The Status of Women in Physics – An International Meeting on What, Why, and How to Change

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I. Too Few Women in Physics

The number of women in physics is low, in the U.S. and globally, and has been increasing only very slowly. The dearth of women in physics is an urgent concern. The best physics demands the best brains from more than just half of humanity; excluding women weakens physics and all of science. Just as important, women deserve the same opportunity as men to have a stimulating and rewarding career in physics. Also, a more scientifically literate public, one that includes girls and women educated in physics, will lead to more public support of science.

II. Organization and Event Details

On March 7-9, 2002, the International Union of Pure and Applied Physics (IUPAP) held an International Conference on Women in Physics at the UNESCO headquarters in Paris, France. This meeting, the first of its kind, was organized with two major purposes in mind:

(1) to understand the severe under-representation of women in physics and related fields worldwide, and

(2) to develop and implement strategies to increase the participation and representation of women in physics.

A large number of international institutes and organizations sponsored the meeting, including major U.S. federal funding agencies, the American Physical Society and U.S. national laboratories. These organizations united in recognition of the fact that an understanding of the status of women in physics will likely provide insights and approaches that could be applied to other fields and professions where women are inadequately represented.

The conference was motivated by the fact that the global scientific work force is under-utilizing a large percentage of the available talent pool. Although the situation differs widely from country to country, there is a remarkable consistency in one sobering pattern: the percentage of women in physics decreases markedly with each step up the academic ladder or with each level of promotion in industrial and government laboratories. The presence of women physicists in the upper echelons is critical for the health and diversity of the field. Since a number of physics faculty positions should be coming open as faculty hired in the sixties and seventies retire, it was especially timely and important to have an international forum to address the under-representation of women in physics.

More than 350 participants in delegations from 65 countries attended the conference. The delegates came from academic institutions, national laboratories, industry, and other sectors. The U.S. delegation was sponsored by the American Physical Society and

selected by the CSWP (the APS Committee on the Status of Women in Physics). Its 12physicists represented a diversity of backgrounds and expertise and had expressed a firm commitment to following up on recommendations that emerged from the conference.

This U.S. delegation's report on the IUPAP meeting serves as a means to restart a national dialogue about the status of women in physics in the U.S.

The format of the IUPAP conference included significant input and feedback from the participants, who brought an enormous diversity of backgrounds and issues to be addressed at the meeting. As an introduction to the status of women in their countries, each delegation submitted a 2-page contribution for the proceedings, as well as a poster on the topics concerning women in physics in their country. The conference itself included plenary sessions with invited speakers and small group discussions on six specific topics

: 1) Attracting Girls into Physics,
2) Launching a Successful Physics Career,
3) Getting Women into the Physics Leadership Structure Nationally and Internationally,
4) Improving the Institutional Climate for Women in Physics,
5) Learning from Regional Differences, and
6) Balancing Family and Career.

The discussion groups generated many ideas for improving the status and representation of women in physics. These were distilled into a set of resolutions ratified by the conference, plus an additional set of more detailed recommendations for use in participants' home countries as appropriate. Specific resolutions were directed at individuals, schools, universities, research institutes, industrial laboratories, scientific and professional societies, national governments, granting agencies, and the IUPAP itself. These consensus guidelines will be used by individual delegations to stimulate change in their own countries, with the exact language modified according to the culture and conditions of each country.

The resolutions and recommendations represent a portion of the key results from the IUPAP conference. IUPAP also plans to provide extensive on line resources related to women in physics, including the materials from the conference, a database of women physicists worldwide, opportunities for global exchange and collaboration, and links to international organizations for women in physics and science, as well as to other international institutes and conferences on related topics. (Further information may be found at http://www.if.ufrgs.br/~barbosa/conference.html).

III. Findings, Results, and Highlights

Prior to the conference, the IUPAP Working Group on Women in Physics, in collaboration with the Statistical Research Center of the American Institute of Physics, undertook an international benchmark study on women in physics. They collected demographic information from more than 800 women in 50 countries. The data included individual experiences and concerns as well as education and employment histories. Results were presented at the conference and are available online (Ivie, Czujko, and Stowe, http://www.aip.org/statistics).

Two-thirds of the women surveyed had Ph.D. or higher degrees. Three out of four respondents said that they would choose the path of physics again, although the same fraction of women felt the situation for women physicists in their country must be improved. By its very nature, the survey did not include women who left physics, or those who never pursued it. Thus, it is worth noting, we do not have data concerning the very women who must be brought into and/or retained in the profession if the numbers are to change significantly.

