STATUS

A REPORT ON WOMEN IN ASTRONOMY

JANUARY 2010

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Women and Mission Leadership

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Only one of NASA's planetary science flight missions in the past 30 years has been led by a women scientist as Principal Investigator. The number of senior women in the field is small, but women are still underutilized, as seen by a cohort age analysis correlating with median ages for various key science roles. Worse, the more junior women are not joining missions as Co-Investigators and Participating Scientists at rates approaching their representation in the field of planetary science. In fact, they are underutilized in these roles not by a few percent, but by greater than a factor of two. The pipeline of women gaining mission experience today is increasing, but it is not keeping pace with the rate that women are now choosing to stay in the field for postdoctoral studies and beyond. The numbers definitively show for the first time that, for whatever reason, women are still underrepresented in mission leadership at NASA.

1. Introduction

The National Aeronautics and Space Administration (NASA) selects two major kinds of planetary science missions for flight: institutional (also known as flagship) and Principal Investigator-led (PI-led) missions. While the traditional institution-directed missions dominated the nation's planetary science missions in NASA's first 35 years, PI-led missions have played a large role over the most recent decade and a half. NASA increasingly solicits mission proposals for small, PI-led missions, directed by a single PI with the support of a small consortium of universities, research laboratories, and/or NASA Centers. Small missions, such as those in the Discovery and Mars Scout programs, and

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Note from Editor

Fran Bagenal (Professor of Astrophysical & Planetary Sciences, University of Colorado, Boulder)

STATUS has been published as a printed newsletter once or twice per year for about 20 years. Most issues are now available on line (http://www.aas.org/cswa/STATUS.html), and we aim to archive as complete a set as possible. You can search these back issues for particular topics – there are all sorts of gems, wise words, plus a history of the past few decades of women in astronomy. With the email newsletter AASWOMEN as well as a plethora of online materials on the topic of women in astronomy, I feel that the printed STATUS no longer serves such a vital need. But, who knows, perhaps a spark will ignite enthusiasm to continue STATUS. For myself, five years of editing the newsletter has been an opportunity to read and research various aspects of women in astronomy and meet others who care about the topic. On behalf of all editors of STATUS, I thank those who contributed material and helped produce STATUS over the years. The status of women in astronomy has improved immensely over the past couple of decades. Yet, as articles in this issue – on the NRC report on gender differences in academia and on women's leadership of space missions – illustrate, there remain areas of our field where women do not yet have equal status. Let the discussion continue!

Fran Bagenal, Editor

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Women and Mission Leadership *continued*

medium missions, such as those in the New Frontiers mission line, are able to accomplish focused science investigations for limited cost. Costs vary by mission line: Discovery missions, for example, are allotted up to $425 million [1]; New Frontiers missions can cost up to $650 million [2]. Both are significantly more focused than the traditional institutional missions, which cost in excess of $1 billion each. With these smaller cost caps comes recognition that the investigations must be tightly focused, teams small, and changes during development resisted. Fifteen years after the first of these PI-led missions was competitively selected, with dozens of missions successfully launched and operated, the concept has been validated. Today there is a fleet of small, focused scientific investigations throughout the inner Solar System, and a set of Principal Investigators (PIs) proven capable of leading these missions to success.

The set of experienced PIs includes few women. Worse, the proportion of women in the pipeline to become PIs, such as those in other leadership positions and on the science teams, is not sufficient to dramatically increase the proportion of women leading future missions. In this sense, current selections, particularly those of Co-Investigator (Co-I) and science mission support positions, have an impact on future selections. Earlier in 2009, NASA confirmed that selection of new missions will be performed using a standard Announcement of Opportunity (AO) solicitation and thorough proposal review that would continue to assess, among many other technical, scientific, and cost related factors, "the commitment, spaceflight experience, and past performance of the PI and of the implementing institutions" [2]. Spaceflight experience does matter, and an aspiring PI would be well-served to work on others' missions before proposing to lead one. As planetary science progresses in large part thanks to data returned from new space missions, participation on flight missions has become an essential aspect of the work of the planetary science community.

A recent policy that required proposing PIs to show prior experience as a PI on a flight mission [3] had the effect, if not necessarily the intent, of barring younger investigators and almost all women from submitting proposals, because of their lack of previous experience in these specific science leadership positions, despite mission experience as members of the science team in numbers more proportionate to their representation in the field as a whole. A recent paper in this journal discussed the question of age [4]. This paper will examine the question of women's leadership on NASA planetary science missions and discuss the pipeline of women poised to propose in the future.

2. Mission management

As budgets permit, NASA periodically releases AOs calling for planetary science mission proposals. In response, PIs propose complete mission packages including instrument design and development; spacecraft bus specifications; integration, test, and launch parameters; mission operations; and a team of scientists essential for successful conclusion of the core scientific investigation. The PI has primary responsibility for implementing and executing the selected investigation, and "is accountable to NASA for the success of the investigation, with full responsibility for its scientific integrity and for its execution within committed cost and schedule" [2]. PIs rely on project managers and project system engineers for much of the daily engineering leadership, but the PI maintains final approval over all trades that may affect the acquisition of the science or the integration of the instruments, as well as any that would significantly change the budget or require greater reserves. Clearly, a mission PI must not only be an outstanding scientist, but must have sufficient project and mission experience to plan and execute a new mission, from design and development to operations. Each mission is selected as a complete package; all members of the science team necessary for design, development, implementation, mission operations, and preliminary data analysis are named at proposal.

Women and Mission Leadership *continued*

2.1. Key science roles

One way to augment the PI's effectiveness is to appoint key players to assist in the planning and implementation of the mission. Key scientists on the mission team can be charged with roles such as managing the science team, interacting with the engineering leads, overseeing instrument development, and planning for operations. Popular options include a Deputy Principal Investigator (DPI), whose role is defined by the PI, and a Project Scientist (PS). The PS is typically appointed by and located at the managing institution, typically a NASA Center or the Applied Physics Laboratory (APL) at Johns Hopkins University. PSs provide day-to-day support and communication between the scientists who have defined the requirements and the engineers building the hardware. In addition, a Deputy Project Scientist (DPS) may be located at the managing institution or elsewhere, such as on location with an industry partner. These four roles, following the nomenclature used in the previous PI experience policy announcements [3], will be collectively referred to as the ''key science roles'' in this paper.

2.2. Co-Investigators

Additional science team members, or Co-Is, each play a vital role on a mission team, and each is generally responsible for implementation of a part of the mission's science plan. The range of responsibilities varies greatly, but may include delivery and/or operation of an instrument, completion of a scientific investigation, and/or performance of supporting observations from ground-based telescopes or other space assets.

