Planetary Decadal Survey
State of the Profession

- The Numbers – demographics
- Diversity, Equity & Inclusion
- Cultural Factors

Task 9: “The state of the profession including issues of diversity, inclusion, equity, and accessibility, the creation of safe workspaces, and recommended policies and practices to improve the state of the profession.”

Think Global, Act Local – some personal observations
The acronym soup of professional organizations

AIP Statistical Research Center
best position to gather numbers
- they know their stuff!

APS American Physical Society
AAS American Astronomical Society
AGU American Geophysical Union
Space Physics & Aeronomy
Planetary

Also GSA, LPSC....
National Academy of Sciences & NASA

- NASA cannot do surveys of the workforce
- NASA can pay NAS to run independent studies
  Such as Decadal Surveys and focused studies ......

Increasing Diversity and Inclusion in the Leadership of Competed Space Missions
How large are these overlapping areas?

EXOPLANETS!

Astronomy & Astrophysics

Planetary Sciences

Solar & Space Physics

Magnetospheres

Atmospheric escape

Comets, Radiolysis

Stellar/solar winds

Star-nebula momentum

Magnetospheres

Atmospheric escape

Comets, Radiolysis

Ideally.... We need demographics of NASA's Science Mission Directorate
1999-2000
Number Physics Bachelor's Degrees
Number Physics PhDs

Many countries missing – India? China?
International

1999-2000
Per Capita Physics Bachelor's Degrees
Per Capita Physics PhDs

Number per Million Population

Greece
S. Korea
France
Taiwan
Turkey
UK
Switzerland
Germany
Japan
Denmark
Canada
Norway
Estonia
USA
Slovenia
Netherlands
Australia
Sweden
Latvia
Probably not what you expect....

Percentage of Undergraduate Physics Degrees Awarded to Women

0% 10% 20% 30% 40% 50% 60%

Germany, USA, Canada, Australia, Italy, Argentina, India, Albania, Iran

(IUPAP International Conference on Women in Physics Proceedings, 2005-2013)
International

1999-2000

Percentage of Degrees to Women

Physics Bachelor's Degrees
Physics PhDs

Compiled by the AIP Statistical Research Center

National Surveys

**Astrophysics:** 2013 AAS Survey by AIP
63% response = 1583 Respondants
-> 2040 PhD astrophysicists in US

**Solar & Space Physics:** 2013 NRC Decadal Survey
AGU-SPA, AAS-SPD, Space Weather Week
51% response = 1305 Respondants
-> 2300 PhD solar, space & upper atmos. in US

**Planetary:** 2011 AIP Survey
62% Response = 2622 Respondants
-> 1200 PhD planetary scientists in US

<table>
<thead>
<tr>
<th>Attendees/Members of Planetary Conference/Section</th>
<th>LPSC</th>
<th>AGU</th>
<th>DPS</th>
<th>All Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPSC</td>
<td>1280</td>
<td>345</td>
<td>90</td>
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<tr>
<td>AGU</td>
<td>264</td>
<td></td>
<td>124</td>
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<tr>
<td>DPS</td>
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<tr>
<td>All Three</td>
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<td></td>
<td></td>
<td>161</td>
</tr>
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</table>

*Not all PhDs*
Planetary Survey 2011 Results

Attendees/Members of Planetary Conference/Section

<table>
<thead>
<tr>
<th></th>
<th>LPSC</th>
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<td>All Three</td>
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<td></td>
<td>161</td>
</tr>
</tbody>
</table>

Missing:
- Geological Society of America
- American Meteoritical Society

Planetary Science is a very interdisciplinary field – scientists span wide range of professional organizations, go to different conferences

PhDs/year in US
Astro ~250
Solar & Space Physics ~62
Planetary ~65

Astro Decadal Survey

Solar & Space Physics

Solar & Space Physics

Total = 475
US National Surveys

1. Half PhDs leave academia
2. Few faculty jobs per PhD
3. PhDs get great jobs
4. More non-academic career advice needed!