The statistics show that women around the world face similar barriers to their success in physics. Even in countries where it is as common for girls to study physics as for boys, the number of women physicists drops sharply with advancing level. At the top of the profession --- meaning senior faculty and directors of research institutions --- women are typically only a few percent or less of the total. To a large extent, the absence of women from physics is an invisible problem; it is not commonly discussed in the international physics community, and few resources are devoted to improving the situation.

The large variations from country to country, and in particular, the 50/50mix of young men and women at the undergraduate level in many countries, indicate that there are no intrinsic intellectual barriers to women's participation in physics. Rather, the barriers must somehow be cultural, i.e., related to societal norms and educational practices in the individual countries.

The conference identified some critical factors leading to the low representation of women in physics throughout the world. First, societal and individual family pressures often dissuade women from becoming or staying involved in physics careers. Both the survey data and the conference discussions made clear that support from women's families, husbands, teachers, advisors, and colleagues is crucial in attracting women to physics and keeping them in the field. Second, the long apprenticeship period in some countries encourages the disproportionate attrition of women in going from undergraduate and graduate studies to permanent positions in their sub-fields of physics. In particular, the "post-postdoc" phase appears to be the most leaky stage of the pipeline, regardless of the greatly differing representation of women in the various countries. Many delegates speculated that this was because of the overlap of the early-career years with the peak marriage/childbearing years, and because of the requirements for frequent relocation and travel.

Third, two serious concerns for women in physics across almost all nations were the dual career or trailing spouse problem (because most women physicists are married to other physicists or scientists), and balancing career and family. These issues tend to affect women's careers far more than men's, with women physicists reporting broken or commuting marriages, and deferred or no childbearing. (From the AIP report, two-fifths of respondents had no children, with one-fifth of those older than 45 years having had no children.) Many conference participants emphasized the importance of choosing one's spouse to ensure mutual understanding and support of each other's careers, and equal participation in family duties.

It is worth noting, however, that family issues cannot be the major barrier to success for women already in physics. For one thing, women without children do not appear have more success in physics than do women with children. For another, countries with strong family support systems(daycare and maternity leave), like some Scandinavian countries, have in fact one of the lowest representations of women physicists. Finally, women are

present in higher numbers in biology, medicine, chemistry, mathematics and other very demanding professions --- there is nothing specific to physics about the conflict between work and family. Still, at least one study has showed that men in physics with children tend to have more influential and well-paid jobs than men with no children, whereas the exact opposite is true for women physicists, showing that male physicists are directly rewarded for factors that their female counterparts are penalized for.

Fourth, women have little exposure to physics early in life; many societies believe that physics is not for "normal" people, much less for women. In addition, there is a general lack of appreciation of the usefulness of physics and a lack of awareness of the excellent job prospects for physicists and specifically for women. These issues, complicated by the fact that young women lack role models and female peer groups in physics, lower the numbers of women in physics in very early stages of education and begin to explain why physics has so many fewer women than sciences with similarly demanding lifestyles, such as biology or medicine.

Fifth, nepotism (the support of one's own students) and "cloning" (the selection and nurturing of students who resemble the professor) lead to the exclusion of women in male-dominated environments, of which physics is one of the most extreme examples.

Sixth, the lack of transparency in recruitment and hiring processes tends to work against women. Shifting or poorly articulated standards for hiring and promotion lead to uneven reviews, which are particularly detrimental to those without strong advocates within the system. These inequities can also serve as a deterrent, making science far less attractive for women.

Seventh, sexual harassment and overt discrimination strongly discouragewomen from pursuing physics and related fields. While perhaps rare, suchan event is devastating when it occurs.

Together these issues begin to explain the dramatic under-representation of women in physics relative to other scientific fields. At the IUPAP conference, much attention was paid to concerns about balancing career and family, including childbearing and the two-body problem, but it was also noted that these issues are common to women pursuing any demanding career. So why are women better represented in other scientific and technical fields than in physics? A closer examination of those factors that are particular to physics must be undertaken. Both the structure of physics education and the "chilly climate" for women in physics may be contributing factors, and indeed may be coupled. Simply increasing the number of women in the physics educational pipeline will not improve the professional situation if women continue to leave the field at a high rate at each juncture in their careers.

