

Women in physics in the United States: Reaching toward equity and inclusion

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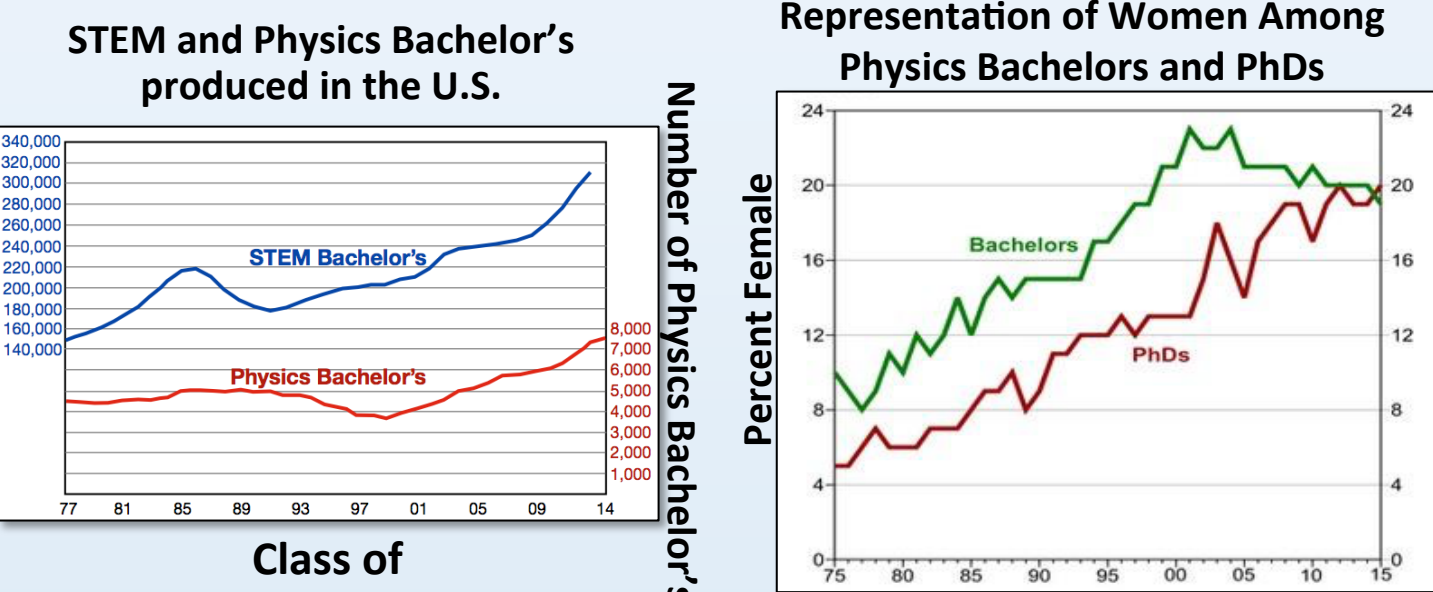
Summary

- In the US, only ~20% of undergraduates, graduate students and assistant professors are women
- Challenges involved in recruitment and retention include microaggressions, active discouragement, poor advising and mentoring, inadequate acknowledgement of achievements, sexual harassment, and others
- Research suggests that unconscious gender bias and stereotype threat produce major impediments in women's advancement in physics
- Intersectionality issues can exacerbate the sub-optimal climate and treatment of women in physics
- Increased participation of women in physics requires a multi-pronged approach: access and encouragement to take high school math/physics courses, availability of research opportunities and funding, presence of mentors and role models, training to reduce the negative impacts of gender bias, and support from professional societies