Solar & Space Physics - Jobs for PhDs

- 62 PhDs / year
- 1 faculty per 5-20 PhDs

Astronomy: Jobs for PhDs

- 1 faculty per 4 PhDs
- 1 faculty per 2 PhDs

Planetary - Jobs for PhDs

- 5% Industry & Other
- 14% NASA labs
- 17% FFR&DCs & Other Fed. Labs
- 16% Non-profit
- 48% University

Recent years??

More varied? Less academic?
EMPLOYMENT

Planetary Survey 2011

- Includes JPL, APL, LPI
- Includes SwRI, SSI, PSI

<table>
<thead>
<tr>
<th>Employment Category</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Industry &amp; Other</td>
<td>5%</td>
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<tr>
<td>NASA labs</td>
<td>14%</td>
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<td>FFR&amp;DCs &amp; Other Fed. Labs</td>
<td>17%</td>
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<tr>
<td>Non-profit</td>
<td>16%</td>
</tr>
<tr>
<td>University</td>
<td>48%</td>
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</table>

Planetary Scientists in PS
Planetary Survey 2011 Results

<table>
<thead>
<tr>
<th>Age</th>
<th>Men Respondents</th>
<th>Women Respondents</th>
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</thead>
<tbody>
<tr>
<td>Lower quartile</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>Median</td>
<td>48</td>
<td>38</td>
</tr>
<tr>
<td>Upper quartile</td>
<td>58</td>
<td>48</td>
</tr>
</tbody>
</table>

Female population is a little younger
Planetary Survey 2011 Results

Undergraduate Degree

Planetary Scientists in PS

PhD Degree

Planetary Scientists in PS
Planetary Survey 2011 Results

Source of Funds to Support Research

- NASA only: 53%
- Both NASA & NSF: 16%
- NSF only: 6%
- Other Source: 4%
- No Funding: 15%
- Not Engaged in Research: 6%
Planetary Survey 2020 Results
- DPS, GSA, LPSC – no AGU!
- 47% response
- 2400 respondants (include students)
- DPS paid AIP for the survey. But did not provide funds to do full analysis.
- The Decadal Survey (via NAS->AIP) should pay for full analysis to be done.

1. PhD production rate increasing – to ~70/year (~30/yr before 2005)
2. Studying in diverse areas (~45% do not use spacecraft data)
3. Population more diverse
4. 42.5% at universities, 31.8% at research institutes, 8.1% at NASA centers
5. PI of instrument or mission - significantly different male vs. women & URM
6. NASA grants & missions support -> ~61% funding of non-faculty
White Paper - Hendrix – DPS 2020 Survey

• Finding #1: Planetary Science as a field is getting larger.

• Finding #2: Planetary Scientists have diverse backgrounds and areas of study

• Finding #3: The vast majority of planetary scientists are employed at either Universities or Research Institutions

• Finding #4: The majority of scientists use NASA grants to fund their research
White Paper - Hendrix – DPS 2020 Survey

• Finding #5: While relatively few planetary scientists have proposed a mission as a PI, white men are more likely to have been involved in a mission proposal as either a PI or Co-I.
  – Recommendation #2: NASA should continue, and increase, their efforts to diversify mission leadership.

• Finding #6: Planetary Scientists' careers are most negatively affected by the balance
White Paper - Rivera-Valentin - Equity

Used 2011 & 2020 surveys

Normalized to National Civilian Labor Force

SR = Student Researcher
NSR = Non-Student Researcher
Used 2011 & 2020 surveys

Normalized to National Civilian Labor Force

Recommendations:
- Recognize lack of equity
- Support further studies
"For every 3 white men that make it through the pipeline, there is 1 white woman. But, for every 20 white women, there are only 1-2 women of color. This means that more than 95% of potentially talented women of color are being left behind and thus are unable to contribute to the planetary science community."