2.3. Participating Scientists

Occasionally NASA, the mission team, or both wish to add more investigators to the science team. These new investigators are called Participating Scientists; they are integrated into the mission to varying degrees. The Participating Scientists are selected by NASA Headquarters, as were those in the originally selected key science roles. For Participating Scientists, NASA, in cooperation with the PI, releases a NASA Research Announcement requesting proposals of complete science investigations that may be performed using one or more instruments on a particular operating mission. These proposals undergo a rigorous peer review that considers the proposed investigation, how the proposed investigation would complement those already planned by the science team, potential contribution to mission operations and planning, possible improvement in the planned data products for team use and delivery to the Planetary Data System, and the need of the proposer to be on the team to ensure the acquisition of the appropriate data during the mission's operation [5]. Through Participating Scientist Programs, teams can boost their membership as needed, a technique that is particularly appropriate when used to bring new scientists into teams that have been working on the mission for many years, and the spacecraft is finally approaching its target.

3. Methodology

Leading a planetary science mission is incredibly difficult; it is not something that is easily attempted without prior experience with a flight mission or project. Qualified PI candidates, therefore, are most likely to be drawn from the pool of scientists who have previously worked on a mission in one of the key science roles or as a member of the science team, such as Co-Is or Participating Scientists. To take a closer look at the demographics of the scientists in these roles, the paper will first examine closely the representation of women in these roles in the oldest PI-led mission line, the Discovery Program, and then look across the broader field of planetary science.

Demographic data are not collected or used by NASA. To perform this study, the author used data collected from publicly available sources, such as press releases and mission web sites. Collated lists of names for Discovery missions were then confirmed with NASA representatives and/or mission Principal Investigators for accuracy. Additional statistical data were received from NASA Headquarters and the American Astronomical Society upon request. All analysis was done specifically for this study and is outside of the selection process at NASA. The results reported in this paper and the preceding paper [4] are the first known demographic study of scientists selected to lead NASA missions.

3.1. Case study: the Discovery Program, 1992–2009

A case study was performed of the demographics of scientists filling the key science roles and Co-Is selected by NASA to implement a mission in the Discovery Program of small PI-led planetary science missions from the program's start in 1992 to mid-2009, and of Participating Scientists selected to participate at later stages of the missions. The Discovery missions are NASA's least complex planetary science missions and can be characterized as relatively low in cost (less than $425 million in Fiscal Year 2006), straightforward in development (less than 35 months from the beginning of implementation to launch), and without constraint of a particular management structure imposed by NASA [1]. The missions are Mars Pathfinder, NEAR, Lunar Prospector, Stardust, Genesis, CONTOUR, MESSENGER, Deep Impact, Dawn, Kepler, and GRAIL. All missions after Mars Pathfinder and NEAR were competitively selected and PI-led.

Where possible, the author has chosen to avoid ''single point'' data bins that would identify a unique individual. In some cases, however, the statistics are so small that there was no other meaningful way to aggregate the results.

3.2. All planetary science missions, 1979–2009

While the Discovery missions are recent and varied, the past 30 years in planetary science have also included many Mars missions, several institution-class missions, and several smaller missions that fall outside the Discovery mission line, including two in the New Frontiers line of larger missions. After the presentation of the case study results, the paper will repeat the

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analysis for the set of all 27 planetary science missions launched since 1979 or currently in development in order to determine the number of women with experience on planetary science missions in the past 30 years.

Besides Discovery, 14 other planetary science missions have been launched in the past three decades; eight of these have been sent to Mars. Mars missions are Mars Observer, Mars Global Surveyor, Mars Climate Orbiter, Mars Polar Lander and Deep Space 2 probes, Mars Odyssey, Mars Exploration Rovers, Mars Reconnaissance Orbiter, and Mars Phoenix. Other planetary missions are Magellan, Galileo, Clementine, Cassini, Deep Space 1, and New Horizons. All these missions have been institution-led except for Mars Phoenix and New Horizons. Two additional PI-led missions, Juno and MAVEN, have been selected but not yet launched, for a total of 11 Discovery and 16 non-Discovery missions.

4. Results from the Discovery Program

4.1. Key science roles

The number of planetary scientists selected by NASA to serve in a key science role on a Discovery mission is shown in Fig. 1, by gender. In each category, only once has a woman been selected in that role. None of the missions have had more than one woman in the key science roles combined. There are therefore only three women who served in a key science role on a Discovery mission, in sharp contrast to the 20 men (see Fig. 1).

4.2. Co-Investigators

Expanding the field to include Co-Is improves the numbers of women, but not the percentage of the population. In addition to the key science roles above, women have been selected to participate on missions as Co-Is 19 times in the history of the Discovery Program; 159 men were selected in the same time period. The percentage of female Co-Is (11%), is therefore consistent with the percentage of women in key roles (13%) but both numbers are small.

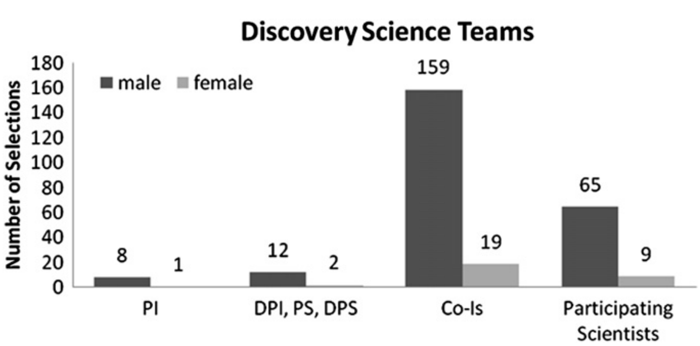

Fig. 1. Gender of scientists selected as PI, DPI, PS, DPS, Co-I, and Participating Scientist on Discovery missions, 1992–2009.

Individual missions show more variation, but even the most diverse do not show equity in proportion to the number of women in the population at large (51%). Each of the 11 Discovery mission teams, analyzed separately, has had a relatively small fraction of women on the science team, in key science roles or as Co-Is (0–23% female).

4.3. Participating Scientists

The argument has been made that the gender diversity of the missions can be supplemented by the Participating Scientist selections made by NASA Headquarters. The numbers do not indicate that this has happened, however. Only nine of the 74 Participating Scientists (12%) selected for Discovery missions have been female. This percentage is roughly equal to both the percentage of women in key science roles and the percentage of female Co-Is.

Interestingly, four of the nine women selected as Participating Scientists were selected as part of a single NRA call, making up 21% of the Participating Scientists on MESSENGER. That leaves just five women on the remaining four missions, leading to the conclusion that, in general, Participating Scientist Programs, while helpful in adding early career scientists to missions [4], have not been an effective mechanism for recruiting additional women for NASA missions. These programs are a tool that can be used to increase diversity on mission teams in many ways, from scientifically to operationally, but these selections have not been shown to add significant gender diversity to previously selected teams.