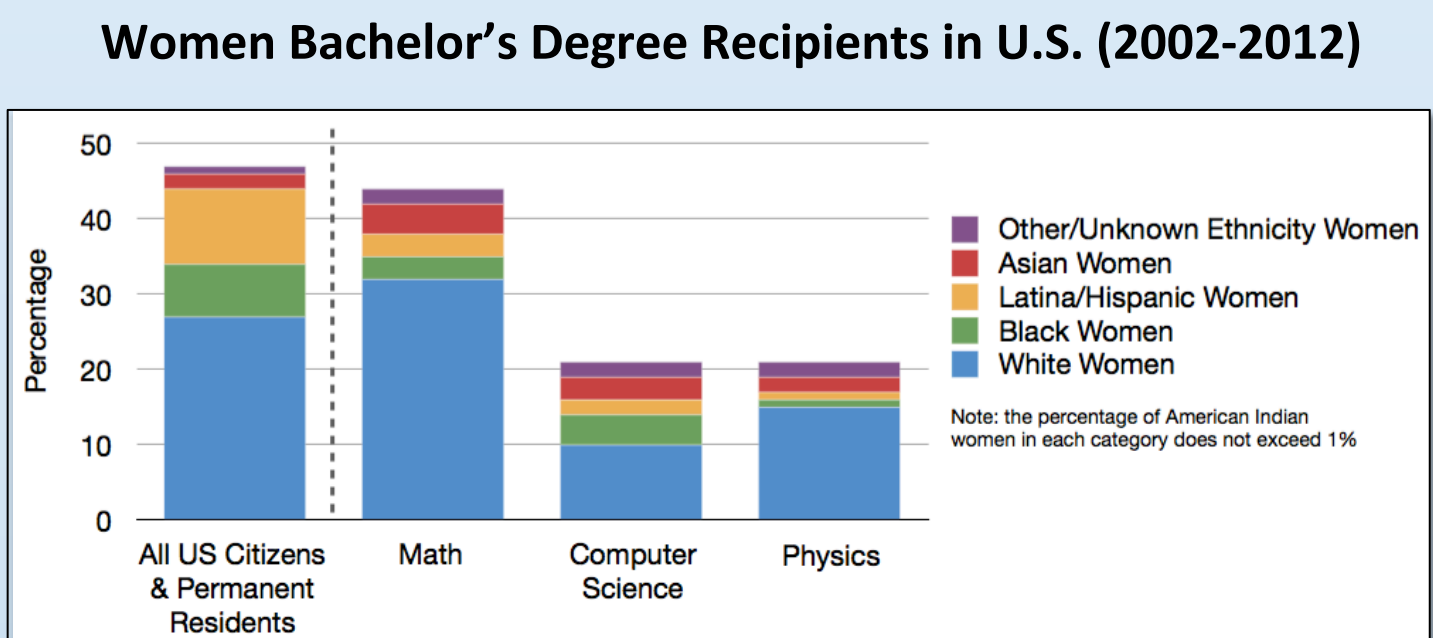
Statistics on physics participation

Note: many surveys on participation in physics fail to track the intersection of gender and race/ethnicity. We include intersectional statistics where available.

