

Challenges to woman in astronomy

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Abstract

The role of women in astronomy is a constantly dynamic and changing issue. While historically women have been publically barred from participating in the field, the modern astronomer can be any gender, orientation, or ethnicity. Despite this, women across all disciplines of astronomy still face significant obstacles in order to be held in the same esteem as their male peers. This paper samples several studies done across the past 20 years looking at several aspects of the modern women's role in astronomy, how it has evolved, how it stands today, and what we can look forward to in the future.

1. Introduction

The field of astronomy is concerned with the study of celestial objects and the phenomena that surrounds them. It uses a blend of math, chemistry, and physics to explore phenomena outside the reaches of Earth's atmosphere. While astronomy remains an interdisciplinary study modern astronomy can be most generally categorized into two focuses: observational and theoretical . Both have the fundamental goal of gaining a deeper understanding about the universe as a whole though their approaches differ. Observational astronomy is what most people picture when you say the word astronomy. Astronomers in this discipline focus on obtaining information through the observation of celestial objects ranging from black holes to exoplanets using equipment such as the famous Hubble space telescope. Theoretical astronomy seeks to codify and create models to predict and explain observational results. Modern theoretical astronomers may use complex mathematical systems and sophisticated computers, but the foundation that these systems are built on relies on the observational results of thousands of years of study. For most of astronomy's invention the primary method of study was looking at the night sky.

In an era before literacy was commonplace throughout the civilized world people were studying the stars. The study of the universe is one of the oldest sciences known to man, with evidence of this type of exploration in almost every ancient civilization like the celestial charts created by the ancient Greeks. The Greeks were among the first ancient civilizations to employ the use of Scientific Cosmology, an

understanding of the universe that would make sense without the influence of a divine presence. Using mathematics, they sought to devise combinations of circular trajectories which would imitate the seemingly irregular patterns in the night sky (Early Star Maps and Astrology). The earliest copy of a sky map dates back to China during the Tang Dynasty (roughly 9th century AD). These observations and records of stars positions throughout the year were vital for predicting the seasons and knowing when to plant their crops (Early Star Maps and Astrology). The Polynesian peoples were using the stars as a means of navigation in order to navigate the oceans over 2,000 years ago. This means of navigation worked by subdividing the night sky into quadrants and tracking stars as they move through these quadrants. Using this method a sailor would be able to discern the cardinal directions (Maps In The Stars).

With a field so old and rich, it is surprising that until very recently, womens approved participation or historical participation has recently come into the public forefront. In today's enlightened environment, we would like to think that issues of female dynamics in the workplace are an issue of the past. While huge strides have certainly been made in the past few decades there still remains a distinct divide between men in astronomy and their female counterparts. How accessible is success in astronomy of today? There has been a huge push in recent years to bring more women into Science Technology Engineering and Math (STEM). This push has seen a concurrent increase in women Bachelor degrees in Physical Sciences from 1980 to 2016, while astronomy degrees obtained during the same time remained remarkably stagnant (Anne Marie Porter and Rachel Ivie 2019). This stagnation can be attributed to several factors creating barriers to women's success in the field of astronomy from a hostile work environment to the sore lack of significant female representation in the post-doctoral field.

2. Discussion

2.1. Workplace Environment

Across America now more than ever people are becoming more cognizant of behaviors in the workplace and the power dynamics that come into play. Harassment in the workplace is now in the forefront of public awareness, with the advent of the Me Too movement. The New York Times summed the movement best saying "The Me Too Movement (is) an advocacy organization that fights sexual violence and harassment" (Harris 2019). While the Me Too movement has primarily fought its battles among the Hollywood elite, the ramifications of its cause was felt in all workplaces across the country. With harassment in the workplace being a highly debated subject, does the world of astronomy come out unscathed? This question was put to the test by a study done by the University of Illinois where they

asked volunteers about their experiences as members of the astronomy community. This data was taken across three types of people in the astronomy workforce: trainees, scientists, and senior scientists.