5. Results over all planetary science missions, 1979–2008

The case study of the Discovery Program has shown some clear trends in age [4] and gender for the various science leadership roles on small planetary science missions. Because of the small numbers of both missions and women in planetary science, however, it is also instructive to look at these trends over the entire suite of planetary science missions over the past 30 years. Expanding the investigation also allows a more complete description of the field of experienced scientists who may propose missions in the future.

5.1. Key science roles

The 16 other missions have been led by 72 PIs, DPIs, and (in the cases where there is no single PI) Instrument PIs (IPIs). There have been 21 PSs and 11 DPSs. Some, like the technology demonstration mission Deep Space 1, have had relatively young teams, while larger, once-a-decade flagship missions have tended to have teams of more experienced PIs and Co-Is. There has been some movement from Co-I to PI across this set of larger missions, but not significant repetition in the lead PI roles.

The data are striking in the analysis of gender. None of the 16 other missions has been led by a female planetary scientist in the role of PI, making the Discovery mission GRAIL the only one of

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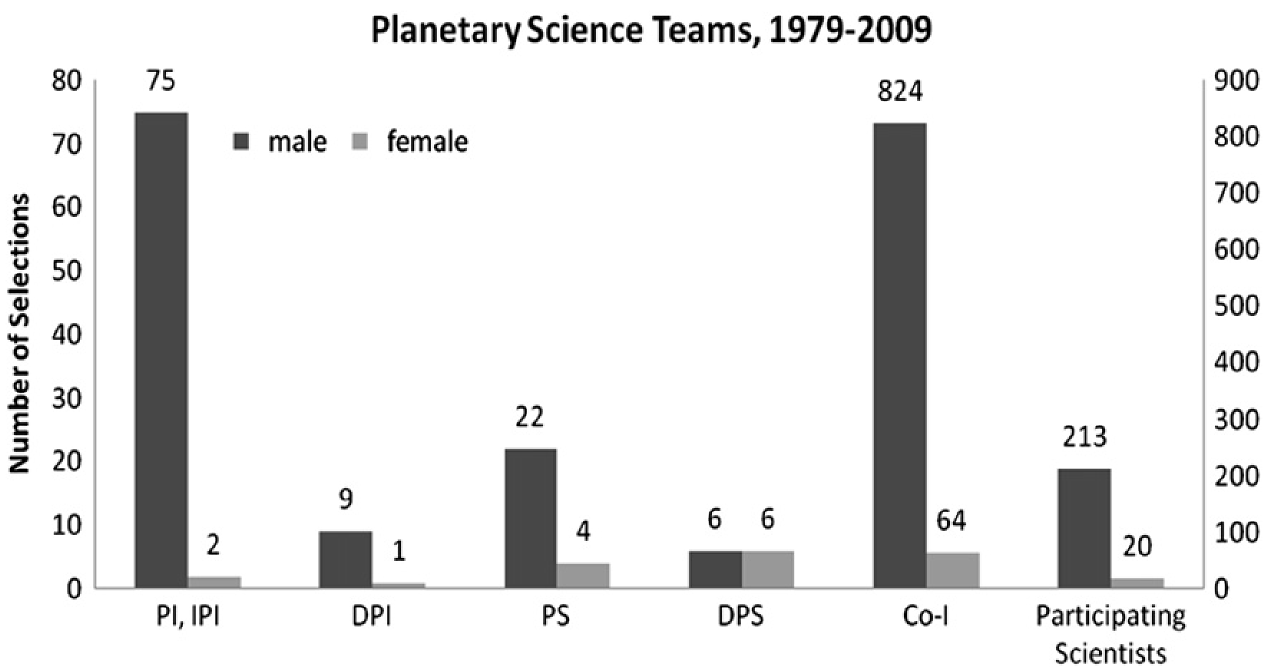

Fig. 2. Gender of scientists selected as PI, DPI, PS, DPS, Co-I, and Participating Scientist on any of the planetary science missions, including the Discovery missions, launched by NASA in the last 30 years (1979–2009) or currently in development.

the 27 planetary science missions in the past 30 years to be led by a woman. Only Galileo has had a female IPI. If one were to add the two launched Discovery missions of opportunity to the data set, only the Moon Mineralogy Mapper has had a female IPI on a stand-alone instrument. Only Dawn has had a female mission DPI. In all, women have made up just 12% of the scientists in key science roles. The combined data set for all 27 planetary missions, 1979–2008, shows a clear underutilization of women in mission leadership in all key science roles except the most junior (see Fig. 2).

5.2. Co-Investigators

It is in the examination of the gender balance of Co-Is, however, that we can most closely approximate the pool of potential PIs. The Co-Is from PI-led missions are among the most recent, but a census of all missions over the past 30 years provides a more comprehensive look at the total community of experienced Co-Is who may be ready to lead a mission. This census, like all the other data summations in this paper, is a count of the selections made by NASA, not the number of actual scientists. For instance, while the number of times that a woman has been selected as a Co-I is 64 (of 888) the actual number of women with Co-I experience is only 41, because experienced scientists often serve on multiple missions. Of Co-Is selected to participate on planetary science missions over the past 30 years, 7% of the selections were women.

5.3. Participating Scientists

Twelve of the planetary science missions have had Participating Scientist Programs: NEAR, Mars Pathfinder, Mars Observer, Mars Global Surveyor, Mars Odyssey, Mars Exploration Rovers, Mars Reconnaissance Orbiter, Magellan, Cassini, MESSENGER, Stardust, and Kepler. In all these proposal opportunities, women have been selected as Participating Scientists 18 times; men have been selected 217 times. Women have therefore participated at a rate of less than 8% of the total.

6. Cohort analysis

A common argument when faced with the question of the underutilization of women in key roles begins with the assertion that there is simply not a significant number of women entering and staying in the relevant fields from which these leaders are drawn, and therefore the number of women at the top of the field is expected to be small [6]. The American Institute of Physics has knocked down this issue in a related area by utilizing cohort analysis: the importance in tracking the collective success of women scientists over time in relation to their numbers in the field. In fact, a recent study shows that women in astronomy are currently significantly more successful in obtaining tenured professorships mid-career than their male peers, relative to their numbers in the field [7]. In the same way any consideration of women's success in proposing and participating in PI-led missions must discuss their representation on missions relative

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to their representation in the field as a whole. We can combine the data in the previous section with the age data released earlier this year [4] and cross-reference it with membership statistics obtained from the American Astronomical Society (AAS) [8] to determine how, for example, women planetary scientists have fared. The AAS maintains historical records for the membership as a whole, including planetary, astrophysics, and heliophysics researchers, and kindly provided a snapshot of the AAS Division of Planetary Science (AAS DPS) membership data from the current membership rolls for use in this study.