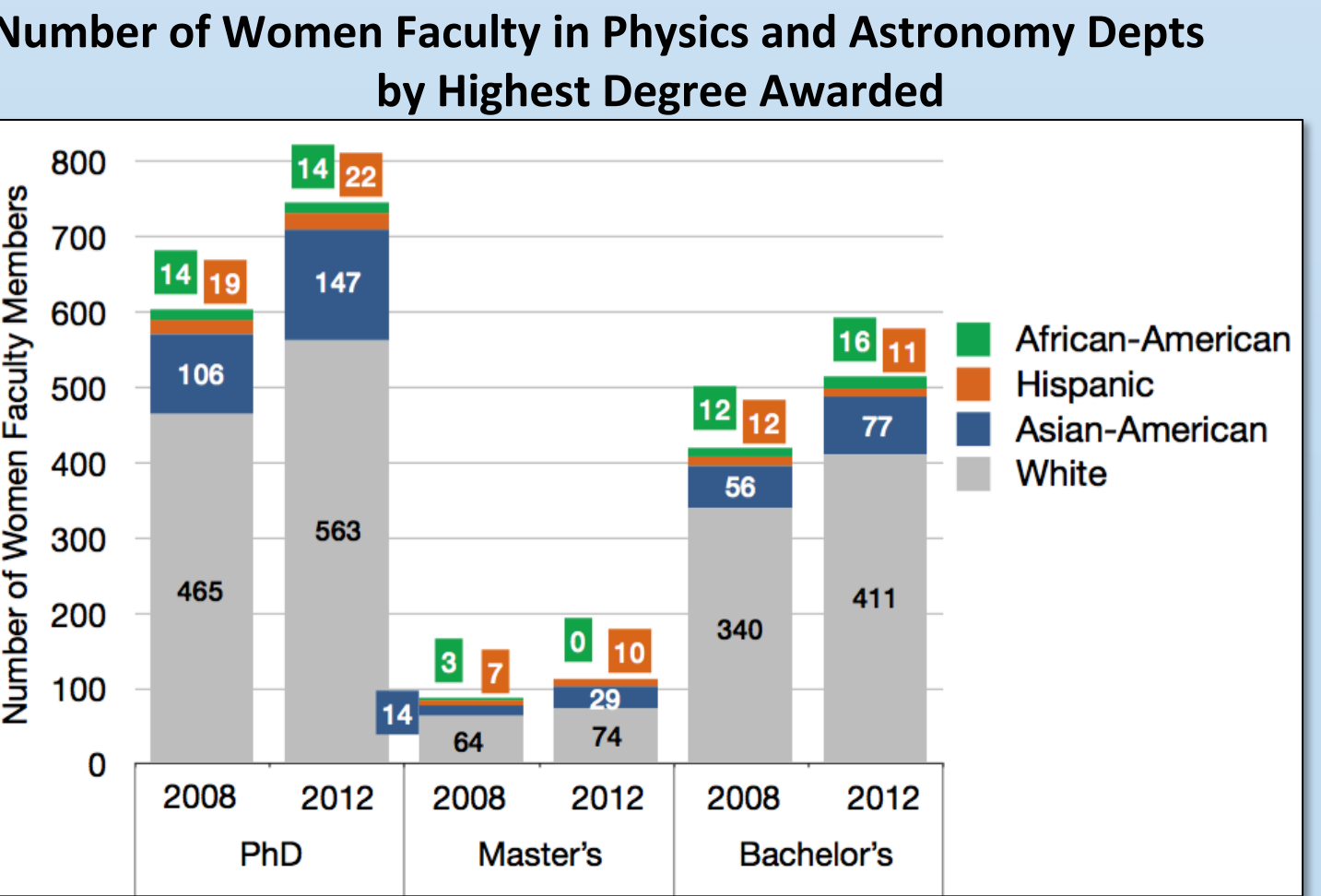
U.S. interest in all sciences, including physics, is steadily increasing. The total number of physics bachelor's degrees increased 80% between 2000 and 2013 (APS, IPEDS). About 20% of physics bachelor's degree recipients are women.



In 2012, the number of women receiving physics bachelor's and PhD degrees was at an all-time total high of 1,915 (1,550 bachelor's, 365 PhD). However, the percentage of Physics bachelor's degrees earned by women decreased for several years in a row (see above, AIP).



Of the physics bachelor's degrees going to women, a disproportionate fraction are earned by white women compared to the general population of the U.S. (see above).



The total number of women physics and astronomy faculty increased an average of 24% from 2008 to 2012 (see above). The gains were almost entirely with white women and Asian-American women. The number of Hispanic and African-American women remained similar, and therefore were a smaller total percentage of all physics women faculty in 2012 (5%, 73 of 1374) compared to 2008 (6%, 67 of 1112).

