

STATUS

A REPORT ON WOMEN IN ASTRONOMY

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A Publication of
the American Astronomical
Society Committee on
the Status of Women
in Astronomy



Dr. Margaret Burbidge is a professor emeritus in the Physics Department and an astronomer at the Center for Astrophysics and Space Sciences at the University of California, San Diego. She entered astronomy at a time when there were few women and their access to astronomical facilities was severely restricted. She not only transcended these obstacles, she made countless critical contributions to the field, as attested by numerous honors and awards, including (naming only a few) the Presidential Medal of Science, the Henry Norris Russell Lectureship of the American Astronomical Society, and membership in the National Academy of Science.

Glass Ceilings and Ivory Towers



Margaret Burbidge

By Margaret Burbidge

THE EDITORS of STATUS have suggested that it might be interesting to compare the situation that faced me, as a young woman wishing to enter the professional ranks in astronomy, with the situation as it is today. First, it is clear from the statistics gathered by various experts that discrimination based on gender is faced by women in astronomy and physics at all levels, from entering students to highly qualified professionals striking the "glass ceiling." To quote the opening sentence of the perceptive commentary by Claude Canizares [STATUS, June 1999], "Recent reports of the death of discrimination have been greatly exaggerated."

Yet when I describe the ban on women using the Mt. Wilson telescopes that prevented me from being considered as a possible candidate for a Carnegie Fellowship in 1947, I am met quite often with surprise: "You mean women were not allowed to observe with the 60- and 100-inch telescopes?" I then have to explain that the ban was peculiar to the Carnegie Observatories directorship and tradition, and was indeed circumvented eight years later by pressure from the California Institute of Technology (Professors William A. Fowler and Robert Bacher).

Such a ban did not exist at Yerkes and McDonald Observatories; Dr. Nancy G. Roman was a frequent user of these telescopes, as I also was after being accepted in 1951 as a postdoc by the University of Chicago. All this ancient history is described in my prefatory chapter in *The*

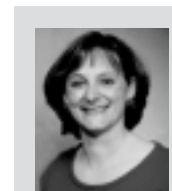
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Editors' Note

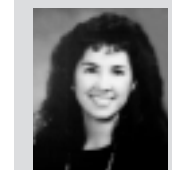
By Meg Urry and Lisa Frattare

MARGARET BURBIDGE led the way for women, in an era when the words "affirmative action" had not even been coined. This issue of STATUS tackles this volatile hot-button topic, which means quite different things to different people. Here are four articles describing distinct views, three from the world of science and a fourth (surprisingly relevant) story from the sports pages.

Harvard physics professor Howard Georgi describes what makes a successful physicist, or rather, how admissions committees tend to focus on a few, easily measured skills that are at best not the whole story and at worst lead to less than optimal



Meg Urry



Lisa Frattare

results. He concludes that affirmative action, which he defines as evaluating scientists appropriately and improving the climate in which we all work, is essential to increasing the number of women and to reinvigorating American science.

Caltech postdoc Lynne Hillenbrand surveys young men and women astronomers about their views on gender issues in astronomy. She explains her own opposition to affirmative action, which she defines as giving prefer-

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Annual Reviews of Astronomy and Astrophysics, "Watcher of the Skies" [1].

However, while such discrimination is seen as barely credible today, discrimination of other kinds exists throughout academia in the United States, as documented by articles in STATUS and elsewhere, and as specifically addressed at the workshop held at the Space Telescope Science Institute, Baltimore, Maryland in September, 1992 [2]. That workshop resulted in a document, "The Baltimore Charter for Women in Astronomy," as described by Meg Urry in STATUS, June 1999, (see also www.aas.org/~cswa/bc.html), with recommendations and a "call to action." A caption below the title of the Charter reads "Women hold up half the sky," a Chinese saying that I first heard in 1977 during a visit of ten astronomers to China, led by Leo Goldberg (I was the only woman in the group, one in ten — a typical ratio). It was said in a dinner-time speech by the woman interpreter, Wu Ling-an, a speech which followed my talk on the situation for women in astronomy in the United States [3].

This brings me to a consideration of the situation for women in astronomy in other countries besides the United States. Steven Beckwith's comparison in the January 1999 issue of STATUS, of the satisfactory conditions for women in France, and the Latin countries in general, as compared with the very much less than satisfactory situation in Germany, accords with my own impressions. In recent travels to astronomical affairs in Europe, I have been asking women about their own experiences. These talks have been completely informal, mostly over coffee breaks or cafeteria lunches during meetings or scientific visits; I have taken no notes, and have collected no statistics. The information I gathered has thus been simply anecdotal, but it agrees with Steve Beckwith's account. In a recent visit to Australia for the celebration of the 25th anniversary of the dedication of the Anglo-Australian 4-m Telescope, I made just one half-day visit to the AAO and the Australia Telescope National Facility Headquarters in Epping, Sydney, so there was little chance to gather any information, but my impressions are that younger women at these institutions receive fair treatment, but there are few role models at higher levels. I was, in fact, the only woman on the original Board that planned the AAT, during my two years as Director of the Royal Greenwich Observatory at Herstmonceux (not as Astronomer Royal, an honorary title which has always been held by men!)

I asked Geoff Burbidge, Editor of *The Annual Reviews of Astronomy and Astrophysics* since 1974, whether other women with long lifetimes in astronomy had been considered as authors of the

ARAA Prefatory Chapters. He thought for a moment, then said: "Only Cecilia Payne-Gaposchkin, and she wrote a historical review entitled 'The Development of Our Knowledge of Variable Stars' [4], not an autobiographical account of her own life." She had, however, already written her autobiography, *The Dyer's Hand*, which has been published as the core of the book "Cecilia Payne-Gaposchkin," a fascinating account put together by her daughter, Katherine Haramundanis, of Cecilia's life from childhood until her death in 1979 [5].

Cecilia was brought up in a family where her brother's life and career were considered of paramount importance, and where Cecilia's acceptance as an undergraduate at Cambridge University and

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Published by
the American Astronomical Society
2000 Florida Avenue, NW, Suite 400
Washington, DC 20009
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STATUS is produced at the
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218

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The STATUS newsletter is distributed to AAS members at the January and June meetings and sent to home institutions of subscribers during the week of the meeting. Contributed articles are encouraged. Deadlines for submission are November 1 and April 1, respectively.

For more information on subscribing to STATUS, submitting articles or obtaining back issues, please visit the STATUS website:
<http://www.aas.org/~cswa/status>

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her successful completion of those years of study owed no thanks to any help from her family.

Realizing that there was no future for her as an astronomer in England, Cecilia then emigrated to the United States — to Harvard College Observatory, at the invitation of Harlow Shapley. In two years, she produced her doctoral thesis, the masterpiece “Stellar Atmospheres” [6] which showed that hydrogen, not iron, is the principle constituent of stars. But Cecilia had to wait for the appointment of Donald Menzel as Director of Harvard College Observatory, after Shapley's term of office came to an end, before Harvard University could be brought to offer Cecilia an appointment as Professor of Astronomy.

Finally, I would like to comment on the situation in the physical sciences in the U. S. National Academy of Sciences. An excellent Symposium on Women in Science was held during the April 1999 NAS meeting; its success was due to the choice of speakers and the dedicated efforts of several women, particularly Dr. Jong-on Hahn, Director of the National Research Council's Committee on Women in Science and Engineering. We await follow-up of that very successful affair.

The 1999 List of Members of the National Academy of Sciences shows that Section 12 (Astronomy) has four women members, out of a total of 78 (including Foreign Associates and Emeritus Members, who are not involved in nominations or voting). This meager score is still better than that of Section 13 (Physics), where one

counts again, only four women members among a total of 181.

I will close by endorsing Meg Urry's list of “ten things you can do,” published at the end of her article in the June 1999 issue of STATUS. Number 9 on this list — “Listen” — reminds us that the concerns of young women today are not what they were 10 years ago, much less 40 years ago. Women can apply for observing time on any telescopes that are available to their male colleagues, and I believe their applications are considered only on scientific merit. But fair treatment in the job market, in the committee structure of academic institutions where appointments and promotions are dealt with, is another matter, and this must be addressed by all of us. ❖

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ences based on gender in order to right past wrongs. She finds near universal agreement that there are instances of gender bias against women and simultaneous concerns among the men about reverse discrimination. Interestingly, the statistics for astronomy do not show gross disparities in hiring rates for postdocs moving to assistant faculty positions. If women are being given preference in hiring, does it perhaps exactly balance any gender biases against them?

Professor David Gelernter takes the more extreme view that affirmative action dominates our college campuses and is pushing women into scientific and technical areas for which they are ill suited and in which they are not interested. Making an analogy to (American) football, he suggests that, for philosophical consistency, colleges should add women to their football squads, never mind whether they are smaller or weaker.

By coincidence we follow with an article on coaching the brilliant USA Women's soccer team

(European football, neatly enough), winners of the 1999 Women's World Cup. Coach Tony DiCicco describes how he changed his style upon learning how differently his female players approached teamwork and personal responsibility compared with male players. Despite the vast gulf between physics and soccer, the analogies to teaching seem right on point.

We hope this issue of STATUS is the beginning of a dialog on these topics. If this helps readers at least realize that the words “affirmative action” connote a very wide range of possibilities, it will already have been progress. Taking a critical look at the statistics of the profession (reported at the January 2000 AAS Special Session on Women in Astronomy in Atlanta and in the June 2000 STATUS), we should be able to raise the discussion beyond an argument for or against vague “affirmative action” bogeymen, to a clearer idea of what actions are needed and justified. Only then will we transcend the divisive nature of those words and begin to coalesce around common goals. ❖



Dr. Howard Georgi is Mallinckrodt Professor of Physics at Harvard University, a winner of the Sakurai prize of the American Physical Society, and a member of the National Academy of Science. Prof. Georgi presented this talk several times as a Phi Beta Kappa visiting scholar in 1997.

Views From an Affirmative Activist

By Howard Georgi

AFFIRMATIVE ACTION seems to have become a divisive issue. I think that this is sad, because I believe that there are situations in which it should not be controversial, if properly understood. I feel strongly that affirmative action to encourage women in science continues to be important, and today I want to explain why. In my view, there are two basic and related issues — evaluation and climate. I firmly believe that improvements in these areas will be good for everyone, not just women.

Let me begin by apologizing in advance about what I will not do. I will not talk about the issue of racial and ethnic minorities in physics. This is not because I do not think that it is important, but because I have so little experience with it that I have nothing useful to say. In physics, at least, there is a chicken and egg problem here. There are so few minorities at any level that it is hard to know where to start. Secondly, I will talk primarily about women in physics, because that is the issue I know best. I believe that problems in other physical sciences and engineering are very similar, but the biomedical sciences undoubtedly have quite a different set of issues, and I don't pretend to understand those as well. Finally, I apologize to those of you who have come expecting a scientific talk, with lots of statistics and graphs. I am just going to tell you stories. I would like to have better statistics, but I really don't think that any statistics can capture the essence of what is going on here.