6.1. Median ages at selection

First, let us look at the case study again, the Discovery Program. In the previous paper, median times since PhD for the key science roles were calculated for the various roles: 28 years for PIs, 32 for DPIs, 18 for the set of PSs and DPSs, 22 for other Co-Is, and 13 for the Participating Scientists. Using a nominal time-to-degree of 28 years, we can calculate that the median ages are therefore 56 for PIs, 60 for DPIs, 46 for PSs and DPS, 50 for Co-Is, and 41 for Participating Scientists. It must be emphasized here that, for privacy reasons, these ages were not calculated based on birth dates; a given scientist may have taken more or less time to complete his Ph.D.

6.2. Gender balance, varying with age

While these median ages are spread by no more than 20 years, from Participating Scientist to DPI, the proportion of women in the field does vary significantly over these 20 years [9]. Where women make up only 10% of the community, for example, it is not reasonable to expect them to make up more than 10% of the science leadership. So to quantify the underutilization of women in planetary science missions, we must look at the relative numbers of women by age and relate that to the median ages of the key science roles discussed above. For simplicity, we will postulate that the median ages calculated for the Discovery Program correlate adequately to the median ages expected for planetary science as a whole. Table 1 combines 2009 data from the AAS on the percentage of AAS DPS members that are women in various age groups with data from the current demographic study to show the representation of women on flight missions, relative to their representation in the AAS DPS population at large. AAS DPS May 2009 membership data included 1237 members; 912 gave both gender and birth date. Of the 912, 165 were women, 746 men [10]. AAS DPS membership data from earlier years were not available.

6.3. Women's participation relative to population

In the Discovery Program the PI role was determined to be filled by scientists with a median age of 56. At 56, 15% of DPS members are women. Across all NASA's planetary science missions in the past 30 years, only two of the 80 PIs or IPIs are female, giving a percentage of less than three. Comparing 3% to 15%, we conclude that women are underutilized as PIs and IPIs in planetary science by more than a factor of five (see Table 1).

Women are, however, filling the role of PS or DPS about twice as often as their representation in the field would suggest. This may indicate a discrepancy between the role of Co-I, filled by the PI of each mission, and the roles of PS and DPS, filled by the implementing institution with the approval of the PI. The trend is not strong enough to make any conclusions on this issue, however, as women are serving as DPI, a critical and PI-appointed position, at about the same rate as their participation in the field.

Co-Is in Discovery are, on average, about 50 years old. Eighteen percent of DPS members aged 48–52 are female. Only 7% of Co-Is on planetary science missions over the past 30 years have been female. Women are therefore underutilized as Co-Is by a factor of 2.5.

The median age for Participating Scientists is about a decade younger than the median for Co-Is [4]. Over this decade, the proportion of women drops from 24% of all DPS members to 18% of all DPS members. The ratio of women to men in Participating Scientist Programs is 8.6%, less than the expected 24% by nearly a factor of three.

Although women are being tapped for DPI, PS, and DPS positions, women are still underutilized in the roles of PI, Co-I, and Participating Scientist in proportion to their representation in the community at the typical ages that fill those roles. This is an issue for the future of the planetary science community, as today's Co-Is are tomorrow's leading PI candidates.

Table 1
Relative representation of women on planetary science missions, 1979–2009, as compared to their membership in the AAS DPS at a given age range. Women are underrepresented in the roles of PI, Co-I, and Participating Scientist; women are overrepresented in the role of PS and DPS, and women are serving as DPI in approximately the same proportion that they join the AAS DPS.

Role	Median Age [4]	% DPS members in 5 y age bracket who are women	%Planetary Scientists in role who are women	Relative representation of women on planetary science missions
PI, IPI	56	15	2.6	Underrepresented ~5
DPI	60	12	10	About the same
PS, DPS	46	14	26	Overrepresented ~2
Co-I	50	18	7.2	Underrepresented ~2.5
Participating Scientist	41	24	8.6	Underrepresented ~3

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7. Women's participation over time

Over time the percentage of women selected as Co-I has increased unevenly. The percentage of women selected as Participating Scientists has increased at a more regular rate (see Fig. 3). The two data points shown in the figure for selection of female PIs and IPIs reflect the selection of a woman as a Galileo IPI in 1991, one of the 18 PIs or IPIs selected that year, and the GRAIL PI in 2006, selected during the same time period as Juno and MAVEN. Although the overall statistics are small, it is also interesting to note that five of the six female DPSs have been on missions launched since 1999.

The only comparable data available to illustrate changing demographics in the field of planetary science over this time period, the decadal AAS DPS surveys, indicated that the overall AAS DPS membership was 14% female in 1995 and 23% female in 2005 [10]. More women are joining AAS DPS over time, and, presumably, staying in the field, but they are not yet selected as Co-Is, Participating Scientists, or many of the other leadership positions in similar numbers.

It has previously been shown that the representation of women in broader fields of physical sciences is growing [6,7,9e 11]. One way to illustrate the increase of women in planetary science and closely related fields over a longer time period is to review the number of women obtaining doctoral degrees and proceeding to postdoctoral appointments in those fields. The National Science Foundation's Survey of Earned Doctorates annually tabulates the demographics of recent PhD graduates and their career path. Planetary science is not a standard field in this survey, but the numbers may be approximated by an examination of the three main fields in which planetary scientists are trained: earth science, astronomy and physics. In 1999, the first year for which such information is available, 23% of earth science postdoctoral fellows were women, 16% of astronomy postdoctoral fellows were women, and 11% of physics postdoctoral fellows were women. By 2006, the most recent year available, the numbers had increased to 28% for earth science, 23% for astronomy, and 15% for physics [11].

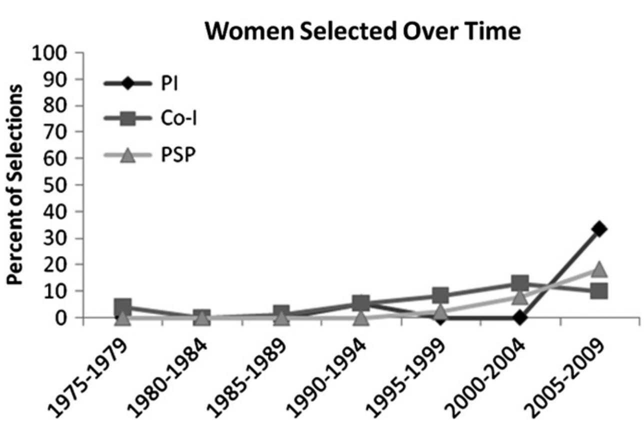

Fig. 3. Over time, the percentage of women selected as Co-I has increased unevenly; the percentage of women selected as Participating Scientists has increased at a more regular rate.

