BEYOND REPRESENTATION: DATA TO IMPROVE THE SITUATION OF WOMEN AND MINORITIES IN PHYSICS AND ASTRONOMY

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REPRESENTATION OF WOMEN
GIRLS AS A PERCENTAGE OF TOTAL ENROLLMENT IN HIGH SCHOOL PHYSICS
Representation of Female Students among Physics Students by Type of Course
All US High Schools

<table>
<thead>
<tr>
<th>Course Type</th>
<th>1993</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual*</td>
<td>46%</td>
<td>52%</td>
</tr>
<tr>
<td>Regular</td>
<td>44%</td>
<td>47%</td>
</tr>
<tr>
<td>Honors</td>
<td>43%</td>
<td>69%</td>
</tr>
<tr>
<td>AP Physics B</td>
<td>36%</td>
<td>41%</td>
</tr>
<tr>
<td>AP Physics C</td>
<td>27%</td>
<td>32%</td>
</tr>
<tr>
<td>Overall</td>
<td>43%</td>
<td>47%</td>
</tr>
</tbody>
</table>

* Includes data for both Physics First and Conceptual Physics for 2009; Physics First data was not collected separately in 1993

http://www.aip.org/statistics
Percent of Physics Bachelors and PhDs earned by Women, Classes of 1976 through 2016.
Number of Bachelor’s Degrees Earned in Physics, Classes 1981 through 2016.
Number of PhDs Earned in Physics 1972 - 2016.
Percent of Bachelor’s Degrees Earned by Women in Selected Fields, Classes 1980 through 2015.

Percent of PhDs Earned by Women in Selected Fields, Classes 1980 through 2015.

- All Fields
- Biological Sciences
- Chemistry
- Mathematics
- Physics
- Engineering
- Computer Science
PERCENTAGE OF PHYSICS FACULTY MEMBERS WHO ARE WOMEN

<table>
<thead>
<tr>
<th>RANK</th>
<th>2002</th>
<th>2006</th>
<th>2010</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL PROFESSOR</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>ASSOCIATE PROF</td>
<td>11</td>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>ASSISTANT PROF</td>
<td>16</td>
<td>17</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>INSTRUCTOR/ADJUNCT</td>
<td>16</td>
<td>19</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>OTHER RANKS</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HIGHEST DEGREE OFFERED</th>
<th>2002</th>
<th>2006</th>
<th>2010</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHD</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MASTER’S</td>
<td>13</td>
<td>15</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>BACHELOR’S</td>
<td>14</td>
<td>15</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>OVERALL</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>
PHD-GRANTING PHYSICS DEPARTMENTS BY NUMBER OF WOMEN FACULTY MEMBERS IN PROFESSORIAL RANKS
UNDER-REPRESENTED MINORITIES
A closer examination of the data reveals that these differences are likely driven more by socioeconomic factors than by race.
# RACE AND ETHNICITY OF PHYSICS BACHELORS CLASSES OF 2014 THROUGH 2016 (3-YEAR AVERAGE)

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent of all Physics Bachelors</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>5,943</td>
<td>74</td>
</tr>
<tr>
<td>Asian American</td>
<td>551</td>
<td>7</td>
</tr>
<tr>
<td>Hispanic American</td>
<td>518</td>
<td>7</td>
</tr>
<tr>
<td>African American</td>
<td>253</td>
<td>3</td>
</tr>
<tr>
<td>Other US citizens</td>
<td>166</td>
<td>2</td>
</tr>
<tr>
<td>Non-US citizens</td>
<td>575</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8,006</td>
<td>100</td>
</tr>
</tbody>
</table>
NUMBER OF PHYSICS BACHELOR’S DEGREES EARNED BY AFRICAN-AMERICANS AND HISPANIC-AMERICANS
### RACE AND ETHNICITY OF PHYSICS PHDS, CLASSES OF 2014 THROUGH 2016 (3-YEAR AVERAGE)

