendered division of labor reflected the derogatory language used to describe work in the physics labs. Doing work like a 'chick' or like a woman, often referred to the kind of menial tasks implicitly assigned to women that clearly carried less importance in the hierarchy of labor in the lab environment.

Around the Clock Scientists

Experiments do not follow office hours. As Traweek (1988) highlights, physics is a science where experiments need to be overseen both night and day. Experiments may run up to several days, and need to be carefully controlled, maintained and observed. That means that the physicist needs to spend many hours in the lab during evenings, nights and sometimes weekends.

Such a context of making data demands presence. To be available for coworkers and ready to maintain different parts in the lab was considered to be a sign of professionalism, according to informants. Experimental work does not run for itself, as one of the informants said. The statement aimed at the physicists' need to be practically skilled, but also to attend experiments, sometimes 24/7.

The image of the scientist as hero who sacrifices everything for the good of science is also a part of a gendered culture. Men in laboratories, working with great machines and getting totally absorbed in experiments is, for example, a persistent media stereotype (Erlemann, 2010). Devotion and time are accepted attitudes towards achieving the goal of conducting science and embody the scientist as hero (Shortland & Yeo, 1996; Milne, 1998). As the plasma physicists I studied worked in a lab with a large and expensive experimental device, they also had the responsibility to maintain the machine and to overlook the ongoing experiments, not only for their own experiments but for a large number of travelling experimentalists who need to use a specific facility at another university or research institute.

Beside the physicists who were working on experiments, a number of the physicists in the lab were also partly hired to maintain the Device. These physicists provided help for visiting researchers who were conducting experiments with The Device. With the maintenance duties, they also needed to be available for visiting physicists at inconvenient hours like evenings and sometimes weekends.

The conditions for conducting experiments and how that affected their private lives were a concern. The working schedule related to the size and the organization of the experimental facility. Having to travel to conduct research at a facility instead of having it at your home campus might seem inconvenient. On the other hand, a facility based at your own university and in your own laboratory might not always be convenient from the point of view of one's private life. One of the junior physicists in the lab had a previous experience going to another research facility 700 kilometers away from the home department. The work in that lab required longer stays away from home. It was really depressing, the junior physicist said, to be away from friends and home.

There are thus both pros and cons to being away from your home department and family when conducting experiments, a senior physicist emphasized when visiting The Device to conduct experiments. Since not all universities have large experimental facilities in today's context of experimental physics, it means that a visiting experimental physicist at a facility has to carefully plan the experiment; they go to a certain lab, conduct the experiment, get the data and then go home.

To work and conduct experiments at a facility in your own backyard might actually lead to more problems than having to visit other facilities. Being an around the clock physicist was more common before the development of larger university facilities or Big Science labs. It was more common with smaller facilities, spread out over many campuses. While such access to experimental facilities might be very practical and constant access to the machines and devices, a senior physicist said that from a private point of view, the small experimental machines were a problem; the machines "demanded" constant presence. With an experimental device, it created an opportunity to conduct experiments 24/7, but that led to a fragmented private life, according to the physicists. People working in those labs had constant bad consciences; either they renounced their partner and children or the laboratory, the experiment and the research group.

The presence of the experimental device demanded attention; its runtime was expensive and so was the equipment. When working as an experimentalist in a smaller lab at their home campus, they were risking becoming more of an around-the-clock physicist. And those physicists were more likely to have a problematic private life, one of the visiting physicists stated. He emphasized that more physicists were more likely to end up in divorce in smaller experimental facilities.

To fulfill and at the same time challenge a prescribed research persona, an ideal image of the experimental physicist was not easy, according to several junior physicists. Unspoken values were taken for granted, including the idea of the academy as an arena for competition and struggles for professional survival; but also the importance of putting science rather than your private life first. But even though there were outspoken ideals regarding the research persona and how to behave as an experimentalist, can these ideals be contested?

Contested Research Personas, Contested Masculinities?
Life Quality and Life Style vs. Career Choices

The close machine - masculinity relationship can be interpreted as a somewhat hegemonic and rigid image of the plasma physicists. Definition of how to conduct science as well as how to be a scientist was narrated in a framework that was not challenging the common discourse on academic work.

Even though physics as science and the life as a physicist were not explicitly challenged, counter hegemonic ideals regarding physics were articulated in contexts that were defined as separate from the academic aspect of physics culture. Alternative career paths or interpretations of what a physicist is were made backstage in private conversations and during the interviews. Narrations and practices of the experimental physicist as a hands-on and skilled labourer building

machines were naturalized in the laboratory. At the same time, the idea of a career outside physics was mentioned less openly.

As Daston and Sibum (2003) emphasize, the scientific persona is a combination of not only the individual or the institution. The scientist becomes carved out as a middle course between scientific biography and the scientific institution, and analytically makes salient the cultural identity that shapes the individual through collective ways of thinking, feeling, judging, perceiving, and working and puts into focus the relation between knowledge and the persona of the knower (Daston & Sibum, 2003).