	Women of Color		White Women		White Men		Men of Color	
	Total	Percentage	Total	Percentage	Total	Percentage	Total	Percentage
Trainees	32	8%	110	28%	43	11%	7	2%
Scientist	8	2%	57	15%	22	6%	5	1%
Senior scientist	5	1%	57	15%	39	10%	4	1%
Total	45	11%	224	58%	104	27%	16	4%

Table 1: Grouped demographic categories for the survey on harassment in the workplace. (Clancy 2019)

The table above gives a complete recording of the demographics of the study done. What was found was that “Women were more likely than men to observe remarks that they interpreted as racist, sexist, that one was not feminine or masculine enough, or disparaging someone's physical abilities or mental abilities” (Clancy 2019). These kinds of comments can add significant barriers to women's mental health and ability to be successful in the workplace. In the same study they reported that 30% of women felt unsafe due to their gender while 2% of men reported the same sentiment. This kind of mentality could be one of the reasons that 13% of the women in this study reported skipping at least one professional event due to feeling unsafe (Clancy 2019). Professional events such as classes, networking events and fieldwork are arguably vital to the success of anyone in their field and barriers to these events is detrimental to anyone in astronomy.

The issue of harassment becomes a much larger issue when you look at the number of women currently in the field of astronomy. Women are even to this day a hugely underrepresented group within astronomy.

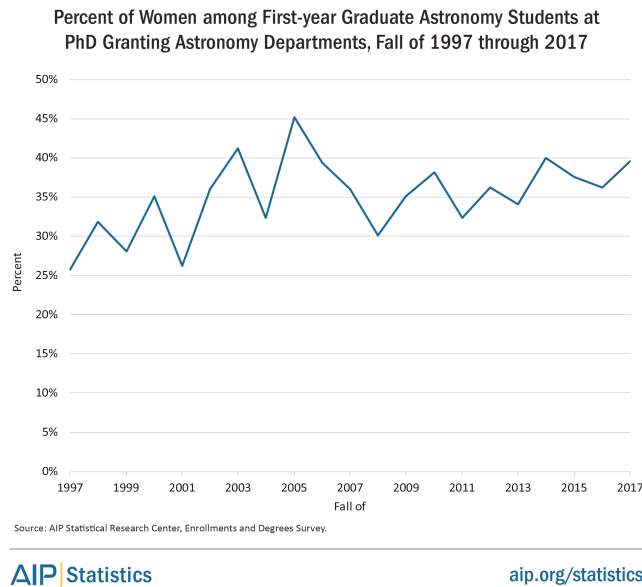


Figure 1: Percentage of first year graduate students that are women in PhD granting Astronomy programs. The overall trend is a gradual increase, but it has yet to reach 50% or flatten off. (Porter 2019)

Figure 1 shows that while the percentage of women who have entered into an astronomy granting PhD program has risen since 1997, the percentage of women in these programs still has not stayed above 40%. This is lagging behind the national average, as women receive well over 50% of all bachelor degrees (NCES 2016). With such a disconnect, it is not surprising that many women still feel unsafe in the world of astronomy. A huge component of completing coursework at the graduate level is the support and mentorship of faculty members. The representation of women in faculty positions such as full or associate professor is much lower than female PhD participants. While around 40% of first year PhD astronomy students are women, 15% of professors and 29% of associate professors are women (Porter 2019). With this amount of representation it becomes increasingly difficult for women to achieve insider status, create networks and procure effective mentors. It is not a small statement to say that mentorships often can make or break a student's success in the academic field. A primary role that the mentor fulfills for a student is to be their cheerleader and speak for their success on their behalf. A study done on mentoring in graduate schools of education in 1985 included these anecdotal quotes:

Thus three components should emerge: mutuality (including items such as "Overall, we have a close relationship" and "My mentee encourages me when I am discouraged"), comprehensiveness ("I discuss my professional dilemmas with my mentee" and "My mentee discusses personal problems with me"), and career ("My mentee and I collaborate on research" and "We discuss my career goals") (Busche 1985).

Even 35 years ago, the significance of the mentorship mentee relationship was paramount in the success of graduate students. With the current lack of proper representation amongst higher level astronomy programs, women will continue to miss out on vital learning opportunities not directly related to the classroom.