<table>
<thead>
<tr>
<th>RACE/ETHNICITY</th>
<th>Number</th>
<th>Percent of all Physics PhDs</th>
<th>Percent of U.S. Physics PhDs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>843</td>
<td>46</td>
<td>87</td>
</tr>
<tr>
<td>Asian American</td>
<td>57</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Hispanic American</td>
<td>38</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>African American</td>
<td>16</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other US citizens</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Non-US citizens</td>
<td>861</td>
<td>47</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,827</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Based on a 3-year average of 966 US citizens.
NUMBER OF PHYSICS DOCTORATES EARNED BY AFRICAN-AMERICANS AND HISPANIC-AMERICANS
### RACE AND ETHNICITY OF PHYSICS FACULTY MEMBERS

<table>
<thead>
<tr>
<th></th>
<th>Physics</th>
<th>All Disciplines*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004 (%)</td>
<td>2008 (%)</td>
</tr>
<tr>
<td>African-American</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Asian</td>
<td>10.6</td>
<td>13.2</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2.7</td>
<td>3.1</td>
</tr>
<tr>
<td>White</td>
<td>82.2</td>
<td>80</td>
</tr>
<tr>
<td>Other</td>
<td>2.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*Data for all disciplines (including non-science disciplines) is located at: [https://nces.ed.gov/fastfacts/display.asp?id=61](https://nces.ed.gov/fastfacts/display.asp?id=61)
NUMBER OF AFRICAN-AMERICAN AND HISPANIC PHYSICS FACULTY BY HIGHEST DEGREE AWARDED BY DEPARTMENT

PhD
- 2004: 5,229 (64 Black, 107 Hispanic, 107 Other)
- 2008: 5,204 (66 Black, 130 Hispanic, 66 Other)
- 2012: 5,196 (68 Black, 141 Hispanic, 68 Other)
- 2016: 5,366 (109 Black, 188 Hispanic, 109 Other)

Master's
- 2004: 815 (29 Black, 56 Hispanic, 29 Other)
- 2008: 721 (29 Black, 50 Hispanic, 29 Other)
- 2012: 665 (32 Black, 65 Hispanic, 32 Other)
- 2016: 682 (21 Black, 78 Hispanic, 21 Other)

Bachelor's
- 2004: 2,562 (60 Black, 60 Hispanic, 60 Other)
- 2008: 2,730 (88 Black, 82 Hispanic, 82 Other)
- 2012: 2,711 (90 Black, 82 Hispanic, 90 Other)
- 2016: 2,869 (105 Black, 94 Hispanic, 105 Other)
NUMBER OF WOMEN IN PHYSICS AND ASTRONOMY DEPARTMENTS BY HIGHEST DEGREE AWARDED

- PhD
  - 2008: 465
  - 2012: 563
  - 2016: 658

- Master's
  - 2008: 14
  - 2012: 6
  - 2016: 29

- Bachelor's
  - 2008: 64
  - 2012: 74
  - 2016: 88

- PhD:
  - White: 106
  - Asian: 14
  - Hispanic: 19
  - African American: 14

- Master's:
  - White: 14
  - Asian: 6
  - Hispanic: 7
  - African American: 3

- Bachelor's:
  - White: 340
  - Asian: 12
  - Hispanic: 12
  - African American: 12
### NUMBER OF PHYSICS DEPARTMENTS WITH AFRICAN-AMERICAN AND HISPANIC FACULTY BY HIGHEST DEGREE AWARDED, 2016