I thought I would begin by going back a few years to when I was chair of the physics department at Harvard, just by way of revealing my biases right at the beginning. When I began as chair, we had no tenured women in the physics department. I am pleased to say that we now have two terrific tenured women on our faculty, both promoted from junior faculty positions. I played some part in both appointments. Of course, the hard part is done by the women themselves, by being outstanding physicists. But a good chair can do some good and a bad chair can do enormous harm, so it may be worth talking about what the chair does.

The first appointment, to Melissa Franklin, occurred while I was chair, and I spent much time and energy shepherding the appointment through endless faculty meetings and, just as important at Harvard, through our Byzantine Ad Hoc Committee system, in which the department has to convince the president of the University that the appointment is a good one. A chair who is willing to work at it and be an advocate really helps.

The second woman, Mara Prentiss, was promoted soon after I passed on the key to the chair's office to the next victim. In this case, while I was chair, I think that I was some help as a mentor, even though we are in very different subfields. I did my best to protect Mara from getting sucked into too much committee work, I helped negotiate for lab space and secretarial help for her. And I gave a lot of advice (some of which I hope was useful). I also made some mistakes that she had to try to recover from. For example, when she first arrived, I assigned her to teach a big lecture course that didn't match her skills very well. My intentions were good — I wanted the undergraduate physics majors to have contact with women faculty early in their careers — but it just didn't work, so Mara had some poor teaching evaluations on her record. Fortunately, she was spectacularly good at other kinds of teaching, particularly getting undergraduates involved in research. So she was able to make the case that her teaching was good in spite of my initial mistake.

Promoting women to the senior faculty uses up the outstanding women on the junior faculty, and I was less successful in attracting new women junior faculty while I was chair. I was able to modify the way we searched for junior faculty candidates. Previously, searches had been run by individual research groups. I convinced my colleagues that all searches should be run by independent search committees through the chair's office. Let me tell you a couple of stories about the first junior faculty search that was done this way. I won't divulge what subfield of physics we were searching in.

Following the suggestion of my friend Barbara Grosz, a computer scientist who was acting Dean of Affirmative Action, I wrote my search letter to specifically ask for a list of top



Howard Georgi

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women and minority candidates in the field, even if they were not at the same level as the candidates the writer was recommending. The request went like this:

"If you know of strong candidates, please write to us at the address above. We are particularly eager to find qualified women and minority candidates. We would be grateful if you could identify for us the top few women and minority candidates in the field, even if they are not on your list. This will help us to assess the status of women and minorities in the field."

I thought that this request was pretty direct and unambiguous and that it was a very clever idea, because it would encourage the letter writers to at least think about the issue of women and minorities. The letter went out to over 100 active workers in the subfield, but the response was quite unexpected. Not one of the respondents (including the women) even acknowledged this request. I am not certain whether this shows the respondents' bias or their inability to read letters. Still, I think this strategy is worth trying in searches in fields of science where women and minorities are scarce. In this search, while we did interview a couple of women, they were clearly a notch below the men, and in my final "affirmative action letter" describing the search to the Dean, I wrote the following:

"In general, I am not quite sure what 'affirmative action' means in a situation in which the minimum job requirement is to be the best candidate. The way I interpret it for myself is this. There is clearly some uncertainty in judging candidates for a junior faculty position. We should do our best to be aware of all the sources of uncertainty. Then if there is a non-negligible chance that a minority candidate will be as successful as the top white males, we should go for the minority. Alas, by the end of this search there seemed to be no such possibility, and the appointment of a woman would have gone beyond affirmative action to tokenism. We will simply have to try again next time. In spite of my frustration,

I feel that the search worked better with the chair's office involved from the beginning and I will encourage the next chair to continue this policy in future searches."

I hope that these stories illustrate what I believe are the two overwhelming facts about women in science. Enormous progress has been made. And there is still a very long way to go. This is a job for optimists, because you take two steps back for every three steps forward. But the average has the right sign.

The last also summarizes my view of affirmative action. I believe that reverse discrimination in a field like physics is not either desirable or viable. To appoint an underqualified faculty member or admit a marginal graduate student because of gender doesn't help anybody. On the other hand, it is depressingly easy, in physics, to fall into the trap of evaluating people according to very narrow criteria. This is a bad thing to do not just because it may discriminate against underrepresented groups, but because it is simply not a sensible way to evaluate people!

Having now revealed some of my biases, let me now go back and try to recall how I got myself into this position.

The subject of women in science is certainly not something that I thought much about during my education or

early in my research career. I think that there were three seeds of my current interest.

The first developed when I started to work with graduate students in the 70's and 80's. I found that working with excellent students was a marvelous way of doing physics, and this got me involved with graduate admissions. I was also lucky enough to have a series of really outstanding women students.

The second occurred when I got tenure and started going to senior faculty meetings at Harvard. I gave my reaction to this in a session at an APS meeting and it was picked up by Science magazine, so it has been widely disseminated, but I'll just quote it:

"I was appalled by the old-boys-club atmosphere that oozed from these gatherings, and I began to feel that an invasion of

"I was appalled by the old-boys-club atmosphere that oozed from these gatherings, and I began to feel that an invasion of dragons was needed to shake up the country club."

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dragons was needed to shake up the country club.”

Dragons being, unfortunately, unavailable, it seemed to me that some women faculty might make the proceedings seem less like something out of an old English novel. This view was shared by many of my younger colleagues — there developed sort of an informal understanding among the younger faculty that it was time for a serious effort to attract women faculty.

The third happened when I became department chair, and started looking into some of the statistics that pour into the department office. Most of these were not broken down by gender, but there was one that piqued my curiosity so I got other data broken down by gender. I discovered that on the average our women majors, even the ones we had selected for, and who stuck it out and got a physics degree, were very unhappy with the department.

Let me now discuss each of these things in more detail. In addition to these three seeds, which directly involved women, I think that my attitudes towards women in science have been shaped dramatically by three decades of academic people watching. I will come back to this at the end.

Graduate students and graduate admissions:

Three things stand out:

1) I had to learn how to work with women graduate students; 2) Having a significant number of women in the graduate school class makes a big difference; and 3) The GRE physics subject test discriminates against women — this is a long one.

1. Learning to work with women students

I was fortunate that when I started to work with graduate students, it wasn't so long after I had been in graduate school myself. I remembered very well what a difficult, complicated time of life graduate school had been for me. I remembered learning, really for the first time, how little I knew about this field that I had decided to spend my life in. I remembered going to seminars (and sometimes even classes) in which I couldn't understand what was going on. I remembered that it took quite a long time before I realized that nobody else understood much of what was going on in those seminars either. So it was easy for me to understand some of my students's problems. This is something that gets harder as I get older.

Graduate school at Harvard is certainly not easier than most. The faculty are a fairly intimidating lot, even those like me who try to be approachable. Even the cocky young men stu-

dents have difficulty, at first, working one-on-one with professors. My experience is that women students tend to be at least outwardly less sure of themselves, which poses extra problems in communication. At first, I was very bad at dealing with this — the students's diffidence made it hard for me to communicate as well. Fortunately, my first female student, Sally Dawson, now at Brookhaven National Lab, was both easygoing and very determined, and stuck with me in spite of my lack of sensitivity. I got much better with practice.

2. Critical mass

Early on in my tenure on the graduate admissions committee, we had a fortunate fluctuation — we ended up with a very small graduate class with a relatively large percentage of extraordinarily smart and interesting women. What impressed me was that this graduate class developed a personality of its own. There was something different about the class as a whole. I am not sure that this had anything to do with the high percentage of women in the class. There were many interesting characters of both sexes. But I think that my experience in getting to know this class and watching these extraordinary young people develop as physicists helped to change my vision of the process of physics education. Since then, I have been very conscious of the need to have some diversity in the graduate class.

Since that year, we have had a number of graduate classes with a large number of women. This makes a big difference in the climate in the first year graduate courses. This is particularly important for us because some advanced undergrads take these courses too. In fact, the women graduate students have instituted a “women's study night” in which the graduate students and undergraduate women get together for pizza and problem sets. This has helped many of our undergraduate women. If your department does not already have some such system, I would encourage you to try to get it started.

3. The physics GRE

I used to be quite good at standardized tests. In fact, when I was in high-school, I felt that I could do pretty well on one of these tests whether I knew anything about the subject of not. It was just a fun game.

I didn't think much more about this until I took the GRE tests. Again, this was great fun. I remember thinking at that time that I was happy that I had been a Chemistry and Physics major, because my chemistry courses helped me a lot in the Physics subject test.

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But when I started in graduate admissions, it was easy to understand why it was hard to get a high percentage of women in the graduate class. A lot of women got eliminated because they didn't do well on the GRE Physics Subject Test.

Our system of graduate admissions at Harvard is pretty labor-intensive. We have a committee of six to eight people who read most of the four hundred or so applications and rate all the serious applicants from 1 to 10. We then average the ratings and decide on whom to admit from the top of the list. Each year, there are a few students who are obvious admits, but there are another hundred who would probably do fine in the Harvard graduate program. From this group, we admit forty to fifty, expecting twenty to twenty-five to accept our offers. We recognize that our ratings have large errors. In a good year, we could admit the second group of 40 students rather than the first, and except for the few superstars 10s, we probably couldn't tell the difference.

The way I think about this process, there are four components of the application: test scores, undergraduate record, essay, and letters of recommendation. By far the most important of these, in most cases, are the letters. If we get letters from people we know, or from people who have recommended other students whom we have accepted, these are just invaluable. The most useful letters are those that are explicitly comparative. "X has better mathematical skills than Y who has also applied from our institution, but Y is better in the lab. In fact, Y is better in the lab than Z who is now a graduate student at Harvard." That sort of thing. We also hope to get letters describing some of the research the applicant has done as an undergraduate. This is really useful.

The assumption here is that the people we will want to admit will make enough of an impression on some of their teachers or research mentors that they will be able to get useful letters. We require three letters, but I tell students who ask that if they can get more than three good letters, it is likely to help. We will certainly read them, because we want all the information that we can get.

Next most important, in my view, is the essay, and other places on the application where the applicant can tell us something personal. The essay is where we hope to learn what the applicant wants to do and why, and to get enough of a sense of his or her personality that we can make a plausible guess about whether Harvard is the right place for the applicant.

Then there are the grades and test scores. Grades are obviously tricky to use because their meaning differs from institution to institution, and even from course to course. We do try to compare grades of applicants from the same institution, and we also look at the pattern of grades in each applicant's transcript. Did an applicant who wants to quantize gravity have more trouble with introductory quantum mechanics than with junior lab, for example? But it is a difficult business to use grades to rank the top applicants.

Finally the GREs. We require both the general tests and the physics subject test. And these scores are very seductive, because they are an apparently quantitative measure of something. But my experience over the years has made me suspicious of paying too much attention to these scores. I have no statistics. I'm going to give you purely anecdotal information. But I'm convinced that there are some problems with the Physics Subject test in particular. So when I am graduate admissions chair, I try to convince my colleagues on the committee not to rely on it very much. In fact, I have discussed with my colleagues on the graduate admissions committee whether we should stop requiring this test, but so far, perhaps because of my limited persuasive powers, we have not made this change.