All this comes down to the basic need for a support system. One woman in the study stated that "among women graduate students, it was rumored that men (students) had more supportive, informal grooming for professional positions than we" (Busche 1985). With an underrepresented staff, the support structure for the modern female astronomer is lagging far behind its male counterparts. An important aspect of any support system is the concept of inclusion, to feel like an insider rather than feeling the need to "break in" to the field. The disproportionately high levels of harassment experienced by women in astronomy serves as an isolating factor and creates barriers to female success in the workplace. This will make women feel less engaged with their work, thus less likely to stay. This is why, without the proper support structures, women are often pushed out of the field. Thus stagnation in the field is an inevitable side effect to a hostile work environment.

2.2. Growth in the Field

Overt harassment is much more easy to spot, but when it comes to unconscious bias, a clearly defined enemy becomes more complicated to talk about. Unconscious bias is our schemas (or expectations or stereotypes) influencing our perception or judgement of others. Often schemas are culturally shared by groups concerning false ideas about gender and race. This mechanism developed as an early adaptation by our ancestors to allow efficient, if sometimes inaccurate, processing of information (Stewart 2009). In the modern world however this can come into action when interacting with different groups. Unconscious bias becomes a concern when taking a look on how it comes into play during the hiring process, and how it plays a role in who gets hired or not. In a presentation at the 2009 Women in Astronomy and Space Science conference, Stewart talks about the role that unconscious bias plays in the hiring process. She elaborates on a study done on psychology professors during the hiring process and how their biases affect the hiring process. They found that "When evaluating identical application packages, male and female University psychology professors preferred 2:1 to hire "Brian" over "Karen" as an assistant professor" (Stewart 2009). This goes to show an implicit hurdle to women entering into the world of academics. This bias can be seen as an explanation as to why there is still significant stagnation in the growth of women in astronomy. How can there be any growth when you cannot even get your foot in the door?

Men in this respect enjoy a benefit for this bias as "Fathers were seen as more committed to paid work and offered higher starting salaries than nonfathers". While under the same evaluation, mothers were rated as less committed to their jobs and therefore more likely to be passed up for promotions and management positions (Stewart 2009). This double standard implies that fathers have a vested interest in

maintaining their positions in the workforce to provide for their families but women are often not given the same generous assumption. Small imbalances individually can seem minor, but over time these can have long reaching consequences for workplace advancement.

Percent of Faculty Members Who Are Women in Astronomy Departments,
2003-2014

Academic Rank	2003	2006	2010	2014
	%	%	%	%
Full Professor	10	11	15	15
Associate Professor	23	24	22	29
Assistant Professor	23	28	30	29
Instructor/Adjunct	15	15	*	19
Other Ranks	15	21	17	22
Overall	14	17	19	19

* too few to calculate

Source: AIP Statistical Research Center, Academic Workforce Survey

AIP Statistics

aip.org/statistics

Table 2: Percent of faculty members that are women in astronomy departments. The higher ranking the title amongst faculty, the percentage of women holding that title decreases. (Porter 2019)

The above graphic describes the distribution of female professors across five tiers of work roles. When examining the changing percentages among the tiers of leadership, there is a common trend that with each upward movement, we see less and less women represented. This phenomenon has been coined pipeline drip (Porter 2019). Pipeline drip in this instance refers to the trend of increasingly fewer women showing up in the positions amongst academia. There are leakages associated with each level that disproportionately slants against women advancing in the field. In the 2016 Academic Workforce study, women were hired into 32% of non-tenure track positions, 29% of temporary positions, 28% of part-time positions, and 23% of tenure track positions (Porter 2019). The overwhelming majority of positions occupied by women in this study were in temporary or part-time positions. This calls into question the efficiency of the college to professor pipeline. A hostile workplace environment can be reason to leave, it was reported that 40% of women of color and 27% of white women felt unsafe in their current career position due to race (Clancy 2017). This feeling of unease could be one of the reasons that academia loses so many women on each level. With a large percentage of women lost at each level of advancement, we have to look deeper into the barriers that may surround the success of women.

At the college level, there is still progress to be made. While the amount of women earning astronomy degrees is rising, it still falls well below it's male counterparts.