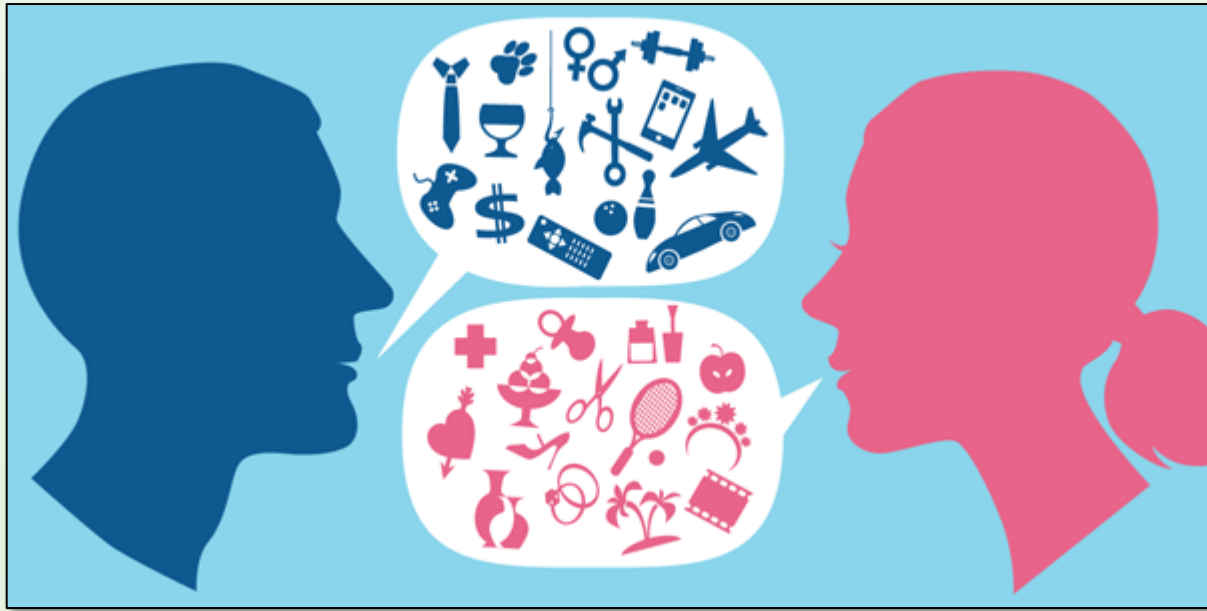
In 2014, 16% of all physics faculty in the US were women (23% Assistant, 10% Full), following a trend of increasing 2% every four years since 2002 (AIP).

Challenges faced by women in physics in the USA

Top issues faced by female physicists

- Inherent Gender Bias
- Discouragement
- A Lack of Role Models
- Intense Competition
- Microaggressions
- Questioned Competence
- Work-life Balance

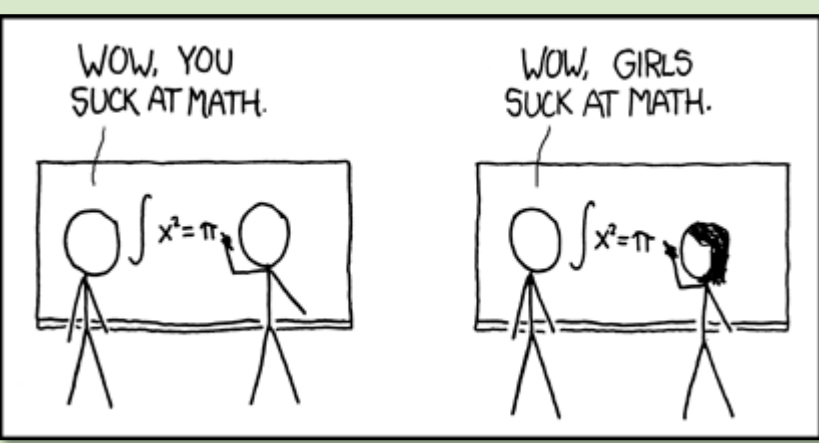
Implicit (unconscious) bias



Because we all grow up in a social community, we learn certain biases from our society. In the US, there is a bias against women in science. This bias does not have to be known or understood by a person to affect that person's actions. Implicit or unconscious bias can cause people to give less credit to a woman's work, make them less likely to hire her even when she is well qualified, change language to be more discriminatory or aggressive, and minimize the true intelligence and competence of the woman. This results in women exhibiting reduced confidence, as well as working environments that lack diversity. Interview data from 2006 with Black female physicists revealed exclusionary practices from peers:

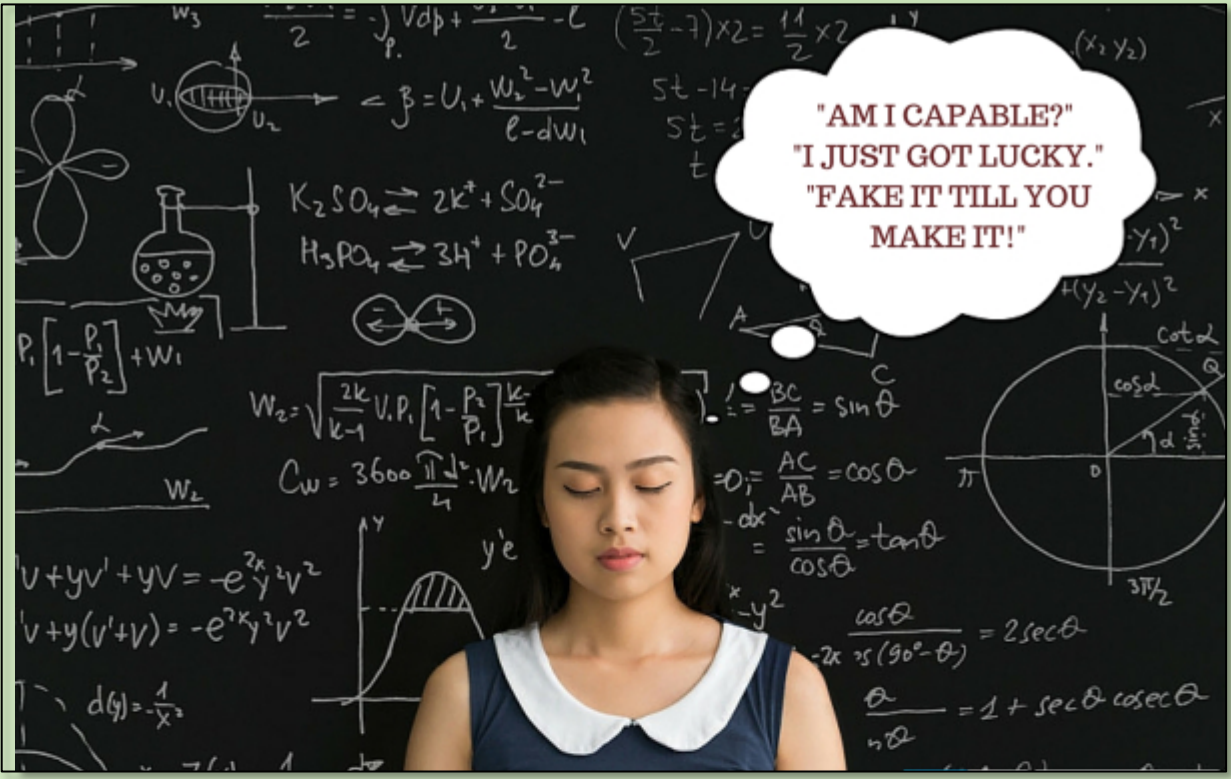
People would not - or they'll tell me, oh, they're not studying and find out they're studying together, so I was studying on my own and having a hard time. So yes, I was excluded; especially in graduate school, I was excluded. -Jane

Stereotype threat



A related phenomenon to implicit bias is stereotype threat (ST). Women can perform more poorly due to the presence of the stereotype that women are not good at science. ST research has determined that dealing with a stereotype uses cognitive resources, which reduce the available resources to use on a difficult task. So women may perform more poorly on a physics task because they are dealing with the stereotype of women being bad at science. The "threat" from the stereotype does not have to be explicit to affect performance. Being the only woman in a physics classroom can trigger stereotype threat. Lower performance (often combined with imposter syndrome and external biases) means that women are less likely to persist in physics.