One reason we still require the physics subject test is that it is quite useful in one situation. Each year, we get a few applications from undergraduate institutions that do not send many students on to graduate school. It is very difficult to interpret the grades and letters from these places. What does it mean when the student is the best in 20 years from a place that has never sent a student to physics graduate school? In such cases, we more or less have to rely on the GREs. At least, a very low GRE score in such a case may cause us to throw out the application early on, unless there is something really interesting about the rest of the application, whereas, if the GRE is high, we may try to get more information about the applicant.

There are three kinds of stories I want to tell: about idiot savants, about foreign students, and about women. I will spend most of my time on the last.

What I mean by an idiot savant in this context has to do with the peculiar character of the physics concentration at Harvard. We have a very large and very diverse group of physics majors for a school our size, on the order of 50 students a year (or more depending on how you count).

We have perfectly normal physics majors who want to learn about all the different kinds

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of physics that people do. And we have some hot shots who want to focus on some theoretical topic like string theory or quantum gravity. Some of the hot shots are really good and eventually become leaders in physics research. We don't want to discourage them completely, so we do not make it impossible to take very advanced graduate courses as an undergrad, even if that means skipping some of the standard undergraduate fare. The group of hotshots is sometimes said to exhibit an approach to undergraduate physics education that could be described as "first one to quantum field theory wins."

In fact, however, the hotshots themselves are a very diverse group. On one end of the scale are the people who are really great, who know a tremendous amount of physics and really love it, and are just eager to see it at a deeper level. These people, as I have said before, are the reason we don't require a more rigid set of requirements. At the other end of the spectrum (and fortunately a much rarer breed) are those whom I call idiot savants.

Every year or so we have some undergraduate student, always a rather aggressive young man with strong mathematical skills, who takes the hotshot route and does very well in a whole set of advanced courses, but somehow manages to do it entirely at the level of symbol manipulation, without learning any physics at all. These students drive you crazy if you are unlucky enough to have one as an advisee. You can tell from talking to them that they don't know what they are doing. But it is impossible to convince them that they really ought to take an occasional course that teaches them about the physical meaning of the symbols they manipulate.

One or two of these idiot savants have actually gone on to successful research careers in very mathematical areas, but most eventually drift out of physics entirely.

The interesting thing is that these are the students who do best on the GREs. Several times I have had the experience of looking at an application from one of these students with perfect scores in all the general tests and the physics subject test, and thinking — "Wow — I know this guy and he doesn't know any physics!"

Let me now switch gears and talk about foreign students. Here, the interesting thing is how dramatically different the results of the GRE tests are for different populations of students. It is clear that if our admissions committee made the physics subject test the primary criterion for admission, we would fill up our class mostly with students from the People's Republic of China. Now there are a lot of very good physics

students in the PRC. We don't admit a very large number of them, but we have taken some over the years, and some have done well. But they are certainly not as good as you would guess from their Physics GRE scores. It seems clear that their education prepares them very well for these tests.

Some of you may have seen the interesting and provocative essay on GREs by Neal Abraham of the Bryn Mawr Physics Department (nabraham@brynmawr.edu) that appeared on the WIPHYS network. He says the following about this:

"Chinese students report that books of prior exams and exam questions are compiled by test takers and are available for study by those taking tests. Since most exams are used for several years and since new exams include some old questions for normalization, these students have a significant advantage.... Chinese test takers do more than 1.5 standard deviations better than U.S. test takers."

This accords well with my own experience. In an admission cycle from 1996 (I wasn't chair last year, so I don't have as much data), not surprisingly, the U.S. students did 100 points better on the verbal test. The other general tests are about the same. But the foreign students did almost 100 points better on the physics subject test. This is even worse than it looks, because students from places other than the PRC do not show this dramatic difference.

This suggests that the physics subject test tests a specific skill that can be taught, and is taught very effectively in Chinese schools.

Finally, let me go on to the issue of women students. Again, my impressions here are based not on statistics, but on people watching. I am treating women here not particularly as an under-represented group, but rather as the proverbial canaries in the coal mine. I am quite sure that there is some fraction of talented young men who have difficulties on the Physics GRE very similar to those experienced by the women. But for some reason, the problem is much more uniform for women. For whatever reason, women are more sensitive to something about these tests.

There are two groups that I will discuss, at different levels — Harvard undergrads, and my own graduate students.

Harvard undergrads traditionally do not do spectacularly on these tests (except for the idiot savants). We assume that this is because of the flexibility of the program and the fact that we do nothing special to prepare them for the tests.

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But we have no way of collecting statistics for this group except for the subset who actually apply to our graduate program. One thing that I could easily do was to look over forty or so graduate school recommendations I have written in the last ten years (which I had on disk in an easily identifiable format) and look to see whether I mentioned the student's GRE score. I found four letters in which the physics GRE was mentioned — all of them were for women — in all of them I was explaining that the student's GRE score was not an accurate indication of her talent in physics.

In fact, I remember two of these cases very well because the students involved were among the most impressive undergraduates I have ever known. These two were not idiot savant students who had skipped the undergraduate courses. Both had excellent undergraduate records and had impressed many faculty members with their deep knowledge of physics.

One case is particularly telling. One of these women was one of our most successful undergraduate theorists ever. I taught her in several courses and I still remember the experience many years later because she came up with genuinely new and imaginative ways of solving familiar problems. When her GRE subject test came in at the 62nd percentile, she and all of the faculty members who knew her were upset. Not that 62% is a disaster, but it was simply clear that she was going to be an absolute star. In fact, by this time in her senior year, she was already doing very significant research. When I looked back in more detail at her grades in the courses she had taken from me, I did notice that she did not do as well as I would have expected on timed tests, and I concluded that she reacted very badly to the pressure on these exams.

Looking back over the outstanding young women physicists I have known as undergraduates at Harvard, I find that the issue of the physics GRE comes up almost universally. Even when women students do OK on this exam, they find it an unpleasant and even humiliating experience. The ones I have mentioned are in the 99+ category, so for them, a poor GRE was not a disaster. They were able to make up for it with excellent recommendations and to go on to top graduate programs. The real problem is the next level. Many very talented women who do badly on the GRE subject exam are seriously affected. Some end up in less than ideal graduate programs. Some get sufficiently upset about it that they consider leaving the field, and some do leave.

Let me now say a few words about my own graduate students. As I said earlier, I have been

blessed with many really outstanding graduate students, of both genders. I get to know these students very well, so I have very good idea of their talents in physics. Now I happen to think that physics talent is a multifaceted thing that cannot be measured by a single number, so I would have been surprised if the GRE score were a very good indication. But it is striking that in the group of my very best students, the physics GREs of the women were much lower than those of the men. I inquired about this of one of my former students, who by any sensible measure was one of the smartest students I ever had (in particular, she is better than I am at precisely the kinds of things I do best). She told me that the physics GRE was simply too “nerdy” to be taken seriously by an intelligent women. I'm not sure what that implies about men.

I keep hoping that the GRE tests will change, but I see no sign of this yet. In our applications in 1996, there was a huge gender difference. The general tests were essentially identical. But the average for men on the physics subject test was 113 points higher than for women. As with the foreign students, I think that this difference actually understates the problem. The women who apply to us are a much more self-selected set than the men. We get many applications from men which are just not even close. Our educational system seems to select for young men who are not easily discouraged. The women's applications are, on the average, of higher overall quality, so the real difference in the physics GRE, I think, is even greater.

So what do I conclude about GREs?

First, the physics GRE tests a very specific skill. This skill can be taught, but it is not clear how much this skill has to do with what we actually want to know about potential physics students.

Second, as presently constituted, it is quite possible that the GRE physics subject test does more harm than good. We should either fix it or we should seriously consider getting rid of it. Getting rid of it would not do very much harm, in my view. But it might also be possible to fix it. The trouble, it seems to me, is that the underlying philosophy of these tests is to RANK, rather than simply to TEST COMPETENCE. The moral I draw from my little anecdotes is that you simply cannot hope to use tests of this kind to rank top candidates.

I believe that a modified version of the test could be quite useful in testing whether candidates have learned enough basic physics skills to go on to the next level, but only if the test is modified to be more appropriate for this more limited goal. What I would do is reduce the

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number of questions by a large factor, somewhere between 2 and 3, to try to eliminate the time pressure. I would focus on basic skills and knowledge, rather than on specialized advanced details. I believe that the tests should be structured in such a way that talented students with good undergraduate preparation should be able to answer ALL of the questions correctly in the time allotted. That is certainly not the case for the current versions of the test.

Before leaving the subject of graduate admissions, I wanted to mention one other issue that is quite relevant to the subject of affirmative action. There is a certain kind of letter of recommendation that we get much more frequently about women than about men. It says, roughly, that she is a great student, but she just works hard — she is not brilliant. This bothers me. Often I believe that this indicates a problem for the letter writer, who can recognize only one very specific form of brilliance, than for the student. Unfortunately, unless graduate admissions committees are alert, it becomes a problem for the student as well. To me, a letter like this in an otherwise excellent folder is a signal to try to get in touch with some of the younger faculty at the student's school, to try to figure out what is really going on.

Undergraduate women

Chairs at Harvard get lots of statistics from various administrative offices around the university. Most of these (unfortunately) are not broken down by gender. But early in my tenure as physics department chair, I got some statistics that worried me. These were “course grading indices” — CGI — which measure the difference between the performance of students in a given course compared with the average of their grades in their other courses. A negative CGI means that the course is hard — this is what we usually see in our undergraduate physics courses. Physics tends to lag behind other subjects in grade inflation. But what interested me about this was that the average CGI for all physics courses was much more negative for women than for men. I found this sufficiently interesting that I enlisted the help of our Office of Instructional Research and Evaluations and got other statistics broken down by gender.

When I got the results, I found that what

was going on with grades was striking. I now had not just grade differences, but absolute grades broken down by gender, and lots of other data as well. In grades, the women physics majors were not doing as well in their physics courses as the men, and were doing better in their courses outside of physics. But even more disturbing (and perhaps not unrelated) were data from the so-called senior survey — filled out by all graduating seniors before they can get their diploma. I had already seen the data for women and men combined. It seemed to show that the department was doing OK, though not spectacularly, in satisfying our concentrators. But when broken down by gender, the picture looked quite different. The men liked the physics major, and the women really hated it! And these were the women who stuck with us and graduated with degrees in physics! Heaven knows how many women we were turning off to physics entirely. I think that it was this more than anything else that turned me into an affirmative activist. This struck me as a simply intolerable situation and I resolved to do something about it.

This was the beginning of my interest in the issue of the climate for women, and I began by reading a bit about it. I read Deborah Tannen's book, “You Just don't Understand” about miscommunication between men and women. I read “Failing at Fairness” by the Sadkers, about the treatment of girls in elementary school. I went to seminars and meetings on the subject. I also got a lot of help and encouragement from women in our department, including Margaret Law, the Director of the Physics Laboratories at Harvard, Melissa Franklin and Mara Prentiss, our two women faculty members, Sheila Kannappan, a graduate student and former Harvard undergrad who was an old friend and had tried to get me to understand these issues for a long time before I finally got it, and Theresa Lynn, then an extraordinary undergraduate and co-president of our Society of Physics Students. We arranged meetings with our undergraduate women physics majors to discuss the issues.