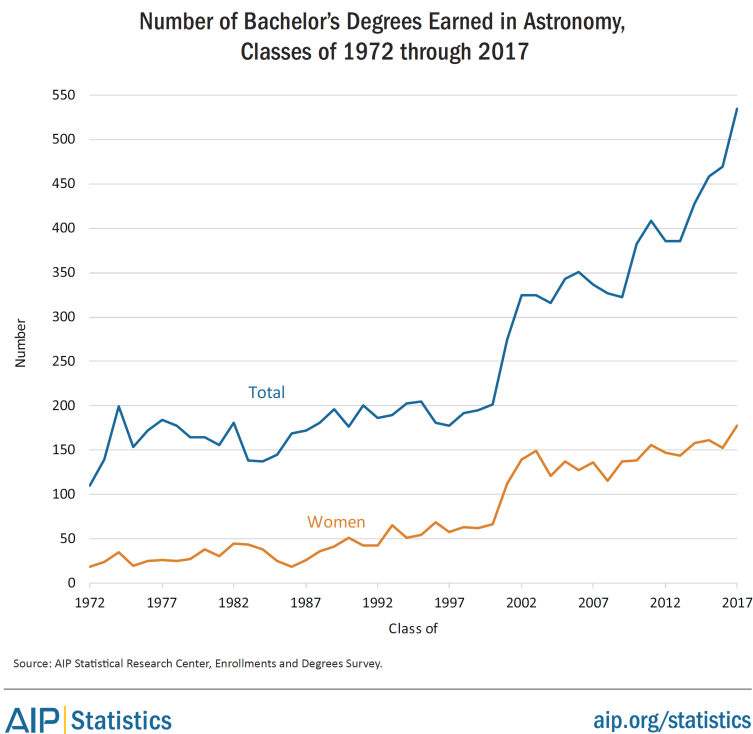


Figure 2: The total number of bachelor degrees in astronomy compared to the number of women earning the same degree. Overall there is a consistent lower increase in the number of women earning an astronomy degree compared to total degrees earned. (Porter 2019)

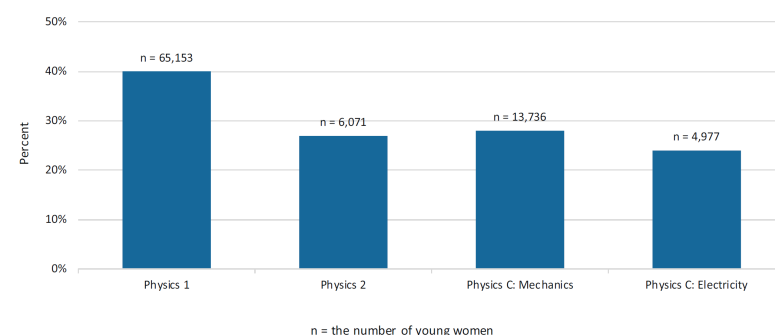
The number of women earning bachelor's degrees in astronomy has steadily been increasing, the number of men earning the same degree has shown a much larger increase. While there are still more women earning astronomy degrees, the gender gap is widening ever still. As long as growth in the female sector falls behind male growth, the gender distribution within academia will remain unchanged. The still present gap between women astronomers and male astronomers is indicative of some systematic barriers that may be present at the early stages of the academic pipeline.

2.3. Systematic Barriers

An integral part of joining the ranks of astronomy majors is the preparations a student makes prior to entering college. With competition for spots among colleges, preparations made in high school is now more important than ever. A foundational class that is vital to the success of any astronomy major is the physics classes they take in high school. For many schools across America high school physics is a requirement for graduation because physics is an integral part of a wide variety of college majors including STEM degrees. As of 2013 it was reported that 4 out of 10 high school students took at least one general physics course before their high school graduation. This is considerable growth since 1987

when high school physics participation was down near 20% (White 2014). This growth is paramount in the success of students in higher education environments. Within physics at the high school level there are different classes with varying difficulty. One such program is the Advanced Placement (AP) physics program. AP programs are higher level physics courses that are paired with an end of the year exam that can give physics credits at certain college institutions depending on the score you receive. The AP program currently offers four such exams: Physics 1, Physics 2, Physics C: Mechanics, and Physics C: Electricity and Magnetism (Porter 2019).