The scientific personas among the physicists are defined both from the definition of the scientific field as well as each person's life history. Here, an analysis of scientific persona and masculinity is an important asset of analysis. Apart from knowledge and practical skills when conducting "real physics", you also needed a certain persona to be able to become a "real physicist" within the academic institution and in the laboratory.

Part of the expected scientific persona was the competitive environment. Outspoken aspects of the competitiveness in science were not considered controversial. On the contrary, the competitive environment was an ideal highly regarded among the physicists. The senior researchers were thus reluctant discuss the willingness to compete and to put an effort in physics among junior physicists (Hasse & Trentemoller, 2011).

Senior physicists in the lab pointed out that the quality of the physics students nowadays was not high compared to "when we were young". That meant physicists who went through higher education in the 1970s. Several senior physicists in the lab stated that physics has "lost" its attraction to the best students and concluded it was also affecting the quality of the Ph.D. students and physicists in general. This harsh judgment not only included what they considered the quality of the students in physics, but also their unwillingness to be part of the academic career competition.

Larger facilities are considered to have a better impact on the physicist's private life. However, most of the Ph.D. students I interviewed were reluctant to have a life in the academy and as a university-based physicist. There was a contradiction between this reluctance and their ideals regarding experimental plasma physics. A type of hegemonic masculinity is performed and articulated among the physicists when both conducting physics and defining physics as a science where building machines are essential. This traditional masculinity is however challenged through the junior physicists' ideas about quality of life and career choices. A problem, according to the head of the lab, was the younger physicist's demands regarding quality of life. Given the competitive system at American universities, there are few Ph.D. students who actually consider it is realistic to have an academic career, according to both senior and junior physicists. They described the competitive career path into which they were by necessity forced as a hazard.

After finishing your Ph.D., you probably need to embark on one or rather two post-doctoral fellowships, said one of the Ph.D. students. After that, you apply for an assistant professor position and eventually get hired. The problem, said the physicists, is the lack of assistant professor positions. This insecure career path was a reason for being hesitant about a life in the academy, but the physicists also emphasized the quality of life aspect.

Other values were emphasized, like having a private life and being able to negotiate with your eventual partner regarding career development. Most of the younger physicists stressed the importance of trying to combine a career with good quality of life which they described as both persons being able to develop their professional life. Senior and junior physicists also mentioned concerns regarding career choices. It was not up to the male in a heterosexual relationship to be the breadwinner anymore, they asserted.

Sexuality and the Making of Masculinity

As part of the identity work among physicists, staging hetero normativity plays an important role. The heterosexual norm is an undisputed marker. Earlier studies show that heterosexuality is considered to be a normal state in the sciences. The entire family with wife and children was not a controversial way of organizing science. A construction of the heterosexual scientist's masculinity was, according to Rose & Rose (1999) a stipulated role. Scientists were not only expected to perform the idea of "real men" in their profession, but also the idea of the real heterosexual man (Rose & Rose 1999: 134). Also, in science education and in popular culture, is the general understanding of the scientist as a hero, where men are ever present (Milne 1998; Cantor 1996).

The normativity of heterosexuality could be expressed in discussions, for example, about children wearing clothes appropriate to their gender. During fieldwork, I overheard jokes about one of the faculty's' small son picking toys with a "Disney princess". Two Ph.D. students were thrilled and commented about the boy picking a princess for a toy: "Oh, I hope this won't leave any bad influence. Perhaps he is affected later in life [lots of laugh]. You know, what will happen ten years from now, when he is fifteen, will it be possible to trace the cause of this"? [Laugh.] Choosing a Disney princess for a toy was considered to be so remarkable that a picture of the boy holding the toy was "a picture for graduation or something [laugh]"!

From the stories of the scientist's private life and the issue of conducting experiments, the idea of the heterosexual relationship was repeated and set as the normal state of intimate relationships. During field work, I overheard many conversations about weekend plans on Friday and the past weekend activities on Monday. Several of the physicists mentioned their wives and their girlfriends while referring to weekend activities.

As field work continued, I recognized that one of the physicists was never included in these conversations. As time went by, I also noticed that he never referred to his private life or to any family members. The silence intrigued me. Thus, the silenced

sexuality fits the image of the scientist as solitary, and is narrated over and over. Even in scientific biographies, the neutral, asexual scientist is portrayed, when an alternative sexual interpretation might be more relevant (Vogt, 2010).

Homosexuality or homosexual relations were not openly discussed. A person's private life based on a non-heterosexual relationship was not a topic in the lab. However, it had no clear association with the person's status as physicist. There were ways of transforming a non-normative status among the physicists if you can perform the right type of masculinity; masculinity performed in relation to the machines can compensate for lack of heterosexuality.