From all this, I don't think that I learned anything that was not already well-known to experts in the subject. In fact, recently I found

“The men liked the physics major, and the women really hated it! And these were the women who stuck with us and graduated with degrees in physics!”

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much of what I learned and developed about climate in courses in a wonderful summary of techniques for improving science teaching of women called "Achieving Gender Equity in Science Classrooms" available on the web at: http://www.brown.edu/Administration/Science_Education/Gender_Equity/

I recommend it as a good summary of the subject. It should be required reading for all science teachers and educational administrators. It recommends the following steps:

1. Observe classroom dynamics
2. Personalize large classes
3. Shift from a competitive to a cooperative educational model
4. Consider a variety of examination options
5. Encourage active participation in labs
6. Fight narrow stereotypes of science
7. Provide diverse role models
8. Make yourself available
9. Foster self-confidence

Anyone who has thought hard about the issue of climate in the classroom can probably unpack each of these. They are elaborated nicely on this web page.

What I want to note here is that I believe that similar steps need to take place at the departmental level, not just within individual classes. There is no magic. The basic idea is simply to treat the students as people. This is good for everybody, but it seems to be more important for the women students.

Here are a few of the specific things that we have done to try to improve the climate in the department as a whole. We have institutionalized the meetings between the women students and faculty and the department chair so that they happen every year. I already mentioned the Women in Physics Pizza and Study Night in which the graduate students and undergrads get together. This was pushed by Sheila Kannappan and other graduate women. With Theresa Lynn and the rest of the SPS, we organized biannual barbecues for the whole department to get the faculty, undergrads and grads together regularly in an informal setting. We organized a holiday caroling group. I should say that singing in the halls of our old brick and cinder-block buildings is great fun — the Q values in these halls are very high, and there are few places where a pick-up group of physicists can sound really good! This has become a tradition. Interestingly, it is one of the few activities in which women and men participate in roughly equal numbers. I invited a group of women physicists to visit our department to study the climate for women. This group was sponsored by the American

Physical Society Committee on the Status of Women in Physics and led by MIT Professor Millie Dresselhaus. Their recommendations helped me to change and I hope to humanize the advising system in the department. Having a departmental advisor who takes an interest in the students as people seems to be particularly important for women. Most of these are small things, and it is easy to dismiss any one of them as trivial. Certainly, no one of them is magic bullet that will solve all our problems. But every little bit of this has helped. It is never enough, but it has helped. I think that it is important for departments to share ideas about what works, even a little.

It might seem that the issue of climate is quite different from the issue of evaluation. But I think that they are related in both directions. Evaluation obviously affects climate in several ways. One of the main reasons for the climate difficulties in the first place is that women are such a small minority in physics classroom, and on physics faculties. Evaluation procedures affect climate by perpetuating the minority status of women. Furthermore, if women feel undervalued, if their contributions are ignored or trivialized, the climate is hopeless. But climate also affects evaluation in a more subtle way. If the climate in a department is one in which everyone is respected and valued as a person, it is easier for search committees and admissions committees to look at the whole picture in the selection process, rather than focussing too narrowly on an overly specific set of skills.

Academic people-watching and affirmative action

Let me close with a few more philosophical remarks, which I hope may give an indication of why I think that affirmative action, as I have defined it, is important not just for fairness, or to make us feel good, but for the long-term health of the scientific enterprise. In spite of all the noise about affirmative action and climate, many scientists still think that physics education is a competition. There is a sense that our primary job as educators is to provide a kind educational density gradient so that we can rank order our students and the cream will rise to the top. I really believe that this picture is not just unfair, but bad for science.

I want to stress that I am not attacking science or scientists in any way. I am certainly not going to argue that we should open up science to include the unquantifiable. In my view, one of the real tragedies in the whole business of women in science is that it tends to be polarized along a feminist axis. The response to feminist

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attacks on the whole structure of "male dominated" science is often to close ranks behind the rigor and uniqueness of the scientific method. Both the attacks and the responses miss the point that I address today. I am convinced that there is very little that is culturally relative or gender-specific about the scientific method or the results of scientific research. But it is obvious that there is much that is culture- and gender-linked in the way science is done and the way scientists are educated. I would like to argue that it is worth experimenting with the sort of different approaches to physical- and mathematical-science education that I have talked about, not because affirmative action requires it but because it is good for science.

The reason that our system of physics education has lasted as long as it has is that this scheme actually works to select an interesting group of students, many of whom become good physicists. However, the fact that our educational system has been very successful in training good physicists in no way implies that we are not losing as many or more students who could be outstanding physicists if taught and evaluated differently. In fact, I am convinced that this loss can and does occur, and that it has a lot to do with our attempts to pick off people at the "top" and let them go on in physics. I believe the notion of "top" doesn't make much sense in the space of intelligence. I should say that one of the reasons I believe this has to do with an accident of my own history.

My own field of theoretical particle physics has attracted many interesting people over the years. We particle theorists find it endlessly fascinating because our experimental colleagues have fed us for nearly a hundred years with a steady diet of outlandish facts about the world at subatomic distances. We struggle to understand a tiny world that appears more bizarre each time the power of our microscopes is increased.

I was lucky to be at Harvard at a fascinating time for this field, the decade of the 70's. I was able to participate in a minor revolution in our understanding of the subatomic world. Cambridge was one of the centers of the uprising. Outstanding particle physicists from all over the world came regularly to give the theory seminars at Harvard or MIT. In these talks,

in the informal discussions that preceded them and in the Chinese dinners that followed, I had a wonderful opportunity to observe interesting minds at work. It was almost as much fun as the physics.

And of course, I had (and have) some interesting colleagues. I have written papers with Shelly Glashow, Steven Weinberg, Sidney Coleman, Bram Pais, and lots of brilliant younger physicists, not least my own students. Many of these people make me feel terribly inadequate, in different ways. I shared an office for five years in the mid 70s with Ed Witten, the chief guru of string theory, who is so smart in so many ways that it is scary.

I noticed immediately that not only did these outstanding physicists have personalities (sometimes engaging, sometimes annoying, sometimes simply odd) but that each had his own way of doing physics (they were almost all men, of course). These were often dramatically, and even bizarrely different from my own. We could talk to each other about the results because we had learned the common language of relativistic quantum mechanics and the phenomenology of particle physics, but the processes that produced the results were many and various — so obviously different, in many cases, that you simply couldn't miss the differences if you were paying any attention to the people at all.

I also had the good fortune to be associated with the Harvard Society of Fellows for over twenty years. Here I had

the fun of getting to know intellectual giants in other fields like philosopher Van Quine, historian Bud Bailyn, biologist Wally Gilbert and literary critic Helen Vendler.

The result of this great-mind-watching is a belief that the space of intelligence has very many, very different dimensions and a very complicated and very nonlinear structure. People who do spectacularly well at one kind of activity in thinking may be only average (or less) at another. No small set of numbers can adequately capture what is going on here. The phenomena are simply too diverse, and too interesting.

If this picture is right, then I should not apologize for telling you stories rather than giving you statistics. Science is done by people —

"... the fact that [we have] been very successful in training good physicists in no way implies that we are not losing as many or more ... who could be outstanding physicists if taught and evaluated differently."

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human brains in human bodies. People are complicated and the sense that we get from anecdotal information may be every bit as valid as what we can quantify.

Because of this history, it is hard for me NOT to believe that there are large and interesting regions in the multidimensional space of human intelligence that are missed by our search

procedures. This is why I believe that affirmative action is important. The concept of "top" needs to be replaced by a recognition of just how complicated this whole process is. There are many tops, of very different kinds, and the more we are able to recognize and gauge many kinds of talents, the better science will fare in the long run. ❖



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Young Astronomers' Views: Employment and Affirmative Action

By Lynne Hillenbrand

The activities associated with "job season" — CV updates, letters, talks, and interviews — are in full swing. Despite general perceptions, it is a relatively good time to be looking for a job in astronomy.

Postdoctoral positions are abundant.

If you are a female graduate student seeking that first postdoc, keep at it — we want you to remain in the field! For those of us looking for more permanent employment, overall numbers are also up, with many university astronomy/physics departments expanding and the number of long-term-temporary positions increasing due to a prevalence of big projects (ground-based surveys, space missions, etc.). That is not to say that the astronomy job market is an easy one, however, as the number of qualified applicants for these new jobs is also rising.

We are fortunate to have choices these days in the types of jobs we consider. As opposed to the case 20 years ago where it was "university professor or bust," today there are astronomy positions in programming, instrumentation, management, teaching, pure-research, and public outreach. The character of long-term employment in astronomy is changing, and so are the required skill sets. Women, having had a successful postdoc, appear just as likely as men to move from postdoctoral to permanent positions (STScI preliminary statistics, June 1999 STATUS).

So what is it like down in the trenches? And do women and men face the same issues when seeking jobs? To find out, I conducted a survey of younger female (N=47) and male (N=37) astronomers, as described in the accompanying

article. Here I discuss results from the survey on perceptions about the percentage of women at various levels in astronomy, and on affirmative action programs. I also did a few more extensive interviews with students and postdocs, including those in the process of leaving the field, to discover what folks are looking for in today's employment environment.

As one might expect there is little common thinking in what individuals want in their lives.

There were no discernible differences between women and men on issues such as importance of career vs. lifestyle, career vs. geography, or career vs. spouse/family. Older postdocs tended to have somewhat different priorities compared to younger postdocs or graduate students. One alarmingly common theme in these interviews though, was that, by and large, today's young people

in astronomy do not expect to be able to enjoy long-term careers in the field. Morale in the trenches is not good! At the postdoctoral level, most people say they will apply for a few select jobs (but not every job), and if not successful they will try to support themselves on soft money for a few years, then perhaps abandon the field. As bad as this sounds, there is one good aspect: there do not appear to be divisions by gender or, among women, because of gender issues, in attitudes toward long-term success. See the accompanying article for further discussion of gender issues in astronomy.

How do the actual percentages of women at different academic stages compare with the perceived percentages? The results of the survey, when split into female and male, faculty, postdocs, and graduate students, show that almost every group tended to underestimate the percentage of women at every level, with each group faring the most poorly at their own level or above. In the mean, female graduate students



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think there are fewer female graduate students than there really are, female postdocs think there are fewer female postdocs than there really are, and female faculty/staff think there are fewer female faculty/staff than there really are. There is some indication that males, overall, misperceive the percentage of women to a greater degree than females do. I followed this up by asking about the percentage of women at all levels "in your research area," hoping to take advantage of familiarity of the respondent with the frequency of male vs. female names from meeting attendance or journal reading. Interestingly, nearly all males put the percentages of women in their own fields at < 5-19%, whereas most females chose between 10 and 29%. From all of this I conclude that "the younger generation" has some slight misconceptions about the true numbers/percentages of women in the field, generally underestimating them, with males underestimating to a larger degree than females. However, everyone seems to be aware that the numbers/percentages are on the rise with far more younger women than older women.