Percent and Number of Young Women who Participated in AP Physics Exam, 2017



Source: The College Board, Program Summary Report 2017.

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Figure 3: The number of high school women who took the AP physics exam. The number of women taking the AP exams decreases with higher tiered classes. (Porter 2019)

Figure 3 shows the percentage of women who participated in the AP exams talked about above. As the AP exams increment up the percentage of women of women greatly decreases. This creates a bottleneck on the representation of women amongst astronomy due to being already “behind the curve”. AP classes serve as an important benchmark for highschool students and the readiness for college courses. With such low female representation in higher level AP physics courses this puts many women already behind their peers at the college level. Representation of women in the lower levels of AP physics courses have their issues as well. While 40% of the test-takers for the 2017 AP Physics 1 exam were women, 30% of these women passed this exam compared to 48% of men (Porter 2019). This trend follows across all four levels of AP physics exams with men consistently outperforming women in each exam. This creates a double jeopardy for women demographics at the college astronomy level. With fewer and fewer women taking the AP physics exams and fewer passing than men, the physics bottleneck is created, putting women at a disproportionate advantage during the introductory physics courses at the start of astronomy majors.

Once women are inside the field however, the glass ceiling is not entirely shattered. While men in the workplace are praised for becoming fathers, women are often villainized for wanting the same thing. In the United States (US) there is currently no guaranteed paid maternity leave (Salam 2019). This often leaves the safety of a woman's job in the hands of the company that she works for. While many companies do provide some form of paid leave for their female employees this uncertainty can have a detrimental effect on the mental well being for soon to be mothers. Once out of maternity leave, the problems don't go away. In the US it is common for the school day to be over between two and three in the afternoon, while the typical workday doesn't end until around 5 pm. This issue is compounded every summer when children are out of school for several months. The big question then becomes, what do parents do with their kids that won't cost an obscene amount of money? The solution for many mothers is for them to take on the bulk of childcare. In the US 42% of mothers have reduced their work hours to take on child-rearing responsibilities compared to 28% of men (Grose 2019). By taking on the responsibilities of childcare, this then puts women behind their male counterparts, who more likely have the luxury of being able to work a full workday.

3. Ramifications and the Future

3.1. Overarching Issues

The academic pipeline from school to college to academia is leaky. In the high school setting we find that women are consistently falling behind their peers in the AP physics community. Even in AP courses that women are participants in, they still fall behind their male counterparts in the testing arenas. This pattern exposes a failing in a system for an entire section of the population. This cascading effect is a cause for the bottleneck on the prerequisites that women have the ability to take advantage of before even entering into a college astronomy program. Once inside the academic sphere, however, there are still significant obstacles facing women in the workforce. The study on workplace harassment done by the University of Illinois emphasized that respondents of the survey were to only report experiences that they had in their current position over the past five years (Clancy 2017). This goes to show that a workplace hostile to women is still very much a current problem that the astronomy community still faces to this day. A work environment like this is possibly why so few women stay in the astronomy field. While a significant amount of women earn bachelor degrees in astronomy, this is rarely reflected in the staff at universities. Around 30% of all astronomy degrees in 2016 were achieved by women, as of 2014, only 15% of full astronomy professors were women (Porter 2019). This lack of representation may be a symptom of the kind of environment that the astronomy field currently is.

3.2. Solutions

There are ways to potentially combat current issues that the field is facing. Use of a “blind” hiring process (names and any gender indicators are removed from resumes) has been found to significantly improve the amount of women called back for in person interviews (Stewart 2009). During the hiring process, committees can engage in what is called Active Recruiting. Active Recruiting is the process where hiring committees make a concerted effort to widen the range of institutions the hiring pool is made of along with careful consideration of candidates that are from less prestigious institutions along with less than traditional resumes. This in practice allows hiring committees to take into account past discriminations from higher-tier universities as well as candidates own internalized biases.