Sexuality or hetero normativity was not spoken about openly. It was - as with defining women as an inappropriate other - an unspoken and yet expressed norm. As part of the interview with the same physicist, I asked questions regarding his private life and how he was trying to organize the relationship between on the one hand physics and on the other life outside physics. It turned out that this specific informant had been living with a male partner for many years. There could be many reasons why this physicist was not included in the above-mentioned conversations, and yet he was fully included in the actual work as a physicist and was a person who was held in high esteem.

During a conference, I followed my informants as they were presenting posters, giving talks, and went to dinner. On the way to the restaurant, the group was talking and joking with each other. As I walked along with several of the physicists from "my" lab (there were people from other labs around the US as well who followed us), I turned to a physicist and asked him how he and his [male] partner were going with their house renovation.

As soon as I asked the question, the group went silent. Everyone stopped talking and went quiet. My informant answered my question in a cautious voice, talking briefly about the changes in the house and what they were planning to do. The silence continued and I felt myself extremely uncomfortable about having exposed one of the informants. Nevertheless, this informant was able to conduct physics through all the experimental practices and was regarded as a very promising scientist. "He is extremely talented", the head of the lab concluded. "Extremely talented" included work with different types of machines; designing, building, and maintaining but also changing equipment, running experiments, handling the data acquisition, analyzing the data, programming, and writing articles.

While certain sexuality was silenced and never made visible, it could be compensated by the act of making physics through machines. The sexuality could be traded by acts of masculinities through the making of physics. The informant not only had the required skills in physics but also other markers of masculinity; that of an athletic lifestyle. Sports activities were used as a marker, also by the head of the lab, who had an image of himself in an agile sport performer on his web page. Both performances of embodied physics and embodied masculinity, with a combination of academic skills and physical strength were valued. Sexuality, thus was silenced.

Masculinity expressed in relation to physics and machines is not dependent on a type of masculinity with heterosexual connotations. However, it is a masculinity that mirrors traditional or hegemonic aspects related to machines, technology, muscle power and danger. Within that form of masculinity, masculinity is made through the embodied knowledge of experimental physics.

Although other types of sexualities than heterosexuality are silenced and made invisible, the "right" ways of performing physics through masculinity is superior to sexual orientation. Experimental physics as conducted within the lab is labor still associated with men and men's activities, as the lab leader described it. That includes men, with embodied abilities to make physics.

Ambivalence

As discussed earlier, physicists are hesitant about an academic career in a competitive environment and how an academic career affects quality of life which is defined as the reason why the competitive academic environment is not considered to be a career option. The competitive environment and reward of getting published, receiving funding and a good position are not considered to be sufficient rewards.

Boundary work of masculinity and physics is made though junior informants defining physics as a future professional research career which lacks attractive prospects and therefore content. For the physicists, experimental physics is associated with muscles and machines. As the senior physicists identify a lesser interest in doing physics, there might also be an ambivalence about the interpretation of the conditions of how experimental physics is performed and academic competition in universities. In my informants' case, that may include an ambivalence about both masculinity performed in an experimental setting, and also gendered career traits, with an ideal of the devoted professor with little time for private life outside academia.

Junior physicists are reinterpreting the status of conducting science, but indirectly, they are also reinterpreting a masculine identity that has for long been a part of science. The ambivalence lies within areas directly related to the ideal images of the physicist's scientific persona as identity mark. The competition, the commitment and the career track are all interrelated to the scientific persona.

Ambivalence lies within how to interpret physics and the academy. Although the junior informants were not interested in a physics career due to the demands, competition and lack of quality of life outside work, they did not contest the idea of the academy. Within the context of the daily experimental practices, the informants did not try to contest the discourse on body, strength and muscles. Neither did they contest the idea of fierce competition or being extremely devoted to their profession, the experimental physicist. During fieldwork, none of the informants challenged the academic system or the structures per se. One junior physicist was

very much engaged in union issues, but that was related to the work load of Ph.D. students in relation to their stipends and fees.

The strategy for the junior physicists was to separate physics from their life aims. When in the lab and conducting physics, they accepted and shared the ideals and definitions of the core of experimental physics. They did not reject its embodied definition of physics or the masculinized ideals regarding physics as dangerous, greasy, dirty and heavy. But they rejected being a physicist committed only to the lab as part of an academic career. The defined relationship between masculinity and machines was not contested, not even by the few women interviewed.

However, competition within physics was not considered to be only negative. The level of competition was an ambiguous issue within the lab. Competition was defined as positive in several ways: might is right. All informants opposed any form of affirmative action. The general idea was that the smartest physics students survived the environment and the competition. To reject an academic career at an early stage was thus also to admit that you were not talented enough to compete and thus to survive within a competition driven academy.