When women are represented at all levels of the decision making, many of these issues are effectively addressed, a point made decisively by U.S. professor of biology Nancy Hopkins about her institution, the Massachusetts Institute of Technology. Sustained cultural change occurs when women are fully integrated at all levels in an institution. This appeared to be the case in France, for example, where representation of women is much better than in the U.S., and where the presence of women in leadership roles is seen as commonplace. When women are marginalized and when a culture is not under pressure to change, the aggressive, competitive, non-collaborative atmosphere that some call "combat physics" can prevail.

IV. Across Many Nations

The IUPAP conference revealed regional differences arising from social, cultural, and economic considerations. Although there were no clear pan-national solutions, an ambitious first step in that direction was the identification of common deterrent factors, as well as of the differing needs of women physicists around the world. For example, marriage and childbirth occurred far earlier in developing relative to developed countries. From the AIP report, about one-third (one-fifth) of women physicists in developed (developing) countries are not married, with about 38 percent (60 percent) of marriages occurring during their education. There were also significant differences in the timing of having children. The percentage of women physicists in developed (developing) nations who made the decision to have their first child in school, after their final degree, or to have no children was respectively 13, 34, and 53 percent (40, 32, and 28 percent).

There were some socio-statistical surprises. Scandinavian countries, whose employment systems reduce some of the family-related barriers to women, nevertheless have some of the lowest female physics Ph.D. rates. Several countries stand out as having large undergraduate enrollments in physics, notably India, Iran, and Italy. In India there are roughly equal numbers of men and women physics students through the Master of Science level. Iran had the highest percentage of female college-level enrollment in physics, whereas Sweden was almost last in the world. In several developing nations, women were free to use their maiden name on their publications but, perhaps surprisingly, in a well-developed country like Belgium, women physicists are required to use their husband's last name on their publications. It was also found that developing nations often led developed ones in providing flexible working hours and state support for couples trying to balance the needs of family and career.

V. Recommendations

A primary focus of the conference was to articulate ways to create a better future for women in physics --- a future in which the physics culture is more inclusive of difference, whether it be gender, race, or class. Some proposed steps to achieve this future are listed here. (These are meant as possibilities rather than a complete set of recommendations, and they are not expected to be applicable in all situations.)

1) Recognize the positive benefits of a diversity of perspectives to physics as a discipline.

2) Include women in the power structure, to help make the decisions that shape the field.

3) Ensure that key decision-making processes are transparent -- i.e., policies are well-known and outcomes are clearly reported. Key decisions include those related to hiring, salary, promotion, resource allocation, peer review, and speaker selection.

4) Work for the positive portrayal of physics and physicists. Increase the visibility of women physicists in the media and press, and in the next generation of physics textbooks.

5) Ensure a grant system and academic path that do not discriminate against women. In regions or sub-fields where the numbers of women are particularly low, institute special incentive scholarships for girls and awards or prizes for women.

6) Abolish a source of age discrimination by using academic age (years since Ph.D.) rather than biological age in competitions for prizes, positions, and grants/fellowships.

7) Recruit more women into national and international collaborations.

8) Emphasize the value of doing physics early in science education. Improve physics teaching, and provide talented enthusiastic physics teachers for schools.

9) Encourage interaction between universities/labs and schools.

10) Provide mentoring programs for young girls in physics. Counsel parents, teachers, and career counselors to encourage girls to pursue physics.

11) Establish flexible career paths from the Ph.D. through the tenure phase in order to integrate the demands of family and career more easily. Provide an option to stop the career clock while women (or men) are preoccupied with family. Organize flexible grant structures that can adjust to non-traditional career paths. Possibly offer permanent positions earlier to women.

12) Provide convenient and affordable day care. Make work-related travel easier during the years when children are young.

V. Conference Outcome

In addition to the highly informative and eye-opening aspects of the conference, the IUPAP delegates shared a sense of excitement and solidarity, generated by the presence of so many outstanding women physicists. Many delegates, men and women both, described how empowering it was to have an international forum in which to discuss the integration of their love for doing physics with their values and goals as human beings and as members of society. Despite the fact that most of the women had overcome severe obstacles in order to reach their present positions, they communicated a sense of hope and a positive vision of the future, with a shared message of "Let us do physics: as women!"

See http://www.if.ufrgs.br/~barbosa/conference.html
A summary of the IUPAP conference may be found in the May 2002 APS News

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