Imposter syndrome



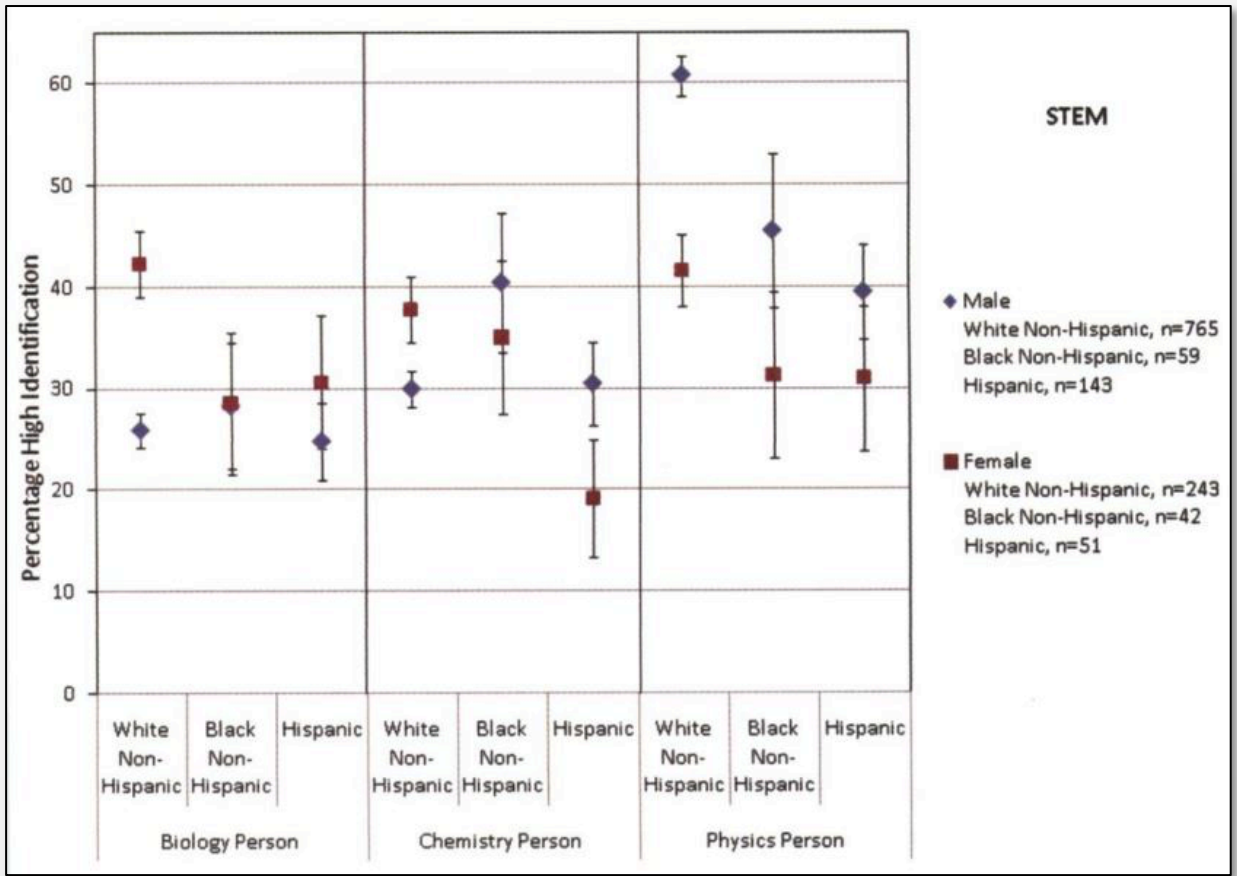
Because women grow up in a society that believes that women are not good at science, a common issue women face is self-doubt in one's abilities. Succeeding in physics is not enough to remove this doubt; women may attribute their success to luck or help from others. This is imposter syndrome: the belief that you are an imposter because your success is not due to your skills and talents but to factors outside of you.

Broadening participation to all women

Women in physics face challenges created by race, ethnicity, language, religion, social class, age, sexuality and other dimensions.