CONCLUSION

At this research site, the ideal way of performing physics and thereby performing gender was an embodied and physical form of masculinity. Other ways of interpreting physics and the physicist's career path within the academy were not considered to be an alternative. Changes regarding private life and family relations were based on changes in experimental practices and the demands of getting access to large experimental facilities. This had an impact on who was attracted into physics education and further, who would be attracted to stay within the academy and thereby reproduce or break with both scientific values and gendered practices within physics. In this section, I will conclude the findings in the study and compare the results with current research in physics.

Since a principal argument of the study establishes a close link between the practical, hands-on work of the experimental physicists with masculinity, a question is raised to what degree this result holds for other branches of physics. As this study shows, there is a problem with women not being attracted to the field of experimental physics, and dropping out of physics. As discussed in an earlier study, forms of power and bullying, comments on laboratory skills and experimental practices started at an early stage for my informants. Not only practices within physics, but also social interaction between students at an advanced level, between Ph.D. students, and senior physicists and their views on women in physics, affect both recruitment in to physics and dropping out (Pettersson 2009; Pettersson, 2013; Gonsalves, Danielsson & Pettersson, 2016).

This study mirrors Traweeks' (1988) research on high-energy-physicists at all career stages which argues that the level of gender division produced in the laboratory also corresponds with the division of professions at a larger societal level. Traweeks' research indicates a gendered problem for physicists, where gender roles are created for both men and women. As problematized by Anna

Danielsson, by seeing gender as a women problem, female-friendly solutions are considered central for including women in physics. Danielsson shows that male students enjoy both abstract and practical work, whereas women have lower self-esteem in relation to practical work.

In work by both Danielsson and Gonsalves, students had gendered expectations in physics, where a "natural" relationship between knowledge, skills and masculinity were assumed as the norm. Danielsson's study showed that men also negotiate with their chosen discipline, physics. Gonsalves' work found that female physicists may gain recognition for hands-on fragile and finicky work, in a context where other practices were defined as masculinized.

Compared to other case studies that analyze the performance of masculinity in physics, this present study also confirms that learning about how to identify and become a physicist is constructed through (male) embodied practical machines and instruments design. This finding is important for physics education research, as it brings into relief the ways that masculinity is associated with various forms of laboratory work, and subsequently the kinds of performances that are recognised through physics practices.

In this study, the informants define a "real physicist" as a man working with machines. Practicing experimental physics as an embodied form of masculinity and having a career as physicist confirm and yet challenge each other. The ambivalence towards a contested masculinity is framed by a discourse on physics as embodied knowledge. As physics is one of the sciences where women are still in a significant minority, the making of hegemonic identities in relation to the challenged masculinity is even more interesting.

Compared to the results of Wajcman (2006) for example, experimental physicists take an oppositional position compared to calculating, analytical physicists. In this study, the informants favor hands-on experiments versus theory, and is an example of how physics as a field contains differences and variations. However, the masculinity performed in the lab in my study, physically and verbally, is close to a hegemonic masculinity that can be associated with blue collar work. The emphasis on the machines, the muscles and the physical efforts when conducting physics is not necessarily related to intellectual work. The physical masculinity related to the labs and the experiments was also a staged masculinity.

A type of hegemonic masculinity is performed and articulated among the physicists when both conducting physics and defining physics as a science where building machines is essential. This traditional masculinity is however challenged through the junior physicists' ideas about quality of life and career choices. As shown for example by Damaske et. al (2014) and Ecklund & Lincoln (2011), early career scientists in other disciplines face similar problems. What thus is unique to experimental physics, is the physicist's dependency on largescale, expensive experimental devices, which tie the physicist to a specific laboratory and therefore also make them dependent on specific research sites. This, in turn, affects the physicist's flexibility regarding career choices and how to form private life.

Keeping up with a strong scientist identity was emphasized by both senior and junior physicists. The plasma physicists represent a type of double hegemonic masculinity front stage. The scientific ideals are in themselves strongly gendered with the ideal image of the scientist. These ideals are closely related to the idea of the scientist as a hero or a conqueror. But it is contested.

ENDNOTES

1. There are four matters - solid, liquid, gaseous and plasma. What separates these four matters is the character of the bonds that hold the constituent particles together. Plasmas can be generated by ionization processes that raise the degree of ionization much above its thermal stability value. One of the features that separates the behavior of plasma in relation to the other three matters is the existence of "collective effects". Given a range of electromagnetic forces, each charged article in the plasma interacts concurrently with a significant number of other charged particles. This activity results in significant collective effects dependable for the affluence of physical phenomenon that takes place in plasma, (see Bellan, 2008; Bittencourt, 2004).
2. A tokamak is a doughnut shaped reactor with a toroidal magnetic field. Tokamaks are used to produce thermo-nuclear fusion reactions, see for example Federici et.al., 2001.

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