<table>
<thead>
<tr>
<th>Number of Departments that have ...</th>
<th>PhD</th>
<th>Master's</th>
<th>Bachelor's</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both African-American and Hispanic Faculty</td>
<td>25</td>
<td>7</td>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>African-American Faculty and no Hispanic Faculty</td>
<td>25</td>
<td>8</td>
<td>53</td>
<td>86</td>
</tr>
<tr>
<td>Hispanic Faculty and no African-American Faculty</td>
<td>75</td>
<td>20</td>
<td>61</td>
<td>156</td>
</tr>
<tr>
<td>Neither African-American nor Hispanic Faculty</td>
<td>76</td>
<td>22</td>
<td>365</td>
<td>463</td>
</tr>
<tr>
<td>Total</td>
<td>202</td>
<td>56</td>
<td>492</td>
<td>750</td>
</tr>
</tbody>
</table>
WILL INCREASING REPRESENTATION FIX EVERYTHING?

• Data should be collected on other important areas
  – Workplace environment
  – Salary

• Even with equal representation, some groups could have limited access to resources and opportunities
PHD+10 (TO 15) STUDY

  – Who lived in the US during 2011
  – 1,544 respondents
  – 45% response rate

• Salary regression showed that men make more than women
  – ~6% more ($p = 0.025$)
  – Controlling for employment sector, time since degree, whether respondent had stayed with same employer, whether or not respondent had take a postdoc, highest degree the department offers (academic only)
GLOBAL SURVEY OF PHYSICISTS, 2009-2010

• About 15,000 respondents from 130 countries
• Conducted in 8 languages
• Separate results for Canada

https://www.aip.org/statistics/reports/there-land-equality-physicists
Opportunities and resources

- Sex
- Economic development
- Employment sector
- Age
### Percentage of respondents with access to key resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Less Developed Women</th>
<th>Less Developed Men</th>
<th>Very Highly Developed Women</th>
<th>Very Highly Developed Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding</td>
<td>34</td>
<td>51</td>
<td>52</td>
<td>60</td>
</tr>
<tr>
<td>Office space</td>
<td>64</td>
<td>74</td>
<td>72</td>
<td>77</td>
</tr>
<tr>
<td>Lab space</td>
<td>42</td>
<td>47</td>
<td>46</td>
<td>52</td>
</tr>
<tr>
<td>Equipment</td>
<td>42</td>
<td>49</td>
<td>58</td>
<td>64</td>
</tr>
<tr>
<td>Travel money</td>
<td>31</td>
<td>47</td>
<td>57</td>
<td>64</td>
</tr>
<tr>
<td>Clerical support</td>
<td>22</td>
<td>38</td>
<td>30</td>
<td>43</td>
</tr>
<tr>
<td>Employees or students</td>
<td>42</td>
<td>53</td>
<td>33</td>
<td>43</td>
</tr>
</tbody>
</table>
### % of R's w/ career-advancing opportunities

<table>
<thead>
<tr>
<th>% Yes</th>
<th>Less Developed</th>
<th>Very Highly Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>Given a talk at a conference as an invited speaker</td>
<td>51</td>
<td>67</td>
</tr>
<tr>
<td>Attended a conference abroad</td>
<td>75</td>
<td>81</td>
</tr>
<tr>
<td>Conducted research abroad</td>
<td>54</td>
<td>71</td>
</tr>
<tr>
<td>Acted as a boss or manager</td>
<td>38</td>
<td>53</td>
</tr>
<tr>
<td>Served as editor of a journal</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>Served on committees for grant agencies</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>Served on important committees at your institute or company</td>
<td>50</td>
<td>62</td>
</tr>
<tr>
<td>Served on an organizing committee for a conference in your field</td>
<td>48</td>
<td>59</td>
</tr>
<tr>
<td>Advised undergraduate students</td>
<td>82</td>
<td>84</td>
</tr>
<tr>
<td>Advised graduate students</td>
<td>63</td>
<td>77</td>
</tr>
<tr>
<td>Served on thesis or dissertation committees (not as an advisor)</td>
<td>52</td>
<td>66</td>
</tr>
</tbody>
</table>
Global Survey of Physicists

Sex
Economic development
Employment sector
Age
Opportunities and resources
Career progress
Relationship between career progress and resources

More quickly  About the same  More slowly

Total Resources

More quickly  About the same  More slowly
Relationship between career progress and opportunities

- More quickly
- About the same
- More slowly
Opportunities and resources

Career progress

Sex
Economic development
Employment sector
Age
Sex*Children
Compared to colleagues, how quickly have you progressed in your career?