Proposes 9 Recommendations
from:
Recommendation #1. The decadal survey report should explicitly recognize the statistically significant underrepresentation of people of color—particularly Black / African Americans, Latinx / Hispanics, and American Indian / Indigenous / Alaskan Native people—and that the diversity initiatives of the past several decades have not succeeded in substantially changing this.

To:
Recommendation #9: Planetary Scientists, their employers, professional societies, and other groups should actively and intentionally find their own ways to assist in improving the diversity in the field.
"Problem: How can we ensure that the voices of the most marginalized in Planetary science are represented in the current Decadal Survey Process?"

Proposes 15 Recommendations to DS process from:
The Decadal Survey co-chairs need to ensure that voices of underrepresented groups, particularly African-American, Latin American and indigenous scientists, are represented in the final survey report.

To:
All Decadal Survey committee members should undergo implicit bias and racial sensitivity training as early in the process as possible.
White Papers related to State of the Profession

27 White Papers on
1. Demographics (4)
2. Improving Diversity & Inclusion at NASA (4)
3. Improving Diversity & Inclusion generally (6)
4. Preventing Harrassment (4)
5. Other issues (9)

Note:
• There is NOT a separate panel for State of the Profession.
• Each panel & the steering group are expected to address these issues – and put statements – including Findings and Recommendations.
• Will the DS fund further analysis of Workforce Survey data?
Think Global, Act Local
– Fran's reflections

- I've been involved in women in physics – stats, culture – for decades

- I saw this 2017 bulletin and thought "Really?! The percentage of bachelors to women has been dropping for 20 years?!"

Physics
– the building blocks of our profession
US PhD Statistics – AIP

- ~2000 Physics PhDs/year
- ~50% non-US
- Does the PhD production meet the workforce needs of our science?
- How will this evolve?
US PhDs – AIP

~2000 Physics PhDs/year

~20% women
US PhD Statistics - AIP

- ~2000 Physics PhDs/year
- ~20% women
- ~3% Hispanic-American or African-American
- Diversity is changing slowly

Why so slow?

Note factor ~40 in vertical scale
1,800 PhDs / 500 positions = 1 in 3.5
other 70% need to find non-academic job

*Career advice needed!*

**Number of New Faculty Members**
Physics Departments in the US

- Bachelor's Departments
- PhD Departments

![Graph showing the number of new faculty members from 2006 to 2014.](image)
Actual and Expected Percentage of Women and Men in Physics in the US

- Pipeline is more leaky for women than men
- Current %age of faculty predicted by % bachelors appropriate years ago

Source: AIP Statistical Research Center
The Leaky Pipeline

Graduate school is differentially leaky for women

Is this partly due to ..... pet theory here .....?
Good news at the faculty level!

Once on the faculty, the % age of women tracks over time

Bagenal (STATUS 2004)
Actual and Expected Percent of Men and Women Faculty Members at Different Academic Ranks, 2014

Source: AIP Statistical Research Center, 2014 Academic Workforce Survey provided data on the actual percent of faculty members, and 2016 Faculty Member Survey provided data on the expected percent of faculty members.

Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie
Percent of PhD Physics Departments by Number of Women Faculty Members in Professorial Ranks, 2002 & 2014

Source: AIP Statistical Research Center, Academic Workforce Survey.

Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie
Most female physicists are unmarried or married to PhDs

Most male physicists are married to non-scientists

Institutions need Dual-Career Programs!
2 – Two-Body Problem

2011 Planetary Science Survey

Same story....