The next question on the survey asked about belief in affirmative action programs at the junior and senior faculty/staff levels. This is a rather complex question to which I requested a simple yes/no answer, in an attempt to make people choose one side or the other. Forced to choose, of the 47 women, 22% were opposed, 56% were for, and 24% refused to choose, instead writing in "qualified yes," "maybe," or "don't know." Of the 37 men, 28% were opposed, 58% were for, and 16% refused strong commitment to one side or the other. In other words, there is no difference between women and men in general sentiment on affirmative action. Votes from both groups run > 2:1 for affirmative action initiatives, and > 3:1 for if you count all of the undecided or qualified-yes votes as forms of "yes."

I happen to be of the minority opinion on this issue. I think we all agree as a community that the number of women in senior-level astronomy positions should be increased, not just to improve statistics, but more importantly to encourage junior women to stay in the field. We want the smartest people we can attract making contributions to astronomy, not turning away to other pursuits because they do not see in the field today models of themselves in 20 years. Women notice when there is an unusually low (or unusually high, say > 25%) proportion of women when visiting a new department. If there are no women currently, it is hard to get any to come — and then to stay. These points I acknowledge. I also think we all agree that no one should be put on a short-list, hired, or pro-

moted simply because she is female. But, if in the final decision process there are two equal candidates, one of each gender, the proponents of affirmative action would support favoring the woman. This is a tricky game to play, in my opinion, because such an environment creates no winners. Young men often feel discriminated against, that they are today's victims of yesterday's mistakes. Young women often feel paranoia that they are hired for reasons other than those of fair academic competition, and often suffer verbal abuse from male colleagues who mistakenly think they have an easier career path because of affirmative action. Nobody wants these circumstances. The problem of underrepresentation of women should be fixed, most people seem to agree, but based on the many comments I received, I think it safe to say that no one wants his/her own career affected by the climate affirmative action creates.

None of these arguments are new, nor are they very different from those applied in other affirmative action debates. At the base of the problem in astronomy is simply this: good jobs are rare, and thus every hiring decision is given more attention and carries more weight than in, for example, the corporate world. Because astronomy is such a small field and because most of us who have persisted through several postdocs are capable of doing faculty-level work, no matter who is hired, people will gossip about why candidate X or Y or AA would have been a better choice. In the corporate world it simply does not matter in the grand scheme of things exactly who is hired, given that there are enough jobs for everyone and that any one of the equally qualified candidates could do the job if hired. In academia, the story is different primarily because there are not enough jobs for everyone, but also because there is more value placed on the unique capabilities of particular individuals. The turnover time for permanent positions in astronomy (and in academia in general) is extremely long compared with that in the corporate world. Thus we cannot, as they can, create a less underrepresented environment for women by enacting a short-term affirmative action program to equalize the percentages of women and men in proportion to the numbers of qualified applicants. Why? In a corporation, the affirmative action hiring period would not have to last all that long given the rapid turnover in employees and the pace of promotions. In academia, by contrast, if each department hires for a permanent position only every 5-7 years, it will take decades of drastically biased affirmative action hiring to remedy current situations. I, for one, do not want to be employed during such an era.

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Making sure that women are not systematically put at a disadvantage is acceptable to me, but creating an environment where women are clearly preferred over men in faculty/staff hiring, I do not support. In my opinion, we simply have to live with the historical inequities until they are slowly repaired with non-biased hiring into

the non-indefinite future. This will take only 2 to 3 times as long as totally biased hiring and amounts to decades in either case. The overall expansion of the field implies that repair can happen on shorter timescales. ♦

Young Astronomers' Views: Gender Bias Perceptions

By Lynne Hillenbrand

I conducted a survey of young-ish women colleagues (I say "young-ish" because I am starting to feel not so young anymore...) to gauge the general thinking of our generation on gender issues in astronomy. To my great surprise, I actually know close to 70 women who are within 8-10 years of their Ph.D. date (in either direction). Replies were received from 47. I also sent a slightly modified version of the same survey to about 55 men in the same academic age range, and received 37 replies.

Of the respondents, 28% (13) of the women and 22% (8) of the men were graduate students, 47% (22) of the women and 44% (16) of the men were either postdocs or soft-money staff, and 25% (12) of the women and 33% (12) of the men were tenure-track faculty/staff. Many questions were of the yes/no variety, and hence subject to multiple interpretations. I gave people the opportunity to add details if they wanted to, but did not want to ask specific questions of an overly personal nature, such as "Are you considering leaving the field?," "Do you want children and if so do you think they will affect your career advancement?," etc., so as not to inhibit participation.

The statistics are small, but the results interesting nonetheless, and rather enlightening in some regards. Several people expressed surprise at seeing such a survey coming from me. I have to admit that I have been less than sympathetic to "women's issues" throughout most of my life, but here I will let the data speak for themselves.

There were overwhelmingly uniform answers to a few of the questions. First, 96% of the women and 97% of the men do think that "gender issues" exist today in the field of astronomy. This was one of several broad, intentionally vague questions on the survey. Nevertheless, it is interesting that only a few denied the existence at all of any gender-related career issues. One perhaps could make the argument that those who do not believe any problems exist simply did not answer the survey, but my suspicion is that this is not the case.

The other question evoking near-uniform sentiment among women, and a surprising majority of affirmative responses from the men, asked about recalling instances of perceived differential treatment in professional interactions from the way a member of the opposite sex would have been treated in the same situation. To this, 94% of the women and 64% of the men said, yes, this had happened to them. Again, the question is vague and does not get at whether the results of differential treatment were net good or net bad. Nevertheless, the replies indicate at least some awareness on the part of both sexes that all is not equal.

For women, being treated "differently" usually implies in an inferior manner. Examples probably are not necessary as I suspect most of us are familiar with stories of gender-based professional discrimination. But there are instances where "differently" can mean better. Family leave, for one, is a circumstance in which most new dads are not given the same advantages as new moms in spending the first 3 months settling in with a new family member. Nor are men given the same slack women seem to get when having to deal with family issues. I know for a fact that I have benefited from having this kind of gender advantage. Also, there are affirmative action programs in place which assist in hiring rates for women and clearly constitute different, but preferential, treatment. I sincerely hope that I have *not* benefited from this kind of gender "advantage" (see accompanying article). Finally, there is a perception among both women and men that extra attention is often paid to younger women compared with equivalent younger men in the field, for whatever biased reason. I am fairly sure that I have been involved in such circumstances, having given more than my fair share of departmental colloquia, for example. These incidents can have either positive or negative consequences for the woman involved depending on "performance" while under the extra scrutiny. More attention is usually good in the "love-me-hate-me-but-don't-ignore-me" view, but can be bad in the case of a woman's comments/questions in a classroom or conference situ-

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ation being treated more critically than a man's would be, or in the case of one woman's poor performance being extrapolated to represent the capabilities of all women.

For men, of the 64% who claimed to have experienced differential treatment, more than half (56%) said these instances had *negative* rather than positive effects for them. This totally surprised me. Specifics, when given, often involved one of the three positives of differential treatment listed above for women. Yes, it was acknowledged by the men that some more senior men in the field do treat women improperly and that this had worked to their professional advantage. Yes, it was acknowledged by the men that qualitatively different kinds of conversations do take place when women are not present, and that this probably worked to their advantage in some subtle way. At the very least, these sentiments reflect that younger men are indeed aware of differences in the way women's and men's presence and scientific contributions are viewed. And it appears that no one of either sex seems to enjoy it, even when the effects are net positive for one's career.

Does the fact that women often are treated differently from men in day-to-day interactions really have to be categorized as "better" or "worse" in every case (in many cases the answer *is* clearly yes), when it might mean just "differently"? Some women claimed that they were well aware of their differential treatment in social matters discussed at work, but that this did not extend to discussions of professional nature. Others said the differences did include professional matters, but attributed it to a preference for boys to hang out and talk with other boys, an aspect of human nature that unintentionally creates an atmosphere of subtle bias. But does not the same sort of thing happen when only women astronomers are together? "Water cooler" interactions could work to women's advantage in the same way they currently do to men's, were there more influential senior women in the field.

I also asked those answering the question about differential treatment in the affirmative about the number of episodes and whether or not there were long-term consequences. For the women, interestingly, the median number of recalled instances of differential treatment was about the same as for graduate students and faculty/staff, at 3-4, but for postdocs the median number was in the range 5-10. Do significant numbers of postdocs leave the field because of dissatisfaction over these kinds of issues? Several women complained that it was hard to separate specific episodes from prolonged, continually bad behavior by the same person. For men, no one raised the

issue of continually differential treatment, and the median number of recalled episodes increased, as one might expect, with academic age, from 2-3 for graduate students, to 4 for postdocs, to 5-10 for faculty.

Interestingly, the young men faculty claimed *more* instances in the mean of differential treatment than young women faculty. Male postdocs claimed fewer instances than female postdocs, and male graduate students claimed marginally fewer instances than female graduate students. As for the long-term effects of particular episodes of perceived differential treatment, 43% of the women and 33% of the men claimed the existence of long-term consequences. Again, these consequences could be either good or bad, but my suspicion based on attached comments is that they were largely bad for both groups. The incidence of long-term consequences was higher (57%) for the 45% of women who claimed personally to have experienced blatant, offensive professional sexism, as distinguished from just differential treatment. Although the statistics are small, at least three men claim to have suffered long-term consequences themselves due to experiences with blatant, offensive professional sexism directed against them.

I asked only the women the following two questions. First, 43% of women claimed ongoing concerns/issues/problems in their current positions that they attribute to gender. This could mean problems with outright sexist behavior, issues of balancing working with spousal/parental commitments, or concerns about commanding the respect of a class, for example. Second, 66% of women said that they anticipated experiencing hindrances related to gender as they advanced in their astronomy careers. By and large, therefore, young women in astronomy do feel that they are at a chromosomally-based disadvantage. I did not ask about sources of any perceived discrimination (e.g. colleague of same academic stature, senior male astronomer, etc.). Yet many women did offer comments to the effect that they thought their male colleagues of the same academic age had less-than-equal views of women's capabilities. Some men, on the other hand, were of the opinion that as soon as some particularly problematic older men either retired or expired, the situation for women would improve.

It seems clear based on the above that gender biases in astronomy and their effects have persisted to the current generation of young faculty, and also to the next generation, today's graduate students. Almost everyone acknowledges the presence of gender issues. Young men seem just as aware as young women that differential treatment exists and, in fact, men as a group feel affected by such gender biases almost as frequently as women, although certainly differently and, one could argue, less emotionally severely in the worst cases. ❖



The following article is reprinted with permission from the June 21, 1999 issue of the Weekly Standard. David Gelernter is a contributing editor to the Weekly Standard and a professor in the Department of Computer Sciences at Yale University.

Women and Science at Yale

By David Gelernter

AFFIRMATIVE ACTION seems to be entering a new phase: As the public turns against it, universities are growing increasingly desperate in their support. I teach at Yale, where the administration has made it clear that (in particular) it wants more female professors in technology and the hard sciences. Other universities have the same goal; they have longed for women scientists for years, but their longing seems to have entered a new phase of grim determination. Yale College happens to be heavily armored in foot-thick academic independence, and we have survived a long series of ideological barrages in better shape than we are usually given credit for. But whatever the outcome at this university, the Yale administration is doing the academic world no favor by joining the crowd that has gathered to poke and prod this particular hornets' nest. The approaching hornet swarm is bad news for universities and society in general.