Comparison with historical trends over a larger time scale is limited to discussion of doctoral recipients, which introduces even greater lag time between data collection and selection as Co-I. In 1966, the earliest year available, 3% of earth science doctoral degrees, 5% of astronomy degrees, and less than 2% of physics degrees went to women. Since the first missions in this study were selected in 1979, this cohort of doctoral degree recipients would have been 13 years post-Ph.D., just younger than the average Co-I selected for Discovery missions (and probably not far from the correct age range for the Magellan mission). By 2006, 35% of earth science degrees, 28% of astronomy degrees, and 17% of physics degrees were earned by women [11].

Clearly, the field is changing. The typically lengthy career path to selection as PI means that women are unlikely to be selected in numbers this high for years, but it is probable that numbers of women in mission leadership will continue to grow with the numbers of women in the field.

8. Conclusions

This paper grew out of an attempt to determine the accuracy of the perception that few women are leading NASA planetary science—and, in fact, space science—missions. Although it is popularly held that the number of senior women in the field is too small to support many women PIs, this analysis has shown that the number of women PIs is actually even smaller than it should be, based on the typical age of PI selection and the percentage of women in planetary science at that age. This statement is no less true for Co-Is and Participating Scientists, although women are being selected as DPI and PS at rates comparable to their participation in the field. The underutilization of women scientists on missions today has consequences for the future. The absolute numbers are quite small—possibly too small to support an equitable number of women likely to propose and serve on missions in the coming years. The pipeline of women gaining mission experience today is not keeping pace with the rate that women are now choosing to stay in the field for postdoctoral studies and beyond. It is not clear why the numbers are so low, particularly at the Co-I and Participating Scientist levels, but this study shows that the representation of women is depressed, and brings the discussion beyond the anecdotal. For a significant number of women to be prepared to lead missions as PI in the next 20 years, they must be selected for Co-I and science roles in greater numbers than the statistics show are true today.

The analysis in this paper is limited by the statistics of small numbers—but the women in planetary science are not. There is no preconception on the part of NASA Headquarters or the author that women should be selected in proportion to their representation in the population as a whole, their participation in the field of planetary science, or their subdiscipline. In fact, it is quite possible that women will lead missions in proportions in excess of their representation in the field, simply because their

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representation in the field as a whole is currently depressed with respect to their representation in the general population.

The figures presented in this paper definitively show for the first time that, for whatever reason, women are still underrepresented in mission leadership at NASA. It would serve the community well to understand the reasons for this, to be sure that needed leadership and talent are not being overlooked when selecting teams to plan and execute the challenging space science missions proposed in years to come. Exploration of the Solar System is a task that requires the very best scientists, engineers, and managers, regardless of gender.

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Gender Differences in Academia

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It's finally out! You can purchase it at your local NRC website! Don't miss the latest in Women In Science demographics studies! Well, it is true that it has taken a while to become public. And the results have been very carefully presented. But I suspect there will not be a mass rush to purchase the 373-page report (downloadable for $43 from The National Academies Press—hard copy predicted sometime in 2010). So, let me give you my quick take on the major results.

MIT astrophysicist Claude Canizares and Yale neurobiologist Sally Shaywitz co-chaired a special committee of the National Research Council of the National Academies and recently presented their report *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty*. The committee was initially chartered to address questions raised by Senator Ron Wyden (D-Oregon) about whether universities receiving federal funds were violating Title IX. They harnessed the statistical power of the American Institute of Physics and launched two detailed surveys of top research universities in 2004 and 2005. Data from these surveys are far from fully mined, but the report presents the main findings.

The first thing to remember is that this study was entirely confined to academia and tenure-track faculty specifically. The percentage of research being carried out in universities vs. elsewhere varies with field, but academia is often held up as the archetype, the "standard model" (rightly or wrongly).

I had been following the slow progress of the committee and bothering the NRC staff with questions about when the report would come out. So, on a 5-hour flight back from the AAS' Division of Planetary Sciences annual meeting in Puerto Rico, I sat back and relaxed with the fat binder of tables, findings and carefully-written (agonized-over?) paragraphs. It is a fascinating read. But I suspect most readers would prefer the executive summary – or the 2 minute-version.

Gender Differences in Academia *continued*

TABLE 3-9 Steps Taken to Increase the Gender Diversity of the Candidate Pool

Step	Number of Departments Reporting
Targeted or special advertising	80
Other	71
General advertising	58
Recruiting at conferences, contacting women directly, using personal contacts	47
Help from diversity/EEO office or coordinator	47
Contacting colleagues and other universities	42
Special language used in advertising	34
Special consideration to females (e.g., making extra effort to interview females)	34
Informal networks	25
Grants or special funds for hiring women	19
Target of opportunity	19
Use of special databases or directories	18
Having a diverse search committee	17
Broadening searches	11

NOTE: Many of the 417 departments provided multiple answers to the open-ended survey question, and 71 departments reported they have taken steps other than those listed in the table.
SOURCE: Survey of departments carried out by the Committee on Gender Differences in Careers of Science, Engineering, and Mathematics Faculty.

This is what I picked out as the salient results:

- Once women get into academia as a member of the tenure-track faculty they seem to be promoted at pretty much the same rate as men. There are some differences between fields and institutions but overall there is little statistically-significant leakage along the academic pipeline.
- Once women apply for faculty positions they tend to have a probability of being hired in proportion to the application rate.
- Applications for faculty positions from women (compared with men) are significantly below the rate one would expect from the rate of PhD production in that particular field.

So, WHY are women not applying for faculty positions? The report does not attempt to address this issue apart from mentioning, almost in passing, that each woman may be applying for fewer positions than her male colleagues. This is consistent with anecdotal evidence from my colleagues. But it begs the question WHY are they not applying for faculty jobs?

One could imagine a variety of reasons why women do not apply for faculty positions ranging from being put off by the behavior of professors they had observed, to the 2-body problem, to perceptions of difficulties in raising a family in academia (as Meg Urry counters "If you think academia is not family friendly,