BIG ISSUE
### Gender Differences in Career Opportunities, Advancement, and Resources

<table>
<thead>
<tr>
<th>Career Opportunities and Resources</th>
<th>Survey Source</th>
<th>Gender Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of promotions</td>
<td>PhD Plus 10 Survey, 2011</td>
<td>No significant difference</td>
</tr>
<tr>
<td>Number of publications</td>
<td>PhD Plus 10 Survey, 2011</td>
<td>No significant difference</td>
</tr>
<tr>
<td>Gave a talk as an invited speaker</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 45% more likely</td>
</tr>
<tr>
<td>Acted as a manager</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 33% more likely</td>
</tr>
<tr>
<td>Acted as a journal editor</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 27% more likely</td>
</tr>
<tr>
<td>Supervised undergraduate students</td>
<td>Global Survey of Physicists, 2010</td>
<td>No significant difference</td>
</tr>
<tr>
<td>Supervised graduate students</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 32% more likely</td>
</tr>
<tr>
<td>Had enough funding</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 53% more likely</td>
</tr>
<tr>
<td>Had enough equipment</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 36% more likely</td>
</tr>
<tr>
<td>Had enough office space</td>
<td>Global Survey of Physicists, 2010</td>
<td>No significant difference</td>
</tr>
<tr>
<td>Had enough lab space</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 15% more likely</td>
</tr>
<tr>
<td>Had enough employees</td>
<td>Global Survey of Physicists, 2010</td>
<td>Men were 36% more likely</td>
</tr>
</tbody>
</table>

"PhD + 10 years" survey

Which factors are most important for pay?? for promotion??

Men had 10% higher salary

---

Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie
<table>
<thead>
<tr>
<th>Career Compromises</th>
<th>Survey Source</th>
<th>Gender Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relocated for a spouse</td>
<td>Longitudinal Study of Astronomy Graduate Students, 2007–2016</td>
<td>Women were 204% more likely</td>
</tr>
<tr>
<td>Declined job for a spouse</td>
<td>PhD Plus 10 Survey, 2011</td>
<td>Women were 346% more likely</td>
</tr>
<tr>
<td>Had a career break for family reasons</td>
<td>Global Survey of Physicists, 2010</td>
<td>Women were 400% more likely</td>
</tr>
<tr>
<td>Became a stay-at-home parent</td>
<td>Global Survey of Physicists, 2010</td>
<td>Women were 463% more likely</td>
</tr>
<tr>
<td>Chose a less demanding or more flexible schedule</td>
<td>Global Survey of Physicists, 2010</td>
<td>Women were 111% more likely</td>
</tr>
<tr>
<td>Changed employers or field of employment</td>
<td>Global Survey of Physicists, 2010</td>
<td>Women were 40% more likely</td>
</tr>
<tr>
<td>Spent less time at work</td>
<td>Global Survey of Physicists, 2010</td>
<td>Women were 104% more likely</td>
</tr>
</tbody>
</table>
Women progress (a little) faster without children. Men progress faster with children.

Gender Differences in Perceived Career Progression by Parental Status, 2010

Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie

The Leaky Pipeline

Shiela Widnall
AAAS presidential lecture 1988

Starting with 4 million 16-year-olds in 1977

- 2,000,000 Total sophomores in 1977
- 175,000 H.S. sophomores with NS & E interest
- 129,000 H.S. seniors with NS & E interest
- 72,000 College freshmen, NS & E preference
- 49,000 Juniors, NS & E major
- 46,000 NS & E B.S. degrees
- 11,000 NS & E graduate students
- 10,000 NS & E M.S. degrees
- 1,900 NS & E Ph.D. degrees

1 in 1000 women obtained Ph.D.s in Nat. Sci. & Eng.
5 in 1000 men obtained Ph.D.s in Nat. Sci. & Eng.
Physics Education – input to our profession

College education
Up, Up, Up!

Physics numbers flat
±20%
Students got the message...

You can get a job with a physics degree!

Physics Bachelor’s Degrees Awarded.
Did women not get the message...

Number of Bachelor’s Degrees Earned in Physics, Classes 1982 through 2017

Women Physics Bachelors Increased but slower than men

Source: AIP Statistical Research Center, Enrollments and Degrees Survey.

aip.org/statistics
Number of Bachelors Earned in Physics Compared to Total Bachelors
Years 1955 through 2017
Delayed for PhDs? more likely...Non-US grads students have higher %-age of women.