Whether or not you approve of affirmative action, it's clear that certain of its goals can be achieved and others can't. If you are determined, say, to increase the proportion of Hispanics in your undergraduate population, you can probably do it; Hispanic applicants are available. If your goal is a large increase in female science and engineering professors, you can't do it, because the candidates are not available. Wounded ideologues (whose programs have been tried and failed) are the most dangerous kind. We ought to prepare and plan ahead.

To do that, we need to understand why this issue has come up in the first place. It's true that women are scarce in hard sciences and engineering. Why? If anti-woman bigotry were the explanation, we could increase our female-professor count by cutting down on the bigotry. But everyone knows that anti-woman bigotry is not the explanation. The very notion is an Orwellian freedom-is-slavery inversion; pro-woman bias has been the rule in academia for a generation. (Of course, affirmative action proponents could

define opposition to affirmative action as evidence of anti-woman bias in itself — but in doing so, they would merely be declaring themselves right by definition).

The real explanation is obvious: Women are less drawn to science and engineering than men are. (They're also less prone to the intense, cut-throat aggressiveness that usually marks the successful research scientist or engineer.) If you visit the comfortable, typical Connecticut suburb

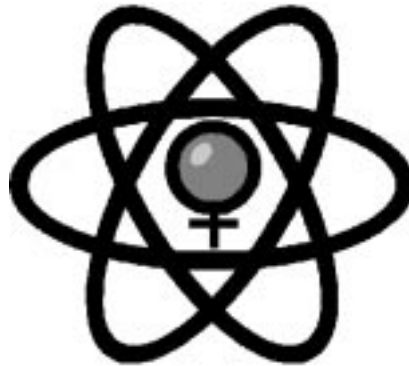
where I live, you can see the big picture in microcosm.

The public schools run a summer program for children. Our older boy has spent a couple of weeks during each of the past several summers in a Lego-and-computers course. At the end of each session, students show off their accomplishments; I've never encountered one girl at any of these performances. Scientists and engineers are mainly grown-up versions of Lego-and-computers children. If you

believe the Bigotry Theory, you must also believe that bigotry explains the scarcity of girls in our local Lego-and-computers group. If you believe that — that our tiny, Democratic suburb is biased against little girls — then you'll believe anything.

In recent years, affirmative action pushers have been less inclined to accuse people of bigotry — perhaps because they know the accusation is insulting and false. Nowadays affirmative action is mainly justified by the need for “diversity”; we can't be a society where nearly all the engineering and hard science professors are male, because — we just can't. It's true that all professional football players are male, but that's different. Football is important; we can't force weak players on the NFL merely for ideological reasons. The public wouldn't stand for it. But in low-profile, unimportant areas such as physics, the public doesn't care much about the players, and ideologues have a free hand.

Honorable people have put forward the “diversity” argument, but consider what this argument implies. If women aren't being kept out of science by force, they must be choosing not to



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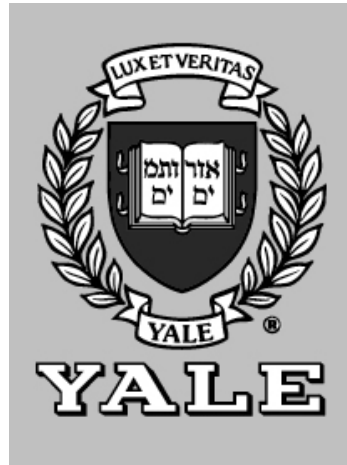
Gelernter continued from page 17

enter, presumably because they don't want to; presumably because (by and large) they don't like these fields or (on average) don't tend to excel in them, which is nearly the same thing. Yet diversity promoters have decreed that, nonetheless, more women shall enter engineering and science. Their attitude is either patronizing or bullying.

Affirmative action pushers have obviously decided that some fields (namely, the ones males disproportionately prefer) are just better than others (namely, the ones women choose). Otherwise, why monkey with female predilections? The result is a diversity crusade that insults women scientists and non-scientists. It degrades scientists by suggesting that they can't make it without a little help from Big Brother; and degrades non-scientists by suggesting that they'd be in a different field altogether if they only had the guts. Of course, modern culture amounts to one long harangue against female tastes; it's hardly surprising that the same message should underlie the latest trends in affirmative action.

To what purpose are universities willing to inflict this damage? So what if we don't have a lot of female engineering and science professors? Some people claim that if we don't have more women science professors, we have no hope of luring more girls into science. A circular argument: We've got to get more women into science, because otherwise we won't be able to get more women into science. And consider the implications of the underlying claim, that girls must have some sort of specially close relationship to female scientists. If that's so, then boys must be specially close to male scientists.

History's greatest engineers, scientists, and mathematicians have nearly all been male. Are we quite sure we want to make this crazy claim? In any case, I can picture my own reaction if someone had told me that, say, I could only learn physics properly from a Jew. That I could only be well and truly inspired by a Jewish professor. That Christian students had an automatic "special relationship" to all the Christian professors. I would have told such a person to drop dead. Yes, I am closer to Jews than Christians in certain ways — and to parrot-lovers than cat-fanciers in certain other ways. But none of these facts needed to be or ought to have been reflected in the demographics of the Yale faculty.



We opponents of affirmative action don't claim that we are defending a system of pure merit against a barbarian onslaught. Everyone who holds a good academic position owes it in some degree to luck. There is no such thing as a university powered by pure intellectual merit. Even if there were, we wouldn't like it, because other kinds of merit (for example spiritual) count too. We aren't defending a perfect system against an idea that would destroy it. We are defending a fairly good system (and America's hard science and technology is fairly good) against an idea that is bound to fail and, along the way, to insult the people it's supposed to help.

And after it does fail? After it becomes clear that no large increase in numbers of female engineers and hard scientists is going to materialize? The next step is frighteningly clear. The administrators who are hot for affirmative action today will be hot for restricted admissions tomorrow. Next step: male quotas on course enrollments and majors. Sound impossible? Can't believe that any college would dare tell your son, "forget that computer science course; male enrollment is maxed out. Can we show you something in Film Studies?"

It's a nightmare, but we'd be foolish not to take it seriously. This is exactly what colleges across the country are doing today to their aspiring male athletes. The affirmative action pushers wanted more college women to play sports. Women didn't feel like it. You can't force women to play if they don't want to. So if a spurious "equality" is your goal, your only choice in the long run is to jettison men's sports, as universities across the country now routinely do. If universities are willing to jettison aspiring male athletes in the name of equality, why not aspiring male physicists? Because physics is more important than sports? Many people, academics and otherwise, don't believe that. In any case, the ditching of men's athletics proves that ideologues can undertake a policy that any normal person would regard as malicious and stupid and get away with it. The public has been conditioned to take anything the bureaucrats dish out and like it. The future is grim unless we start worrying about it right now. ❖

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This article is reprinted with permission from the Boston Globe, where it originally appeared on June 18, 1999. The slightly shortened version below appeared in the Baltimore Sun on June 24, 1999.

A Softer Touch for Tough Women: Coaching World Class Soccer

By John Powers

THE COACH FROM MARS is talking about communicating with players from Venus. "There is a different approach," Tony DiCicco says. "You can't be an in-your-face type coach with women. You have to recognize the differences."

The 50-year-old DiCicco, who has directed the U.S. women's soccer team to 93 victories and an Olympic gold medal in five years, has collected enough data — both empirical and anecdotal — for a graduate-level seminar on gender subtleties.

Female players take criticism much more personally than males do, DiCicco has observed, even if it's not directed at them individually. Their bonds with each other are decidedly deeper. And they're more concerned about balancing their sport and their personal lives than men are.

And yet, the American women may be on top of the world because they're comfortable playing like Martians on the field. Their practices are relentlessly cutthroat — cleats going hard into ankles, heads knocking in mid-air, shoulders banging shoulders on the dead run. "One thing we want in practice is intensity," says DiCicco. "We don't want them to be kick-arounds. We don't grow from them."

The desire for victory, the demand for excellence, and the willingness to sacrifice for it, DiCicco says, is gender-blind. He's seen Michelle Akers play on rebuilt knees and fight a daily battle with chronic fatigue syndrome for nearly a decade. He watched Mia Hamm, running on a sprained ankle, set up the goals that beat China at Olympus. He saw Joy Fawcett scrimmaging two weeks after giving birth.

The most significant difference between Mars and Venus, DiCicco will testify, is that Mars doesn't have to nurse in the dressing room between halves.

DiCicco got a tutorial in gender subtleties when he signed on as Dorrance's assistant in 1991. "After we lost a match to China, I mentioned a couple of players' names individually when we were watching the video," he remem-

bers. "Later, it got back to me that they were blaming themselves for the loss."

That was the first in a series of lessons that DiCicco took to heart. "In the men's game, you point something out and it bounces off," he says. "Or they say, yeah, but other guys were screwing up worse than me." When you talk to the entire team, DiCicco says, each woman thinks you're speaking to her. "With men," he says, "you talk to the group and each guy says, yeah, those other guys better get it done."

The bonding among female players, DiCicco says, is profound. "It goes way beyond teammates," he says. "It's about relationships. I'll say, write down your best team for me and invariably they'll put their best friends on the list whether they belong there or not. Men are more objective. They may hate the guy, but if he gets the job done, they want him in the lineup."

And to women, having balance between their on-field and off-field lives is vital. "If they get disconnected," DiCicco says, "you might as well send them home."

So DiCicco, who has talked shop with Ben Smith, who coached the U.S. women's ice hockey team to the gold medal at Nagano, keeps his residency camps short to minimize family frictions. "Train them in short blocks, then get them out of there," he says. DiCicco has also learned to pick his team early. "So they have a chance to bond," he says. "Because they may have lost a friend."

Yet beyond the Mars/Venus nuances, the more delicate challenge for DiCicco has been directing, and revitalizing, a team that was already world champion before he took over.

DiCicco has learned when to push his squad and when to back off. "We're a wacky group with a lot of personality and energy," says Julie Foudy. "But Tony knows when to be intense with us and when to let us be loose."

DiCicco also understands that the pressure on his players is enormous. They're not only supposed to win back the Cup, they're supposed to inspire a generation of American girls and lay the groundwork for a women's professional league. That is the real difference between Mars and Venus when it comes to U.S. soccer, DiCicco's warriors can tell you. Mars was only expected to survive the first round when the Cup was here in 1994. Venus is expected to do it all. ❖



Dr. Sethanne Howard was the January 1999 speaker for the AAS Committee in the Status of Women in Astronomy meeting in Austin, Texas. Her talk "4000 Years of Women in Science and Technology" is described further at <http://www.astr.ua.edu/4000ws.html>.

Science Has No Gender

By *Sethanne Howard*

For over 4,000 years the historical record has, now and then, included scientists, engineers, and natural philosophers. For over 4,000 years there have been women in that list just as there have been men. Who would have thought it? It's true. Science is as traditional a role for women as it has been for men. There are names from long ago — names of real women such as En Hedu'anna (c. 2330 BCE — ancient Sumeria) and real men such as Imhotep (architect of the first pyramid — ancient Egypt). We, men and women together, have been scientists and engineers as long as we have been human. The human species is a species of technicians — we affect and predict our environment — that's technilosity (to coin a word). The pursuit of science is greater than any fantasy, than any game.