Gender and race

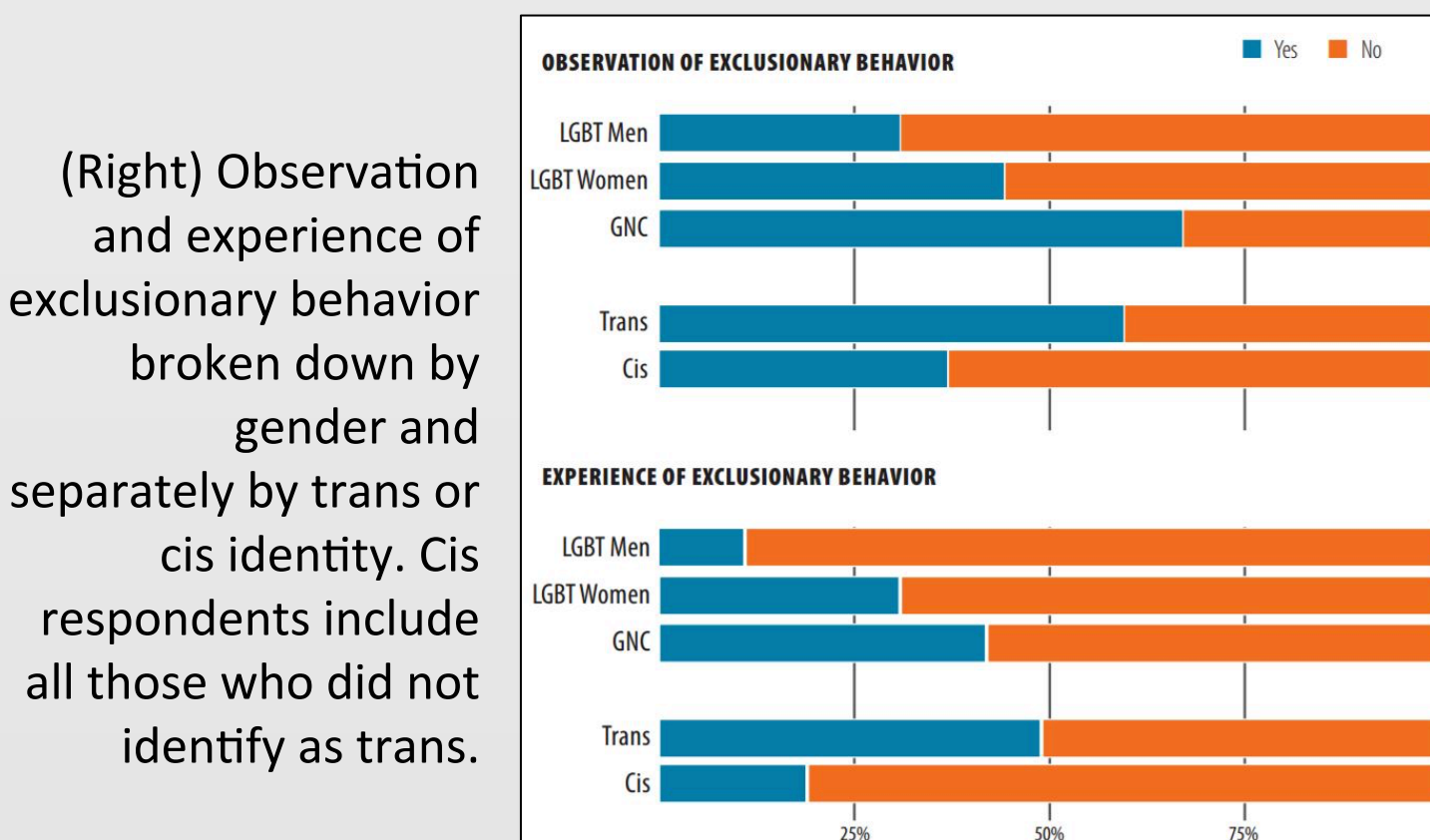
Analysis of nationally representative survey data of college students in STEM revealed that Black and Hispanic male students were less likely (40-45%) than White male students (60%) to strongly identify as "physics people." White women were less likely (40%) than White men to identify this way. Black and Hispanic women have the lowest percentages (roughly 30%) of any group for identifying strongly as "physics people."



(Above) Percentages of each group to respond positively to survey questions about being a biology, chemistry, or physics person. The questionnaire asked students: Do you see yourself as a physics person? Figure from Hazari, Sadler, & Sonnert (2013)

Gender and sexuality

A 2015 survey that gathered responses from 324 lesbian, gay, bisexual and transgender (LGBT) physicists indicated that LGBT women were more likely to report having experienced exclusionary behavior in the past year than LGBT men (around 30% of women vs around 10% of men).



- LGBT refers to persons who self-identify as lesbian, gay, bisexual, transgender, queer, questioning, intersex, as well as other sexual and gender minorities.
- Gender-Nonconforming (GNC) is an umbrella term for gender identities outside the gender binary (i.e., outside of the categories of men and women).