- More quickly
- About the same
- More slowly

<table>
<thead>
<tr>
<th>Category</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children, Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Children, Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children, Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Children, Men</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IMPORTANCE

Documenting gender differences in salaries and access to opportunities and resources can result in policy changes.
LONGITUDINAL STUDY OF ASTRONOMY GRADUATE STUDENTS

• Result of Women in Astronomy Conference, 2003 in California, USA
• At that time, about 60% of younger members were women, and AAS wanted to know outcomes for these members.
• Would women have a higher attrition rate? Are women more likely to leave the field? If so, why?
LONGITUDINAL STUDY OF ASTRONOMY GRADUATE STUDENTS

• Partnership between American Institute of Physics and American Astronomical Society (AAS)
• Includes everyone who was in graduate school in astronomy or astrophysics in the US, 2006-07
• Data have been collected from the same cohort of people in order to document individual career paths
• Three waves of data have been collected:
  – 2007-08
  – 2012-13 five years later
  – 2015-16 eight years later
THIS ANALYSIS

• Second survey
• limited to people who
  – completed PhDs at the time of the 2nd survey
  – were not postdocs at the time of the surveys
HYPOTHESIS

We hypothesized that women would be more likely to work outside of astronomy and physics. In other words, being female would have a direct effect on leaving the field, independent of other factors.
IS WORKING IN OR OUT OF FIELD AFFECTED BY

• Being male or female (40% female respondents)
• Taking a postdoc
• Two-body problem (a work/family balance problem that refers to the difficulty of finding 2 jobs in same geographic area)
• Having a mentor other than advisor
• Relationship with advisor
• Imposter syndrome (at time of first survey)
• Time since degree
SECOND SURVEY
DOES BEING MALE OR FEMALE INDEPENDENTLY AFFECT OTHER VARIABLES IN MODEL?

- Gender
- Not a post-doc
- Mentor other than advisor
- Advisor relationship
- Imposter score
- Two-body problem
- Time since degree

Working out of the field
SECOND SURVEY
FACTORS THAT INFLUENCE WORKING OUT OF FIELD

- Relocated for spouse or partner
- Limited career options for someone else
- Completed a postdoc
- Changed advisors

More likely to work out of field  More likely to work in field
ANOTHER HYPOTHESIS

• There may be indirect effects of gender on working out of field.
• In other words, women may be more likely to have experiences that increase the likelihood of working out of field.
SECOND SURVEY
TESTING INDIRECT EFFECTS OF GENDER
EXAMPLE OF ONE MODEL

- Gender
- Mentor other than advisor
- Imposter Score
- Two-body problem
- Advisor Rating

Change Advisor
SECOND SURVEY
THE INDIRECT EFFECT OF GENDER ON WORKING OUT OF FIELD

- Gender
  - Imposter score
  - Advisor rating
  - Relocated for spouse or partner
  - Was not a post-doc
- Changed advisors
- Limited career options for someone else
- Working out of the field
CONCLUSIONS FROM SECOND SURVEY

• We hypothesized that women would be more likely to work outside of astronomy and physics. In other words, being female would have a direct effect on leaving the field, independent of other factors.

• However, there is no direct effect of being female on working outside the field. The effect of being female comes through other factors.

• Women may be more likely to leave astronomy because
  – Women are more likely to report less than satisfactory advising.
  – Women are more likely to report two-body problems related to the need to find two jobs in the same geographic area for a spouse or partner.
Thanks to my colleagues
Susan White and Patrick Mulvey

For more information

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