Out of our joy in study, and our endeavors on mountain tops, oceans and laboratories come solutions to problems — the problems of the world. You want a solution to a problem? Well, at some point you have to start with someone who can think. "Reserve your right to think, for even to think wrongly is better than not to think at all." This was written by Hypatia — a scientist who taught mathematics in the Great Library in Alexandria, Egypt in the 5th century. She was quite an interesting lady. The people who think are the people who can resolve the world around them into sensible chunks. The people who can combine the sensible chunks into useful solutions are scientists and engineers.

Scientists do tend to share certain attributes: luck, intelligence, education, ability, courage, and sweat. There is no gender lurking in these features. None. THE RESULTS OF SCIENCE HAVE NO GENDER. That is worth repeating. THE RESULTS OF SCIENCE HAVE NO GENDER. We cannot back out of some invention, some theory, some solution whether or not the originator was female or male. Results are results are results. The path may vary (one could cogitate on variational calculus here, but I digress — the gender parameter in variational techniques is beyond my comprehension), but

the result will happen over and over again — or we throw it away and start fresh.

Talking about the Topic

One may ask why I write these things. I accumulated, mainly through serendipitous sources, information about some technical and scientific and creative women of the past. These women left a remarkable legacy. They were as resourceful and passionate about their work as any scientist today, and certainly as creative. I started small. I gave a few talks in local schools about women in meteorology (I was working for the U.S. Navy as a ship router at that time). Then I made a discovery. People did not know about these women! They

were surprised! Their textbooks never mentioned women in science. Who let this happen? How did these women disappear? THE RESULTS OF SCIENCE HAVE NO GENDER. Why don't we honor these women?

Now I had a goal.

After all, I was always a scientist — at least as far back as I can remember. I knew women did science — after all, I did it, and if I could do it, then anyone could do it. The hard stuff was writing all that poetry for English class! Well, this lack of information can be fixed. Tell people about those neat women. In the early 1980s I starting giving little talks, one after the other, in schools, colleges, Service Clubs, even departmental colloquia. People gave me more names, I gave more talks, and soon it was a Shapley Lecture, and things were now rolling on their own power. I learned how to *advertise* the talk to engage the interest of a school. With the help of Dr. Deborah Crocker at the University of Alabama we created a web page with all the details: www.astr.ua.edu/4000ws/4000ws.html

The editors of STATUS asked me to write an article, a background kind of thing, about my public lecture titled "4,000 Years Of Women in Science, Technology, and Other Altogether Creative Stuff" [that was given at the January 1999 meeting of the AAS/CSWA in Austin, Texas]. The title used to be "4,000 Years of Women in Science," but several engineers and inventors complained (with justification), so I changed it.



Women Hold Up Half the Sky

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The talk is a lot of fun to present. It is not an “in-your-face” kind of talk. It celebrates the wonderful women of the past without berating the wonderful men of the past. Being a bit prejudiced, I feel that astronomers have an edge here. We teach astronomy’s history to our students. For most of history, the history of science is defined by the history of astronomy and mathematics. Women were astronomer-priestesses in Sumeria. That is just about the beginning of the historical record. Throw in the engineers and inventors and one has a remarkable list. Of course, I am prejudiced here. Also toss out the physicians and nurses, because there were far too many of them to count. (This is called cleaning up the data in astronomy circles — this one category would swamp all the others — and is the others we want).

The audience reaction is usually quite positive. There are often those “oh neat!” type of comments. The one place where the talk fails to enchant is at a science department colloquium. You all remember those talks. If they don’t present lots of equations, then one’s time has been wasted. Frankly I always fell asleep during equations, but again I digress. My talk does not have any equations.

After I had gathered lots of names from the past I noticed what appear to be trends. The numbers are small and the interpreter (me) not an historian, so the conclusions may be completely faulty. I noticed that there were times in history where women had opportunities seemingly better than today. Remember, of course, that the vast, vast majority of people had no opportunity for scholarship. They were slaves, serfs, bound to the land, and with predestined lifepaths. Both men and women were denied. Now consider the part that is left. Anthropologists tell us that women in ancient Sumeria were physicians, astronomers, mathematicians and such. There were times in Europe (late Dark, early Middle Ages) that the women as well as the men were schooled in the great abbey schools. How can you explain a person like Hildegard (11th century), and Radegunde, and, and ... unless you see that women had opportunities too. Things changed when the abbeys and convents were closed, the libraries burned, and admission to universities was permitted only to the men. Yet even though the

access was difficult and even dangerous, women still succeeded.

Italy remained an interestingly unique place. The doors to the first modern university opened in Italy in the 9th century; they were open to men and women alike; they have stayed open to men and women through the centuries. Why, I wonder?

So has the 20th century changed things? I don’t know. It has certainly changed the percentages. There are now numbers of women in science too large to ignore. We are an economic force. This means our ability to change the system is great. What has changed during my life? I think more

families than ever before support their daughters in choosing technical careers. That is a good thing. I think that society is slowly allowing us to succeed as women both in and out of our careers, instead of insisting that we act as pseudo-men. That is a good thing. I think astronomy has been a wonderful place for women — always. Yes, we have been denied tenure, telescope time, grants, etc, but we are still here! We are succeeding; we are making changes; and we are doing great science too. I never thought astronomy had a problem; I did know that society did. Our problems have less to do with our being astronomers than with our being women in the late 20th century United States.

Here I have to actually declare my age — see how far women have come — I shall

actually do this. Sigh. I prowled around the edges of astronomy for many years, picking up a Masters Degree in nuclear physics along the way (they didn’t offer one in astronomy). I actually left the field to work for the U.S. Navy. The U.S. Navy was looking for someone who knew spherical trigonometry. They were amazed when I said “uh yes, of course.” I was the only applicant who understood the mathematics of navigation on a globe so I got the job. Celestial mechanics can take you far! After a few years of that, I found that working for a living instead of doing astronomy was not much fun. So at the old age of 42 I returned to grad school to complete the Ph.D. degree. I was very fortunate in my advisors, and in my fellow students.

So please tell your daughters and sons that the results of science have no gender. That science is a traditional human activity, and it involves thinking, and it is joyous. ❖



The Hymn to Ishtar Tablet, Nippur C. 1750 B.C.E. The tablet contains one of the world’s first poems — by En Hedu’anna — the first astronomer priestess of Babylon. The tablet is at the University of Pennsylvania’s University Museum in Philadelphia, Pa.



Kristy Dyer is a Ph.D. candidate in the Physics Department at North Carolina State University, working on supernova remnants and shock excitation.



Ruby Payne-Scott

Ruby Payne-Scott

By Kristy Dyer

THE FIRST WOMAN radio astronomer was an Australian, Ruby Payne-Scott. She worked on solar observations in the early history of the field with Joe Pawsey, A.G. Little, L.L. McCready and D. E. Yabsley, and J. Bolton.

Ruby Violet Payne-Scott was born in 1912 in Grafton, New South Wales. In 1933 she received a Bachelors of Science first class, with honors in math and physics, from Sydney University. She received a scholarship and obtained her teaching certification. In 1936 she finished a Masters in Physics (Ph.D.'s were not offered at Australian universities at the time). She was only the fourth or fifth woman in Australia to get an advanced degree in physics.

From 1936–1940 she conducted medical research in cancer radiology and worked for Amalgamated Wireless Australia. In 1941 Payne-Scott went to work for CSIRO as an Assistant Research Officer, working in the classified Radiophysics division on the war effort. “She soon became known around RP for her considerable intellectual and technical prowess, forthright personality and ‘bushwalking’ advocacy” (Home, 1988).

In March and April of 1944, Payne-Scott and Pawsey hung an aerial horn operating at 10 cm wavelength out the window of their lab, trying to detect “cosmic static.” Their receiver had a temperature of 3500 K, too high to detect radiation from the Milky Way.

However they should have been able to detect the sun (J.S. Hey had published a classified document in England on “Metre-wave Radiation from the Sun” in 1942), but their notes merely state they did not attempt to measure solar radiation. According to coworkers, the team had an efficient division of labor: McCready built the equipment, Pawsey was the supervisor and Payne-Scott was responsible for the mathematics and analysis of the data.

It is worth noting that Australian radio astronomy suffered from isolation both during and after the war. Australian journals were not widely read and there were great delays in publishing in British journals and research carried out by Martin Ryle’s group in England was often in direct competition with Pawsey’s group.

As a result, Hey (1973) credits McCready, Pawsey and Payne-Scott with being the first to relate solar radio emission to sunspots (“Solar radiation at radio frequencies and its relation to sunspots,” *Procedures of the Royal Society*, 1947, McCready, Pawsey and Payne-Scott) although Ryle and Vonberg’s work was published earlier, in 1946. The Pawsey group used a “Lloyd’s Mirror” — a cliff-side telescope that used reflections off the surface of the sea to create an interferometer. The paper contains a digression with far-reaching implications: “It is possible in principle to determine the actual form of the distribution in a complex case by Fourier synthesis by using information derived from a large number of components.” This was probably the first mention of Fourier synthesis in the context of radio astronomy. She goes on to comment that since it was not practical to vary the height of the cliff, in principal one could vary the frequency — in anticipation of multifrequency synthesis.

Payne-Scott was one of the few women scientists working for Radiophysics, a position not without incident. The National Standards Lab librarian scheduled a meeting to take the women to task for inappropriate behavior: smoking and wearing shorts. While Joan Freeman (the smoker) refused to attend, Payne-Scott changed into shorts for the purpose of the meeting. Not long after, the librarian was replaced with a more enlightened one.

Later Payne-Scott moved to the Potts Hill site where she worked with Little on developing a new interferometer and using it to observe solar noise storms and outbursts. Paul Wild, in *The Australian Physicist* (5, 117, 1968), described the experiment: “... another Pawsey-inspired experiment was put into operation and brilliantly performed by Payne-Scott and Little.”

At the time, the Commonwealth Civil Service had a policy that women could not hold a permanent appointment and be married. Ruby Payne-Scott had quietly married William H. Hall in 1944. She wrote a letter to protest the policy (not mentioning her own marriage) in which she expressed the opinion that the marital status of employees was not the government’s business. However in 1950, pending the birth of her first child, Payne-Scott resigned her job for “personal” reasons. She returned briefly in 1952 to attend URSI General Assembly, where she appeared in the front row of the conference photo.

She went on to raise two children and teach school, staying active in the Sidney Bushwalking Club. By the



Ruby Payne-Scott (far right) and her “Bushwalking Club”



Dr. Michelle Thaller is an outreach scientist at the SIRTf Science Center at the California Institute of Technology.

