WOMEN IN ASTRONOMY: THE STUDENT PHASE

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ABSTRACT

National data on the gender distribution of astronomy students shows large losses of women compared to men at the university levels. Examination of the astronomy department at one institution reflects the national trends. It is apparent that women actually leave doctoral programs in disproportionate numbers compared to men, a fact which can be addressed by individual departments. We discuss the major social factors contributing to these phenomena, termed micro-inequities, in both group and interpersonal situations.

1. INTRODUCTION

The small fraction of women in science, including astronomy, results from the attrition of women from scientific fields at all stages. In the physical sciences, there is no doubt that this attrition rate is highest during the years of formal education, namely grade school through graduate school. Since the former is beyond the scope of this meeting, we will focus on the undergraduate and graduate student experience. It is obvious that this educational stage is crucial in determining the number of women who pursue professional careers in astronomy. However, we note that the social dynamics that we discussed during this workshop are broadly applicable to all levels of the female student experience and beyond.

2. NUMBERS OF WOMEN STUDENTS

What are the facts regarding the gender distribution of astronomy students in higher education? In this section we present data from the National Science Foundation (NSF) and American Institute of Physics (AIP). These statistics reveal the numbers of women undergraduate and graduate students relevant to astronomy in recent years. We also examine the graduate student population at one institution, the University of Arizona, in view of the national trends.

2.1. Women Graduates in Astronomy and Physics

Figure 1 presents the recent evolution of the fraction of female bachelor's degree recipients in physics and astronomy. These results were computed from data compiled by the U.S. Department of Education.[1] Figure 1 reflects the common knowledge that astronomy does attract a greater proportion of women than physics as a whole. However, since over half of astronomy graduate students were undergraduate physics majors, compared to roughly a third who majored in astronomy,[2–5] the statistics for

physics bachelor's degrees are very relevant to astronomy. Furthermore, since statistics for astronomy are usually plagued by the uncertainties in small actual numbers, it is instructive to examine the trends in physics.

Encouragingly, Figure 1 does show an increase in the proportion of women receiving bachelor's degrees in the two main fields prerequisite to astronomy graduate school. Figure 2 shows the evolution of the same distribution in actual number of graduates, with total numbers represented by the solid lines, and male graduates by the dotted lines. The physics population does show a progressive separation between the two curves, reflecting a real increase in proportion of women. On the other hand, the astronomy curves (multiplied by 10 on this scale) maintain a virtually constant separation. This implies that the increasing proportion of female degree recipients shown in Figure 1 is largely an artifact due to the overall decrease in total numbers of astronomy bachelor's degrees over this period, as also discussed by Billard.[6] The trend of greater consequence to professional astronomy is that of undergraduate physics, which shows a true improvement in numbers of women; however, the rate of increase is slow, only about 5 percentage points over the decade.

Figures 3 and 4 show the corresponding data for women obtaining master's and doctoral degrees in astronomy. Again, inspection of Figure 4 shows that the real increase in numbers of women graduates is unimpressive, despite the similarity, compared to Figure 1, of any trends inferred from Figure 3. Encouragingly though, the fraction of women master's degree recipients is similar to that of the bachelor's degrees.

A matter of great concern is the fact that the proportion of women doctorates is consistently less than for the other degrees by about 5 percentage points. We therefore have a significant attrition of women between the undergraduate and doctoral levels, a fact that can be addressed by college and university astronomy departments. More importantly, statistics from the AIP show that in the last 4 years (academic years ending 1988–1991), first-year women graduate students in astronomy proportionately outnumbered women doctorate recipients by an average of 25%.[2–5] This strongly suggests that the disparity in bachelor's/master's degrees and doctoral degrees is largely a result of women actually leaving Ph.D. programs. The most recent survey results, for the 1990–91 academic year, show that women comprise 25% of first-year graduate students, 20% of all astronomy graduate students, and 16% of doctorate recipients.[2]

2.2. Case Study: the University of Arizona

We consider the specific case of the astronomy department at the University of Arizona, which offers a terminal master's degree and doctorate. There is no master's degree enroute to the Ph.D., a fact which should be kept in mind when comparing M.S. statistics with the national data. This is one of the larger top-ranked departments, having 31 teaching faculty, 20 non-teaching research scientists, and 7 postdoctoral scientists in 1991.[7] These include 3 women faculty, no women non-teaching research scientists, and 3 women postdoctoral scientists. It may be relevant to note that there are other large astronomical research institutions in the local environment, including NOAO and the planetary sciences department. According to statistics on the astronomy graduate program compiled by Schmidt, McLeod, & White,[8] the mean size of entering classes since the inception of the graduate program in 1960 through 1991 is 6 students.