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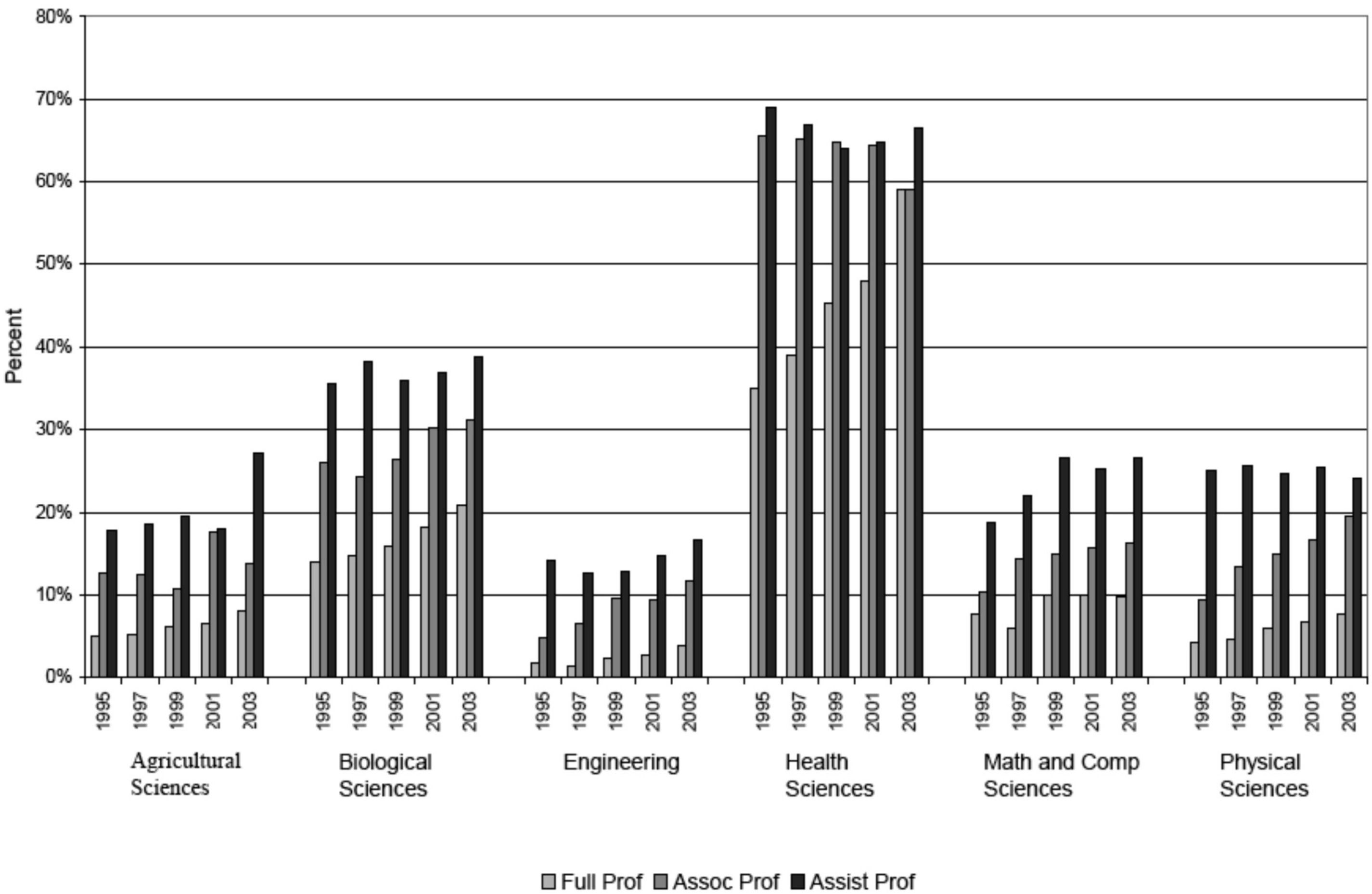

Percentage of faculty who were women by rank and field, 1995-2003. Source: NSF survey of doctoral recipients. Tabulated by the NRC.

try Walmart"), to … perhaps they just prefer to work somewhere else like JPL or STScI or Green Bank.

What does it take to get women to apply for faculty positions? Here are some findings that could be helpful for universities wanting to hire women faculty:

Finding 3-6: Five factors were associated with the probability that at least one female would apply to a position, including: (1) the type of position; (2) the number of family-friendly policies in effect at the institution; (3) a set of discipline indicators; (4) prestige of the institution, and (5) type of institution. No other factor was statistically associated with the probability of at least one female applicant.

Finding 3-7: Most institutional and departmental strategies proposed for increasing the proportion of women in the applicant pool were not strong predictors of the percentage of women applying. Most steps (such as targeted advertising and recruiting at conferences) were done in isolation, with almost two-thirds of the departments in our sample reporting that they took either no steps or one step designed to increase the gender diversity of the applicant pool.

Finding 3-8: The proportion of females on the search committee and whether a woman chaired the committee were both significantly and positively associated with the proportion of women in the applicant pool.

(Bother. More service work for women faculty. There goes my hoping to get off the next search committee…)

What are the sorts of things that help recruit women? Here are some examples from the report:

- Increased institutional efforts in signaling the importance of a gender-diverse faculty. This might be accomplished by increasing the frequency of positive declarative institutional statements, by establishing a committee on women, by exercising close oversight over the hiring process, or by devoting additional resources to hiring women.
- Modified and expanded faculty recruiting programs. Consider, for example, creating special faculty lines

Gender Differences in Academia *continued*

earmarked for female or minority candidates, ensuring search committees are diverse, encouraging intervention by deans when applicant or interview pools lack diversity, and systematically assessing past hiring efforts.

- Improved institutional policies and practices. These might include inserting some flexibility into the tenure clock, providing child care facilities on campus, establishing policies for faculty leave for family or personal reasons, significantly stepping up efforts to accommodate dual career couples, and continuing to offer training at all levels to combat harassment and discrimination and to raise the awareness of all campus citizens.
- Improved position of candidates through career advising, networking, and enhancing qualifications.
- Defining searches broadly to encourage a more diverse applicant pool.
- Posting the job advertisement in a wide range of outlets.
- Contacting professional associations that represent women (e.g., the Caucus for Women in Statistics, Society for Women Engineers, Association of Women in Science, etc).
- Evaluating the applicant pool during the search to determine if sufficient numbers of women are applying.

When departments were asked about their hiring practices only slightly more than 10% reported taking three or more steps to recruit women (see table). I suspect that the most important factor is asking qualified women to apply. So… are you a qualified woman, e.g., less than 10 years out from PhD, couple publications per year, some significant first-author papers—and a moderately thick skin? Apply, apply, apply! You have nothing to lose.

International Year of Astronomy (IYA) Cornerstone Project: *She is an Astronomer* (SIAA)

C. G. De Pree is Associate Professor of Physics & Astronomy, Agnes Scott College, and Director at Bradley Observatory, Decatur, GA.

"Promoting gender equality and empowering women is one of the United Nations Millennium Development Goals. The aim of the IYA2009 cornerstone project, *She is an Astronomer*, is to provide information to female professional and amateur astronomers, students, and those interested in the gender equality problem in science and provide a focal point and forum for women in astronomy."

The International Year of Astronomy (IYA) is a yearlong, global celebration of the 400th anniversary of the first use of the telescope ion 1609. IYA has a number of "cornerstone" projects, including the Galileoscope (a small, affordable telescope), and From Earth to the Universe (a collection of astronomical images on display in public locations around the world), positioned to increase public awareness and participation in astronomy.

The *She is an Astronomer* (SIAA) cornerstone project has as its goal providing information to all those who are interested in gender equality in astronomy. The main repository for information about the SIAA project and its activities is its web site (http://sheisanastronomer.org), which was launched at the European Astronomy and Space Science meeting (20–23 April, 2009), held at Hatfield, UK. The site been expanded since its initial launch. Project Chair, Helen Walker, noted that "Women were contacting *She is an Astronomer* as soon as the website went live, telling us about activities and events in their part of the world."