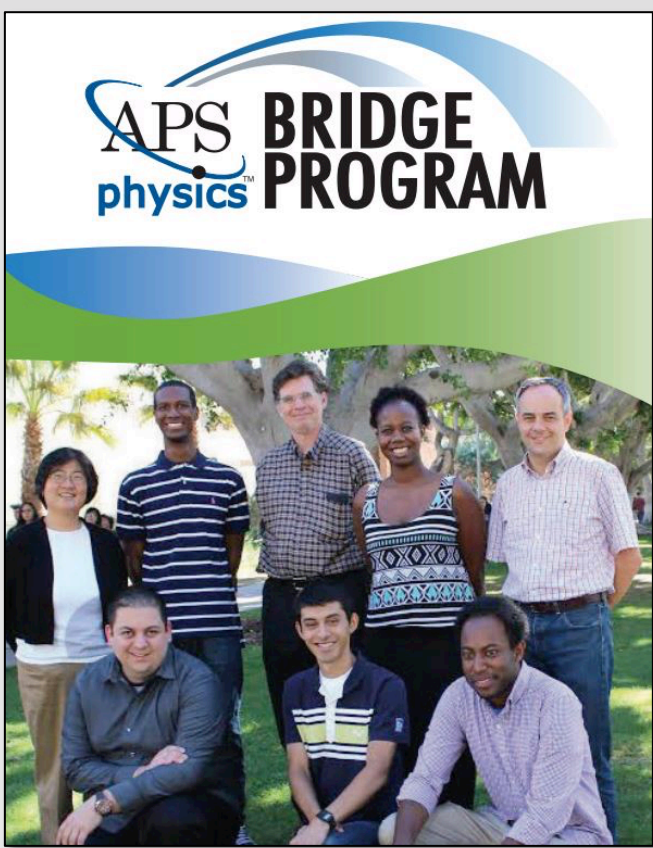
Improving access for all women

In response to differing access among students to informal study groups, **Emerging Scholars** programs were formed to connect women and students from ethnic groups that are underrepresented in physics to resources and support, resulting in improved grades in physics.

Requiring **Graduate Record Examinations (GRE)** for admissions to US graduate schools is relied on too heavily and severely restricts the flow of women and students from ethnic groups that are underrepresented in physics into the sciences. More innovative PhD programs have achieved completion rates above 80% and are greatly boosting participation

by women and ethnic minorities underrepresented in physics by including an interview process that examines experiences, leadership, service, and goals to assess maturity, perseverance, and adaptability, which are important for success in graduate school.

Bridge Program sites provide coursework, research experiences, and mentoring to students who have potential for success in doctoral education to clarify the transition to graduate school with the goal of increasing the number of physics degrees earned by students from ethnic groups that are underrepresented in physics.



Catching them early

- Early influences play a critical role in helping women break the stereotypes and develop an identity as a physicist
- Encouragement, outreach and mentoring of young women can positively impact their determination, persistence and their choice of high school and college physics/math courses
- About half of HS physics students are female

CUWiP

One successful approach: the Conference for Undergraduate Women in Physics (CUWiP)



Started in 2006 with 1 site, 29 attendees; this year (2017) 10 sites, 1500+ (reaching nearly every female physics undergrad). Three days of lab tours, poster sessions, presentations, panels, and networking events.

- CUWiP Conference evaluation suggests
- very positive understanding of physics careers and how to pursue them
 - growth in physics community and mentoring relationships
 - belief that career successes of women in physics were due to luck and other people's perception (as opposed to talent in physics and being prepared and seizing opportunities) [See the section on Imposter Syndrome]

Careful framing of the rewards, opportunities and challenges involved in being a female physicist is essential for recruiting and retaining young talented impressionable women

Gender bias in physics website

genderbias.compadre.org

A website was created to serve as an international forum for discussing gender bias in physics. Experiences shared on the site will be analyzed for effective strategies to combat gender bias.



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Conclusions

- Women face many challenges that produce barriers to their identity as a physicist and their recruitment and retention in physics
- These barriers include societal stereotypes including implicit gender bias and stereotype threat, lack of encouragement at all stages, poor advising and mentoring, climate in the physics departments/physics community including inadequate resources, lack of acknowledgement for accomplishments and support along with a feeling of isolation, not fitting in and lack of role models
- Intersectionality can significantly increase these barriers
- To ensure that excellence is not compromised, we must recognize the stereotypes, work to breakdown the barriers from early stages, provide adequate resources, support & mentoring, and improve the climate for women in physics
- Some approaches are showing positive outcomes
- Research-based approaches implemented as part of a comprehensive plan can help change society's views towards women in physics, promote an equitable culture in physics and ensure excellence of physics research and education

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