Figure 1. The fraction of women bachelor's degree recipients in physics and astronomy over the decade from 1976–1986. The solid and dashed lines are simple linear fits to the data for physics and astronomy graduates, respectively.[1]

Figure 2. The actual numbers of physics and astronomy bachelor's degree recipients over the decade from 1976–1986. The data for astronomy graduates are multiplied by a factor of 10 for comparison on this scale.[1]

Figure 3. The recent fractions of women master's and doctoral degrees in astronomy. The dashed and solid lines represent simple linear fits to the data for master's and doctoral degrees, respectively.[1]

Figure 4. The actual numbers of astronomy master's and doctoral degrees in recent years.[1]

For the entire existence of the Arizona graduate program from 1960 to 1986, Schmidt *et al.* report that women comprised roughly 11% of entering graduate students, but only 5% of doctoral graduates. In actual numbers, these were 17 among 158 total entrants, and 5 among 98 total doctoral graduates. The more recent years were not included in these computations since entrants from 1987 are still enrolled in the program. The data also show that while significant fractions of both men and women discontinue their studies in the doctoral program, women are less than half as likely to obtain their Ph.D. as their male cohorts. On the other hand, 28% of the master's degrees were awarded to women, showing that the dearth of women Ph.D.'s was balanced by a relative plethora of female M.S. recipients. In fact, women are proportionately 3 times *more* likely to obtain a master's degree than men. Given the overriding importance of the doctoral degree in attaining professional research positions in astronomy, the lower fraction of Ph.D. women has obvious consequences for the postdoctoral population and beyond. Clearly, it would be a severe disadvantage to maintain such a pattern with lower numbers of women doctorates if women are to achieve full representation at all ranks in the field.

With regard to the most recent entering classes at the University of Arizona, since 1986 the proportion of women has improved dramatically. Compared to an 18% fraction over the decade from 1977–1986, female first-year students in the last 5 years (1987–91) numbered 14 among a total of 34 students, or 41%. However, the corresponding proportions of actual students at the beginning of 1992, who would be the student body expected to reflect these numbers, consisted of only 10 women among 30 students, or 33%. Although the numbers involved are small in any single department, we believe these patterns are not unusual. The case at the University of Arizona is consistent with the AIP data shown above, reflecting a higher attrition rate among women graduate students compared to men.

2.3. Foreign Women

If we are to correct the lack of women scientists in the United States, it is also important to examine the proportion of foreign students included in the statistics of women graduates from U.S. institutions. Ellis & Mulvey[9] tabulate the number of women minorities graduating with physics degrees from American universities in 1988–89, by citizenship and gender. Unfortunately, these data do not include the number of non-minority foreign students, but this would presumably scale similarly to the minority foreign students. The data show that it is at the graduate level that the numbers of female foreign students significantly affect statistics of women obtaining degrees. For the year 1988–89, foreign minorities alone comprised 41% of all women master's degrees, and 35% of all women doctorates. On the other hand, the corresponding proportion for women bachelor's degrees is a mere 3%. In part, the high figures reflect the higher fraction of foreign graduate students in physics. Considering a typical study program of 2 years for the master's degree and 5 years for the Ph.D., the proportions of all foreign, first-year, physics graduate students in 1986–87 and 1984–85 were 43% and 39% respectively. These data suggest that foreign graduate students consist primarily of minorities, and also that foreign women students have a lower attrition rate than their American counterparts.

To evaluate the significance of the foreign graduate women in astronomy, the mean fraction of total foreign astronomy doctorates is 29% over the last 4 years.[2–5] Based on the situation in physics, we may then expect roughly one quarter of female doctorates to be foreign citizens. Indeed, inspection of the graduate student body at the University of Arizona shows 2 foreign students out of 10 women graduate students. Clearly, these data diminish the pool of female job candidates in the United States. We emphasize, however, that we are in no way condoning curtailing of opportunities for foreign women students, but rather an improvement in the education of American women.

2.4. Women Undecided on Career Choice

The data presented above show that significant fractions of American women pursuing higher education in astronomy and physics do not complete the degree programs leading to a professional research career in astronomy. Since this attrition occurs at the college and university level, the problem can be addressed by individual teaching departments. Women students tend to be undecided with regard to career choice more often than men, at both the undergraduate and graduate levels. In 1987, of those students planning a major in science or engineering, 12% of women freshmen were undecided in career choice compared to 7% of the men.[1] Similarly, the survey of graduates who received physics bachelor's degrees in 1988–89 shows that of the 128 graduates who were undecided about their next career step, 24% were women even though women composed only 16% of all physics bachelors.[10] Both data sets suggest that women are over 1.5 times more likely than men to be undecided about their career choices. We find it probable that many of the women lost at the graduate student level may be found in these "undecided" categories, where it may still be possible to encourage the continuation of their scientific careers.