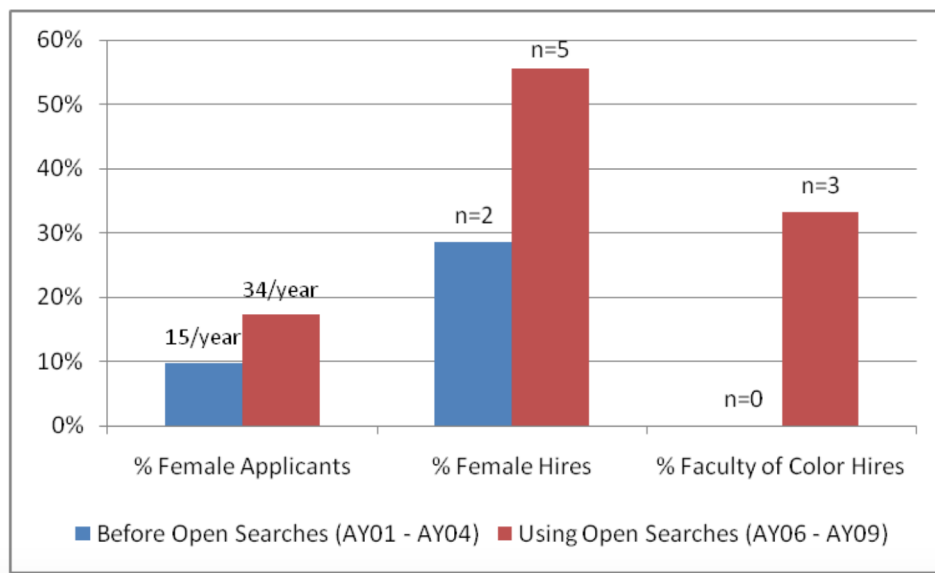


Figure 4: Demographics of applicants and hires for the University of Michigan using traditional hiring techniques compared to Open Searches. Using Open Searches there is a significant increase in the number of female and people of color hires. (Stewart 2009)

This type of active recruiting has been employed at the University of Michigan (U of M) as demonstrated by Figure 4. This department's use of Open Searches (a similar concept to Active Recruiting) raised their female hires up to 60%.

The solutions would have to be multilevel, bringing awareness to all employees the nature of implicit biases, and how they can be addressed. This heightened sense of responsibility would potentially lower incidents of harassment, and lower the probability of guilt and blame being placed on any one individual.

Clancy called for “First, a code of conduct or other education on appropriate work behavior should be required of all trainees and employees at all levels”. A code of conduct would be vital in outlining potentially harmful behavior and give a universal understanding of the expectations of appropriate behaviors towards others.

A huge push for many college campuses is the creation of extensive mental health services for all of its students. Mental health facilities play a vital role in any students success in their schooling, giving them the tools to keep themselves sane under the pressures that college can bring. This is a much more poignant stressor for women in STEM, as many do still feel like they are not “part of the club”. Mental health resources can give these women the tools they need to combat exhausting emotional labor. Michigan State University (MSU) provides for its students a counseling and psychiatric service called CAPS. CAPS provides many students with free counseling services to combat the stressors of schooling, personal matters and more. As well as providing counseling and psychiatric services, MSU has the Center for Survivors facility, which specialises in providing counselling and resources to survivors of sexual abuse or assault. These types of programs are incredibly important in making the college environment safer and more accommodating for women.

Other ways to make the workplace more accommodating for women is increased protection for mothers. Workplace flexibility can play a vital role in whether or not a woman will even choose to return to work. By providing services and paid leave for mothers, this ensures that the decision to start a family doesn’t have to come as the expense of a fulfilling career. Providing resources such as private pumping stations and fostering a community within your organization made of other mothers can be vital in ensuring the transition from female employee to working mother can be as seamless as possible. Many companies in the US have found success by establishing plans of gradual reintegration for mothers back into the workplace. Plans like this include extended maternity leave, offering initial reduced hours during the first few months of returning to work, and keeping important meetings near the center of the day to provide flexible mornings and afternoons (Stahl 2020).

The current climate in astronomy is facing the potential for dramatic changes. These changes will hopefully bring about a more diverse group to the academic field. Our awareness of these problems has never been more acute than now. The data points to a problem astronomy is facing, but it also points to many solutions. Hopeful pushes in the right societal direction can only be meaningful when backed by hard systematic changes.

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