The IAU General Assembly in Rio, Brazil turned out to be a whirlwind of activity for Walker who has been organizing the year's activities.

"I have been delighted to find even more countries than I knew about have been doing things for *She is an Astronomer* and IYA2009," she said. "In Turkey female astronomers visited schools, in the Russian Federation they have celebrated the work of some of their senior scientists. It is proving hard to keep up with everything!"

"One incredible surprise with the project is the excitement it has generated," says Walker. SIAA activities continue through the end of 2009, and a full list of the activities related to women in astronomy is appended below.

The field of astronomy continues to attract women, and like all disciplines, it will benefit from the participation of women.

There is great disparity in women's representation, with some countries having no female professional astronomers at all and other countries having over 50% women. The fraction of women in the profession at more senior levels drops in all countries, suggesting that scientific careers are heavily affected by social and cultural factors, and are not determined solely by ability, and that the changes in representation at younger ages has not yet percolated up through the ranks.

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She is an Astronomer *continued from page 11*

In order to investigate some of these social and cultural factors in an informal way, profiles have been collected from interviews of female astronomers around the world. The SIAA Project invited female astronomers from a variety of nations, at different stages in their careers, to reflect on their career and life trajectories. The project supplied a questionnaire to help women focus on the key issues related to their careers and lives, but they did not have to answer the questions directly and could submit an essay instead. You can browse the current set of questionnaires (which are regularly updated) at http://www.sheisanastronomer.org/index.php/profiles.

Raising awareness about women's contributions to astronomy is another goal of the SIAA project, and the group has taken a variety of approaches in this regard. One of the most dramatic is the beautiful color calendar (in English and Spanish) that highlights the lives and contributions of historical women astronomers. The 2010 calendar is available for download at: http://www.sheisanastronomer.org/index.php/downloads/calendar

As the Task Group Chair of the SIAA project, Helen Walker presented a talk on the project and distributed questionnaires to collect statistical information on women working in astronomy around the world at the IAU General Assembly in Rio, Brazil. The information in these questionnaires will be used to supplement a variety of information about women in astronomy that has been collected at the web site. She also presented Resolution B4 on gender equality for a vote at the IAU meeting.

The General Assembly of the IAU voted in favor of Resolution B4 (printed in full below) on Thursday, August 13, 2009.

For further information about *She Is An Astronomer*, please contact Helen Walker
helen.walker@stfc.ac.uk
(UK) +44 (0) 1235 446 490

Image credit: Naveen Nanjundappa/Bangalore Astronomical Society

RESOLUTION B4

On Supporting Women in Astronomy

Preamble:

On supporting women in astronomy

Let us assume, no, let us assert that women are as capable as men of doing science, and that women do good science too. In an ideal world the mix of men and women doing astronomy would be 50-50. If we look at this General Assembly, there are a lot of women present, and yet... I have the numbers from the National Organizing Committee—667 out of 2109 participants are women—31.6%. Were 30% of the speakers women in the sessions you attended? 30% of the invited speakers? 30% of the session chairs?

The IAU itself does less well—in 2003, 12.1% of all IAU members were women. This rose to 12.9% in 2006, and now in 2009 it stands at 13.6%—around a 0.7% increase per triennium.

So, what to do? There has been no previous resolution concerning support for women in astronomy. The IAU has passed non-target-specific resolutions before, for example the Washington Charter on communicating astronomy to the public, and education-related resolutions. We know one size does not fit everyone—each individual IAU member and each National Representative knows their community and where their effort should be best focused—school, university, early-career, late-career—where support and encouragement is most needed in their community.

We need more astronomers. We need good astronomers. The IAU strategic plan for example will need a lot of astronomers. Science is advanced by having the largest possible pool of astronomers, and we are currently fishing in a pool with too few—a significant fraction is missing, so let us increase the pool.

Please support Resolution B4 and support them. Thank you.

Resolution:

Proposed by:
the EC WG IYA Task Group "She is an Astronomer"

Supported by:
the EC WG Women in Astronomy

The following persons will be available for consultation and, if necessary to speak on the above resolution at the General Assembly on 13 August 2009:

Proposer: Helen J. Walker < helen.walker@stfc.ac.uk >
Seconder: Sarah T. Maddison < smaddison@swin.edu.au >

She is an Astronomer *continued*

The International Astronomical Union XXVII General Assembly,

RECALLING

1. the UN Millennium Development Goal 3: promote gender equality and empower women,
2. the IAU/UNESCO International Year of Astronomy 2009 goal 7: improve the gender-balanced representation of scientists at all levels and promote greater involvement by underrepresented minorities in scientific and engineering careers,

RECOGNIZING

1. that individual excellence in science and astronomy is independent of gender,
2. that gender equality is a fundamental principle of human rights.

CONSIDERING

1. the role of the IAU Working Group for Women in Astronomy,
2. the role of the IYA2009 Cornerstone Project "She is an Astronomer",

RESOLVES

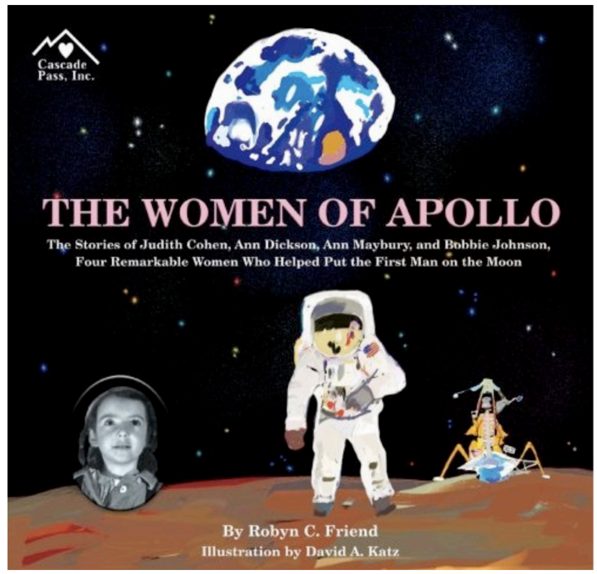
1. that IAU members should encourage and support the female astronomers in their communities,
2. that IAU members and National Representatives should encourage national organisations to break down barriers and ensure that men and women are given equal opportunities to pursue a successful career in astronomy at all levels and career steps.