3. MICRO-INEQUITIES

What causes women to leave astronomy, and science in general, in disproportionate numbers? In recent years, the concept of *micro-inequities* has been introduced to describe subtle aspects of an environment, whose cumulative effects may significantly degrade a person's comfort level and self-esteem in that environment. These micro-inequities may manifest themselves in the behavior and speech of people propagating this subtly hostile environment, or they may take other forms affecting the physical and social workplace. In this breakout session, we concentrated on the personal behaviors contributing to the "chilly climate" for students.

We set out, in our discussions, to identify the context in which micro-inequities occur and recur within a student's daily experience. The precise manifestation of these inequities varies from one situation to another and, consequently, so do the effects on any one student. The cumulative effect often results in the long-term erosion of self-esteem which, in turn, contributes to women students of astronomy leaving the field. The goal is to prevent this devastating situation from occurring by identifying the problem before it escalates and by responding quickly to mitigate the consequences.

It is vital for students to identify specific micro-inequities as they experience them because becoming aware that a problem exists is the first step towards counteracting it. It is as a student that one first experiences the situation but unless one realizes what is

going on, the effects will accumulate. Also, students become teachers before long and therefore play a crucial role in changing "the system" so that micro-inequities do not continue to plague generation after generation of students. It must be noted that the problem is exacerbated by many macro-inequities such as the lack of accountability of individuals and institutions in academia. Therefore, in the breakout session, we focused not only on student awareness but also on student empowerment.

Most of the participants in the breakout session were women students (undergraduate and graduate). Several male and female post-docs and research scientists were also present. Very few faculty members attended. This was somewhat unfortunate because student concerns need to be addressed by the astronomical community at large if the situation is ever to change. Perhaps it is a signal that students will lead the way on this issue.

We employed the techniques outlined in a workshop that was developed by Priscilla S. Auchincloss and Arie Bodek, physics and astronomy faculty members at the University of Rochester.[11] The purpose of this workshop was to improve the "chilly climate" in the classroom for women, minorities, and other non-traditional students.

In this breakout session, we focused primarily on the "chilly climate" for women students by concentrating on two typical scenarios. One was that of a group interaction taking place in a classroom or at a department colloquium. The second was an interpersonal interaction of a student with another student, an instructor, or an academic advisor.

3.1. Group Scenario

We addressed the group interaction first. As an illustrative example, we introduced the following scenario:

> D was strongly motivated in her study of astronomy, and she was confident of her ability. Her questions during lectures sometimes went beyond the "basics." But she noticed that the lecturer often replied to her with "Let's save these questions until later." Then, when a male student asked a similar question, the speaker would take the time to answer him directly, saying, "That's a good question..." D wondered if people thought she was showing off or being too outspoken.

Many women students could relate to this experience. Many felt that they had often been overlooked or ignored. In short, they were treated as if they had been invisible. This phenomenon is ironic because these same students also expended a great deal of energy dealing with the consequences of being a visible minority. They spoke of what it is like to be constantly in the spotlight. The women were often stared at in class and asked out by male classmates. At department colloquia, women students were asked more often than men to set up the refreshments. The seemingly contradictory state of being visible and invisible simultaneously is something that is difficult, if not impossible, to appreciate unless it is personally experienced.

We also discussed the transition from college to graduate school. It is in graduate school that most scientists face for the first time the challenge of teaching. It was generally acknowledged that an awareness of the difficulties one experienced in college

can be used to create a very different kind of classroom from the one to which many of us are accustomed. Women who had attended women's colleges seemed to have a more positive overall experience than those who attended co-educational programs. The transition period into graduate school, however, was sometimes felt more keenly by those who came from women's colleges since they were not used to being in the minority.

Many forms of exclusionary behavior occur at department colloquia as well as in the classroom. We discussed the importance of assertiveness in these situations. While students agreed that this was an issue, they pointed out that they were eager to be challenged. What they objected to was the ineffective manner in which many instructors and speakers contribute to the isolation of women students by rarely calling on them, by ignoring their comments, or by condescendingly answering their questions. Students in the discussion group felt that instructors often fail to take a more active role in breaking down typical patterns of behavior in the classroom. The same could be said of those who introduce colloquium speakers. They too could take a more active role in moderating the scientific discussions. There was a general consensus that establishing an interactive environment is a significant first step towards reversing the situation. Positive intervention was viewed as necessary to achieve this goal.

We asked the group to consider the ideal environment in which to learn. People felt that the goal would be to create a supportive environment in which women are challenged just as often as men to ask questions, to solve problems in front of the class, and to express their ideas. The vision was of the group as a community in which the participation of all the group members is actively solicited by the instructor or speaker.