~16% by 2020?

Source: AIP Statistical Research Center, Enrollments and Degrees Survey.
Percent of Astronomy Bachelors and PhDs Earned by Women, Classes of 1987 through 2017

Source: AIP Statistical Research Center, Enrollments and Degrees Survey.

AIP Statistics — aip.org/statistics
Fraction of college (BA/BS) degrees to women

Bachelor's Degrees Earned by Women

- All Bachelor's
- Biology
- Chemistry
- Math & Stats
- Earth Sciences
- Engineering
- Physics
- Computer Science

Source: IPEDS and APS
Compared to Other Sciences

Percentage of women at various academic stages

- **High School**: Physics = 45%, Chemistry = 50%, Biology = 55%
- **College Entrance**: Physics = 40%, Chemistry = 50%, Biology = 60%
- **B.S.**: Physics = 35%, Chemistry = 50%, Biology = 65%
- **Ph.D.**: Physics = 30%, Chemistry = 45%, Biology = 60%
- **Asst.**, **Assoc.**, and **Full Professor**: Physics = 20%, Chemistry = 30%, Biology = 50%

Percentage of students in physics, chemistry, and biology who are women at various academic stages. Source: AIP, HERI, & IPEDS
Girls more than keep up in math!

But there is still a small difference in Physics – but not much.
US Dept of Education - 2012

Overall education... across all fields... women are doing well

How about in Math/Physics/Engineering?
Where majors start-end
• What does this look like separated by years?

• When do students move? Why?

• Gender? Minorities?

• What does this look like at your institution?

Let's do the research
It's not just about grades....

- women and men equally likely to change their major in response to poor grades

- Women more likely to switch out of male-dominated STEM majors in response to poor performance compared to men

still

Is this true at your institution? ^ Got the stats?

NATIONAL BUREAU OF ECONOMIC RESEARCH
Kugler et al. 2017 http://www.nber.org/papers/w23735
Under-Represented Minorities
Number of Bachelor's Degrees Earned in Physics
1955 through 2018

The Proportion of Physics Bachelor's Degrees Awarded to African Americans and Hispanic Americans
Past 6 months – organizations are making statements, delivering webinars, doing studies, publishing reports, ....

Eight Deliberate Steps AGU is Taking to Address Racism in our Community

Robin Bell, AGU President and Susan Lozier, AGU President-elect

THE TIME IS NOW
Systemic Changes to Increase African Americans with Bachelor's Degrees in Physics and Astronomy
### Top 10 Majors by Concentration of African-American Bachelor's Degrees

<table>
<thead>
<tr>
<th>Major</th>
<th>Percent White</th>
<th>Percent African-American</th>
<th>Percent Hispanic</th>
<th>Percent Asian</th>
<th>Percent Other Races &amp; Ethnicities</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Student Counseling</td>
<td>56</td>
<td>38</td>
<td>&lt;0.5</td>
<td>6</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Human Services and Community Organization</td>
<td>65</td>
<td>21</td>
<td>11</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Counseling Psychology</td>
<td>72</td>
<td>20</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Health and Medical Administrative Services</td>
<td>71</td>
<td>18</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Public Administration</td>
<td>67</td>
<td>18</td>
<td>10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Social Work</td>
<td>71</td>
<td>16</td>
<td>9</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Miscellaneous Social Sciences</td>
<td>77</td>
<td>16</td>
<td>3</td>
<td>4</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>General Medical and Health Services</td>
<td>71</td>
<td>15</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Public Policy</td>
<td>72</td>
<td>15</td>
<td>6</td>
<td>7</td>
<td>1</td>
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<tr>
<td>Community and Public Health</td>
<td>73</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

Doing good things for society... not the best paid
46% of Physics Bachelors enter the workforce on graduation

Of these, 65% go into the private sector
Let's get them the right skills & career advice!
Only 47% of physics classes are taught by a teacher with a degree in the subject, compared with 73% of biology classes and about 80% of humanities classes.