Women in astronomy at Harvard circa 1917 and at the European Week of Space and Astronomy 2009 (with Bridget, the ExoMars rover prototype)

SNIPPETS
NEWS BRIEFS AND HIGHLIGHTS

Women of Apollo

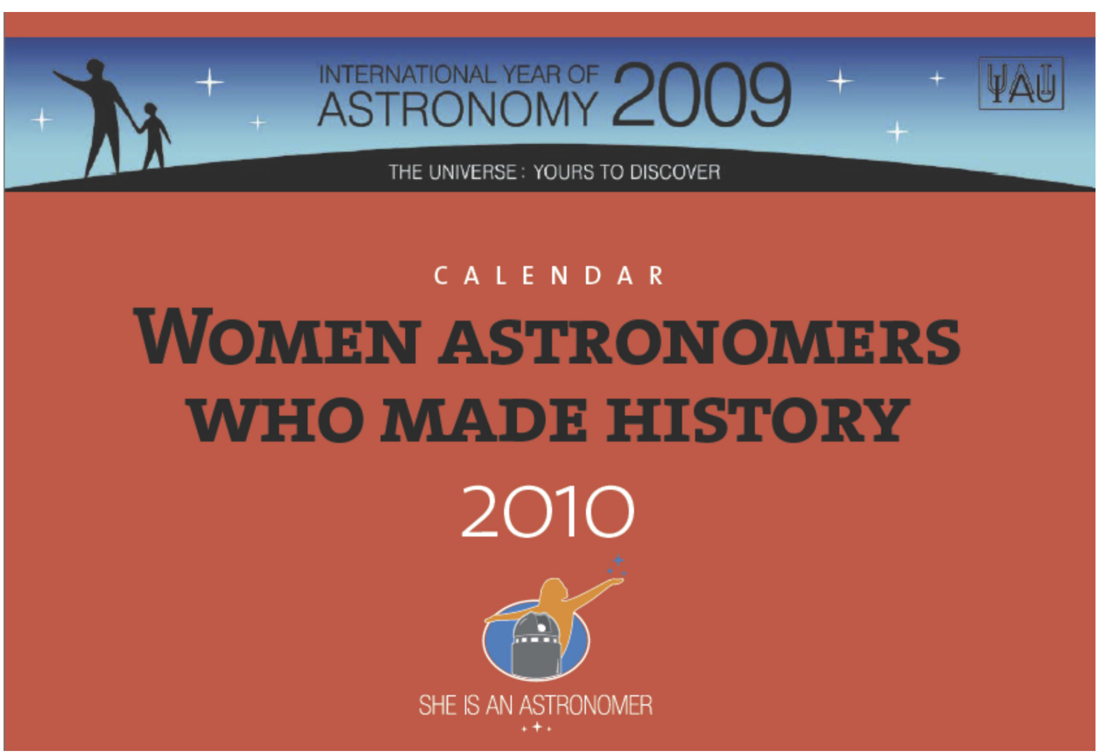
The 40th anniversary of the Apollo 11 landing on the Moon was a fabulous nostalgia-fest for those of us who, as young kids, were excited and inspired by the men walking on the Moon. But what of the women scientists, engineers and potential astronauts of the time?



Women were excluded from being astronauts, as discussed in several books, including Margaret A. Weitekamp's *Right Stuff, Wrong Sex* and Stephanie Nolen's *Promised The Moon*. A couple of women engineers from the Apollo era have oral histories on the NASA site, e.g.: Dorothy B. Lee, engineer (http://www.jsc.nasa.gov/history/oral_histories/LeeDB/DBL_11-10-99.pdf) and Jeanne L. Crews, aeronautical engineer (http://www.jsc.nasa.gov/history/oral_histories/CrewsJL/CrewsJL_8-6-07).

A couple of years ago Robyn C. Friend wrote a book for children called *The Women of Apollo* (illustrated by David A. Katz, published by Cascade Pass, Inc.) which brings the same inspiration of the lunar astronaut's exploration but also shows the roles of some of the women involved in the Apollo program.

Women Astronomers Calendar



Celebrate IYA with a 2010 wall calendar—looking for holiday presents for nieces? Or perhaps something for the department office or coffeeroom….

SNIPPETS *continued*

Observation on Micro-inequities

The following is from the blog of a Female Science Professor. This particular blog is a mine of "musing from a mid-career science professor at a large research university." http://science-professor.blogspot.com/

Every time I post an anecdote about a possible situation in which I may or may not have been treated in a way that could perhaps be described at least in part as sexist, I always receive one or more comments:

- giving alternative interpretations of the incident,
- informing me that I am too sensitive,
- wondering why I am offended by such a minor incident, and/or
- telling me that I must hate men (or asking me why I hate men so much).

And there are always comments from women reporting similar incidents that have happened to them.

I agree that any one single minor incident could be interpreted in other (non-sexist) ways. It is important to realize, however, that many of these little incidents are examples of micro-inequities.

Micro-inequities are ways in which people are ignored, disrespected, undermined, or somehow treated in a different (negative) way because of their gender or race (or some other intrinsic characteristic).

A micro-inequity can be very micro. It can involve an action or words or even a tone of voice or a gesture. The inequity can be a deliberate attempt to harm someone or it can be unintentional, rooted in a person's perceptions about others.

Whatever the source and however minor each separate event, over the years the cumulative effect of these little incidents, words, and gestures on an individual and on various segments of society (academia, business, even within families) is not so micro.

There is a complete spectrum between the mini-incidents and the big unambiguous ones that most people would agree are sexist or racist. Clearly we need to eradicate the big unambiguous examples of discrimination, but are some (most?) people willing to accept micro-inequities because the incidents are, in many cases, so ambiguous? Where do you draw the line between deciding that someone is oversensitive vs. the target of habitual disrespect?

Even if most people support the general concept that people should not be disrespected or marginalized because of gender or race, in reality quite a few people are willing to overlook micro-inequities. It is certainly easier to label someone as oversensitive or too quick to see things through the notorious gender (or race) lenses in a mundane situation than to deal with the ambiguity of identifying a micro-inequity.

The conversation I described in my post last Friday was of a type I think of as an I-can't-believe-you're-a-professor incident. For me, this is one of the more micro kinds. I was not harmed by that particular incident. I was not even particularly inconvenienced by it. It was but one of many such incidents I have experienced in the past 20+ years. Any one of them is indeed a micro-incident, and many have multiple possible interpretations.

Over time, however, these incidents are a constant reminder that many people find it difficult to believe that women can or should be scientists and/or professors. They reinforce our sense of isolation, and together they send the strong message that women don't get the same level of respect that men do, even when we are doing the same jobs.

You don't have to believe that every such incident is an example of a micro-inequity, but in the case of FSPs who experience such things routinely, the alternative is to label us all as oversensitive man-haters who feel victimized by the slightest hint of disrespect (which we are probably misinterpreting because we are actively looking for sexism). That doesn't sound like any of the women scientists I know.

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STATUS - January 2010
American Astronomical Society
2000 Florida Avenue, NW, Suite 400
Washington, DC 20009

The subject of tonight's discussion is: why are there no women on this panel?