3.2. Interpersonal Scenario

We then explored the interpersonal interaction. As an illustrative example, we introduced the following scenario:

> When Z came to Steve for help, he appeared self-assured but did not bother to understand the nature of her question. He just solved the problem quickly and left it up to her to look at the solution on her own time. Sometimes he used words that she did not understand like, "The canonical way to solve this problem is..." He gave the impression that if one did not understand the material right away, it was because of stupidity. When Z pointed out an equation that she didn't understand, he said, "But this is so simple," manipulating the variables with incredible speed. Z finally gave up and told Steve that she understood the material, even though she didn't, in order to make him feel that he had explained it and not appear stupid herself, and left.

As in the previous discussion, similar types of negative behavior resurfaced. Students still were treated in a condescending manner in individual interactions with a T.A. or an advisor. Unfamiliar jargon was used in giving the explanation. The explanation was stated rapidly without any concern for whether the student understood what was being stated. In laboratory classes, when a woman would ask a question on how to do

something, the male student partner or the T.A. would take over. This trend would recur in problem-solving sessions with some male students. Clearly, this behavior does not happen with all instructors or all students. The point is that a disturbing and significant trend does exist and we can take action to reverse this.

It was disturbing to hear that many students were treated as invisible even in instances in which very few people were involved. Students related experiences in which they would make a comment which would be ignored only to see the idea be presented a few minutes later by a man and, at this point, be heard. Women were sometimes left entirely out of a conversation because the conversants assumed that these women would not understand what was being said.

We also discussed the marginalization of students. This does not result from any one event, but is rather the product of many forms of exclusionary micro-inequities. Sometimes the behavior might be due to oversight. This can happen if an advisor neglects to invite her or his student to dine with a colleague who might be visiting the lab or giving a talk. The behavior is also often subtle. It can happen when a student points out an inappropriate (*e.g.,* sexist) comment or action and then finds herself suddenly labelled "humorless," and placed in "the witch/bitch trough."[12]

3.3. Action Items

In our discussions concerning both the group and interpersonal interactions, we identified three basic types of micro-inequities: the condescending treatment, the invisibility treatment, and the spotlight treatment. We summarized ways of improving the environment with the following list of "Do's":

- Do express confidence in a person with questions and convey that you understand the question or complaint.
- Do actively solicit each person's participation and make eye contact with everyone in the room.
- Do treat each individual as a professional and equal member of the group.

An awareness about the "chilly climate" in science is building. Across the U.S., students have responded to this reality by becoming active in changing the academic environment. Students have founded support groups, started seminar series in which students give science talks to other students, and developed workshops in sensitivity training. The next step is to build an international support network, for it is important for the various groups to communicate among one another.

One of us (JRF) has compiled a directory, entitled simply, "Women's Groups," which was distributed at this meeting. This document contains descriptions of various groups and serves as a "Yellow Pages" for organizations addressing the concerns of women in astronomy and related disciplines. The directory complements networks such as the AASWomen and WISENET electronic bulletin boards, creating a powerful foundation for change.

4. CONCLUSION

We have demonstrated with demographic data that women leave astronomy in greatly disproportionate numbers during the student phase of their careers. The surprising constancy in the number of female astronomy students shows that we cannot afford to be complacent about the recent increase in the proportion of women. In earlier centuries, when astronomical research was not conducted primarily in academic institutions, women contributed to astronomy in proportions similar to today.[13] The shifting of the discipline to the institutional realm appears to have excluded women along the way, due to institutional prejudice and micro-inequities. There are many interpretations for all the information about women in astronomy, and further debate and discussion on these topics will clarify the specific problems that need to be addressed. In any case, it is clear that we must work more aggressively in academia to improve the academic climate for women.

The effort must be extended by everyone, faculty and students alike, if the situation is ever to change. The discussions in this breakout session dramatically indicated that we, the astronomical community, must take time to simply listen to students as they describe their experiences. There is a dangerous trend in the community to tell a woman what "her problem" is. For instance, we often hear that students, especially women, need to be more assertive. While many students in the discussions felt that this was a relevant issue, most felt that many difficult situations could have been averted if the instructors had been more sensitive to their questions and concerns. The attrition of women from astronomy at the undergraduate and graduate levels indicates that individual departments can take decisive action to stem the flow of women from the field.

Finally, we hope that sensitized students will be inspired to change the status quo. Students can lead the way in attracting and encouraging fellow students to cherish creativity, and to never lose the sense of wonder for astronomy. After all, it is a subject that requires one to gaze up every so often and entertain the endless possibilities.

MSO thanks Jill Bechtold and Gary Schmidt for comments on the draft of §§1 and 2. JRF thanks Sophia Yancopoulos for comments on the draft of §3.

ENDNOTES

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