Sofia Krukovsky

By Michelle Thaller

I HARDLY HAD TIME to notice while I was working on my dissertation, but all of the old UNIX machines in the Georgia State University astronomy department were named after lesser-known historical astronomers. My advisor's machine was Plaskett (he was, after all, a massive star specialist), while the professor next door had Hogg. There were some female names too — like Hypatia, whom I remembered from Carl Sagan's "Cosmos" TV series. He described her death (lynched by a mob of Christians) as he strolled through the halls of the library of Alexandria, courtesy of the magic of video matting. Another machine was named Sofia. There are actually a number of historical astronomers named Sofia, but the machine in question was named in honor of Sofia Kovalevskaya. Sofia would probably never have thought of herself as an astronomer, but some of the mathematical work she did laid the foundation for understanding rotational and orbital dynamics, important considerations in astronomical problems.

On January 15, 1850, Sofia Krukovsky was born into a family of lesser Moscow aristocrats. Typical for that social stratum, she was neglected by her parents and raised by a strict governess, who instilled in Sofia the traditionally feminine traits of self-doubt and insecurity. The child was ignored to the extent that the walls of her room were left bare of decoration, so the servants covered them with cast-off old notes from her father's calculus studies. For Sofia, this was a rare link to her father and family, many of whom, it turned out, were mathematicians. When she was fourteen years old, she taught herself trigonometry in order to understand a prob-

lem in an optics textbook. She corresponded with the book's author, Professor Tyrto, who convinced her father to cultivate the impressive natural talent that lurked in the unassuming young woman.

After a few years of private tutoring in St. Petersburg (as schools were not open to young women), Sofia wished to attend university. The closest universities that admitted females were in Germany, but there was another problem; they would only admit married women (single women would have compromised the concentration of the male students). So, Sofia accepted a marriage of convenience to Vladimir Kovalevsky. The marriage caused problems for Sofia, and throughout its fif-

teen years it was a source of intermittent sorrow, exasperation and tension — her concentration was broken by frequent quarrels and misunderstandings with her husband. Sofia didn't lack for money, however, so the young paleontologist and entrepreneur accompanied her to Heidelberg. Soon after, she decided to move to Berlin to study under the famous mathematician Karl Weierstrass. Dr. Weierstrass didn't know what to think of the young female student at first, but Sofia's work won him over, and a true professional friendship was formed. She is quoted as having said, "all my work has been done precisely in the spirit of Weierstrass." In four years she had produced three papers (on partial differential equations, Abelian integrals and Saturn's rings), each of which Weierstrass deemed worthy of a doctorate. The first of these, "On the Theory of Partial Differential Equations," was even published in Crelle's journal, a tremendous honor for an unknown mathematician.

Sofia was awarded a doctorate in 1874, but was unable to find work despite the impassioned recom-



Sofia Krukovsky

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1970s Payne-Scott was debilitated by Alzheimer's, and died in 1981, close to her 69th birthday.

Ruby Payne-Scott worked only nine years in radio astronomy from 1941 to 1950. "And sadly, so ended Ruby's contributions to radio astronomy, her papers seemed to be so full of points and suggestions that were able to be developed and become outstanding discoveries in later solar papers from the Radiophysics Laboratory and elsewhere" (Richard McGee, private communication).

Thanks to Miller Goss (NRAO) and Richard McGee (CSIRO) for their research on Ruby Payne-Scott. We look forward to a possible book. ❖

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mentations of Weierstrass. She returned home to aging parents, and for some time dedicated herself to domestic responsibilities. A daughter was born to her and Vladimir. Soon after, Sofia returned to her work in mathematics with a renewed fervor. Gosta Mittag-Leffler, a former student of Weierstrass's invited her to lecture at the University of Stockholm. At first this was a temporary position, but after five years of excellent teaching and spectacular publications, the university offered her tenure. In 1885 she was offered the Chair of the mathematics department.

These years, while filled with professional triumph, were unfortunately marred by personal tragedy. None of

Vladimir's business ventures had panned out, and in a fit of despair he had committed suicide in 1883. Vladimir and Sofia had been separated for two years, and after the initial shock, Kovalevskaya immersed herself in mathematical work in an attempt to rid herself of feelings of guilt. In cruel succession, Sofia's beloved sister Anya died in 1887.

In 1888 she completed perhaps her most important work, "On the Rotation of a Solid Body about a Fixed Point." Prior to Sofia's work, the only solutions for the motion of a rigid body about a fixed involved cases where the body was symmetric. In her paper, Sofia developed a description of an asymmetrical body's rotation where the center of its

mass is not on an axis contained in the body. This work was done in isolation, as she was excluded by her gender from any mathematical library and/or professional society. Nonetheless, the paper was entered in a competition for the French Academy of Science's Prix Bordin ... and won. The paper was so highly regarded, the prize money was increased from 3000 to 5000 francs.

Sofia had been plagued by depression and anxiety all her life, and a scandalous affair with an academic colleague in

Stockholm didn't help matters. In 1890 her health began to fail, and in 1891, at the height of her mathematical powers and reputation, Sofia died of pneumonia. She was honored in 1951 and 1996 with a series of postage stamps (see images), and has a lunar

crater named after her as well. Throughout her life, Sofia had to constantly prove that she deserved consideration as a serious mathematician, and finally at the end it seemed that the academic community had accepted her. Her life was filled with the personal stresses imposed upon her by her social status, rigid upbringing, forced marriage, and unusual career choice. With so many weights on her mind and spirit, one wonders what else she might have produced had she had an easier path.

References for this article can be found at <http://www.agnesscott.edu/riddle/women/kova.htm>. ❖



NOTE

There will be a Special Session on the Status of Women in Astronomy at the January 2000 AAS meeting (Saturday, January 15, 10 am), organized by Meg Urry (STScI), Claude Canizares (MIT), and Priscilla Benson (Wellesley, and Chair of AAS Committee on the Status of Women in Astronomy). Short talks by Urry, Canizares, and Lotte Bailyn (MIT), will be followed by a panel discussion moderated by Steve Beckwith (STScI Director).

Notes From A Life

Contributions from our readers

NOTES FROM A LIFE, first printed in the June 1999 issue of STATUS, are anonymous vignettes describing the quotidian life of a woman in science. Here follow more "Notes" sent to us by our readers.

One reader suggested we publish "solutions" — ways to get past the occasional insult or awkwardness. Given the long interval between published issues, we suggest that responses to "Notes" be given in the AASWOMEN electronic newsletter, where real dialog is possible. Meanwhile, we continue to welcome submissions of "Notes" for publication in future issues of STATUS.

♀ I attended a conference in astronomy education in Australia in the summer of 1999. One of the invited speakers, a young man, presented a graph in which one of the points was represented by a silhouette of a shapely woman reclining, obviously nude. To cap it off, he announced, "I know that some here will find this offensive, but I couldn't find a male figure." My reaction was to sit there with my mouth open, but fortunately one of the older women knew how to react — she hissed. Loudly. I like this hissing reaction, but I think that the next time this kind of thing happens, I'll also get up and walk out until the next speaker is introduced — nobody's making me sit there to be harassed.

♀ As a young postdoc in a high-powered physics department, I attend a colloquium by a famous French man in which the opening slide is a topless dancer in a grass skirt on a Hawaiian beach. Some guys laugh and one female graduate student leaves quietly from the back (there are only a handful of women present). I myself am torn — I do not want to appear humorless or to overreact (cultural norms being different in France, for one thing), and I very much want to hear the talk, but after about 20 minutes I realize I have not heard a word he said and have not seen anything shown after that awful picture. Later, I ask some of my more enlightened colleagues about the episode. They are slightly

embarrassed but none ever says anything to the speaker, even the colloquium host, who saw the slide ahead of time. The speaker, by the way, later wins a prestigious prize named for a famous woman scientist. If it happened again? I think I would stand up, say clearly that this was unacceptable in late 20th-century America, and then walk out.

♀ Yet another inappropriate image was displayed at an astronomical conference in 1991 in Flagstaff, Arizona that I attended as an undergraduate. A male speaker intentionally puts up a slide of a female Greek statue in the buff, stating that its intended purpose was to "wake up" the audience. It was obviously unrelated to the astronomy topic at hand. The material that the speaker was presenting was totally put in the background while I spent the next 15 minutes absorbing what just occurred, analyzing the audience's response and thinking that this guy was a total jerk, regardless of his scientific achievements.

♀ A senior scientist and fellow Italian citizen, whom I know well but have not seen in several years, visits the institution where I am on the faculty. I say hello, and he replies, asking if I could take his clothes to the dry cleaners. He did not make the same request of an Italian man on the faculty, even though they are very good friends and had

Send your
"Notes" to
cmu@stsci.edu or
frattare@stsci.edu



Illustration by
Ann Feld

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spoken frequently prior to our encounter. I declined to run his errand.

♀ I am on a postdoctoral search committee at a university astronomy department. I read about 100 applications, each of which has typically three letters of recommendation. One letter, written by a male faculty member for a female applicant, emphasizes twice how tiny, sweet, and charming the applicant is, and gives a specific example of how amusing and cute it is to watch the applicant in the laboratory wrestling with astronomical instrumentation larger than she. The overall tone of the letter is extremely condescending and does little to address the scientific qualifications or creativity of the applicant. Should I have written the postdoctoral applicant, advising her never to ask this faculty member for a letter of recommendation again? Or does that violate some basic confidentiality rule?

♀ A colleague and I are walking down the hall in our Institute. Both of us were hired recently on the same project; I am more senior in years, he has the (slightly) more senior position. The head of the Institute walks up and starts talking to my colleague, ignoring me, even though he has met me on more than one occasion. Thinking he has forgotten my name, I put out my hand and remind him who I am. Despite the fact that they are discussing the instrument I work on, and technical issues with which I am directly involved, I am completely excluded from the conversation. My two colleagues make eye contact only with each other and I feel completely invisible, despite trying to participate in the conversation. After several minutes of being ignored, I walk away, wondering what (if anything) I might have done differently, or what it means that my new boss ignores me so thoroughly.

♀ Photographs are planned to be taken of all of the faculty in our astronomy department, as part of designing a new recruitment brochure for prospective graduate students. Our department has two women faculty and 20 male faculty. The female department secretary sends all faculty e-mail suggesting that coats and ties should be worn on photograph day. Fortunately, this offends the men's sense of fashion as well as the women's sense of politics; only four out of 22 faculty wear ties for their photographs.

♀ A research postdoc friend confides that within weeks of having his first child, his advisor pressures him to tough it out and still maintain 12-14+ hour days especially during normal working hours so as to make it convenient for the advisor. The non-teaching job and career are top priority — and the postdoc should put the newborn and the spouse all after the job. The temporary solution for the postdoc is to have his spouse quit her job to be the full-time parent but he is thinking of leaving the postdoc position and astronomy. The next semester the postdoctoral advisor has a child himself. As expected, it affects the advisor's work schedule for about a week, then things get back to normal with his wife tending to the newborn, taking care of other children, continuing her at-home business, and recovering from pregnancy complications.

The postdoc's reply to his lessons learned: "I actually feel better now about working since I've learned from other students that [my advisor] has always been this way. So it's not just me, as I originally had feared. I do think that if you look closely at all the most successful astronomers, you will find this trait in common almost 100% of the time. Their astronomy careers take precedence over everything else in life. It's unfortunate, but it appears to be a trait that gives them an edge over the others in the field who want other things out of life — and any advantage you can get in our competitive field is important." ❖



JAN. 2000 STATUS

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