Thought Experiment:
What would it take to put a teacher with a physics bachelor in every high school in the US?

- 45,000 high schools
  15 years "Typical career length" – survival span (optimistic)
  = 3000 Physics bachelors per year going into teaching

- Currently 9% of 8000 = 720

- Crank up production another factor 4

- Incentivize? Pay better?

- Change "Physics" to "Natural Sciences"?

- Placement at local schools?
Solutions - 1
– Keep the UGs going

A – More interactive classes – less "chalk&talk"
B – Affirmation exercises (they're cheap!)
C – The Sophomore Roadbump
  – provide undergraduate "study buddies"
  – don't put most traditional teachers in E&M 1!
D – Socialize (safe) study spaces – university wide
E – Invite Physics Education Researchers to give a Dept. Seminar
F – Dept/AGU/AAS/APS needs to provide more advice on non-academic careers
Recruitment:
• what are the realistic predictors of success in grad school?
• cast a broad net – makes a better environment

Program
• set fair, consistent, expectations
• design a program that supports and encourages a broad spectrum
• evaluate and articulate progress in a fair, consistent manner – so students know where they are early & often

Non-academic career advice
– get people from the real world out there to come give advice on real-world careers
A society that puts generous resources into educating women - and should make a major effort to benefit from the investment on the long term

Institutions need to develop policies and resources – Dual Careers Recruitment Office, Family Support, "stop the tenure clock", etc;
– be flexible, adapt to specific cases/needs

Think long-term – 2 years of supporting "re-entry stipend" pays off over 25-30 year career (e.g. to pay for post-doc to keep research going)
• Don't blame the women. 
  *Telling women to become more like men is not the solution.*

• Change the institutional environment
  *BUT don't just ask women faculty/researchers to "fix" the problem*

• Hire more women faculty/researchers - it's non-linear

• But it is as much CULTURE that drives women away
  - *Women are less content with their work environment*
  - *2-body problems, family issues*
  - *But also hostile environment - many subtle obstacles*

• **Leadership - from the very top - is critical**
Physics Education – the input to our profession....

.... and service teaching = bread and butter

http://www.aip.org/statistics/reports/roster-physics-2013
Solutions – 5 - National

• Sponsor AIP to do the demographic surveys – SMD-wide – in time for next Decadal Surveys
  • How are numbers changing?
  • What fraction of researchers are non-US to meet needs of the field?
  • How is the field changing?
  • What workforce is needed for next decade?

• Urge APS/AGU/AAS to provide career advice

• Make physical science education a priority – high school, college, graduate
  – surely we can do better than 8600 physics majors out of 300 million people!
Demographics Surveys – 1 Across NASA-SMD

• **Goal:** Is the workforce in the US meeting the needs of SMD? How is the workforce evolving?

• There are significant *overlaps* between areas (e.g. growing field of exoplanets, solar/stellar physics, planetary magnetospheres). How large are these overlaps? Until they are measured we do not know the population served by SMD.

• **Similarities & best practices** - AIP have many years of experience in running demographics surveys. It will be important to follow their best practices as well as ask (at least some) same questions across surveys.

• **Efficiency of scale** - AIP gathers email databases from AGU, AAS, APT, etc, counting and eliminating duplicates.

• **Survey fatigue** - AIP gets a good ~60% response to their surveys but if multiple, uncoordinated surveys are sent out for each sub-area by different organizations the community will likely quickly stop responding.
Demographics Surveys – 2
Across NASA-SMD

Approaches - the Decadals are offset by 2 years.
1 - Do a single, cross-SMD demographics survey every, say, 6 years. The data for a field could be up to 6 years old.

2 - Do separate demographics surveys for each Division, coordinating questions and cross-comparing data.