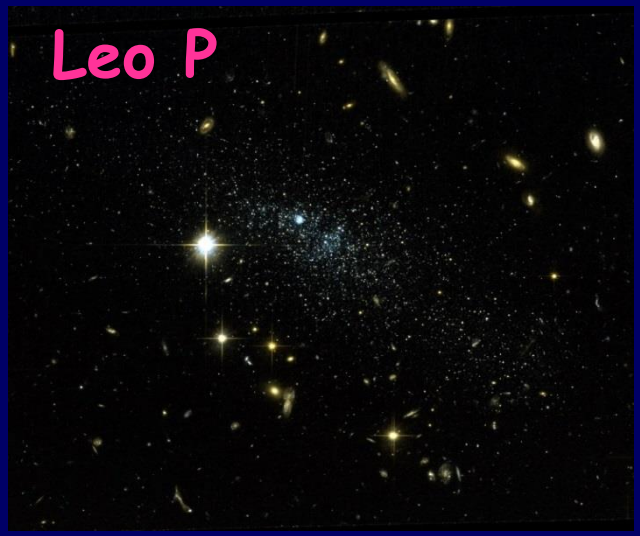
Careers for astronomers
and
Tips on applying to graduate school



Martha Haynes

UAT16 16.06.15

UAT 16.06

Why study astronomy?

Why study astronomy?

Why NOT study astronomy if you really enjoy it?

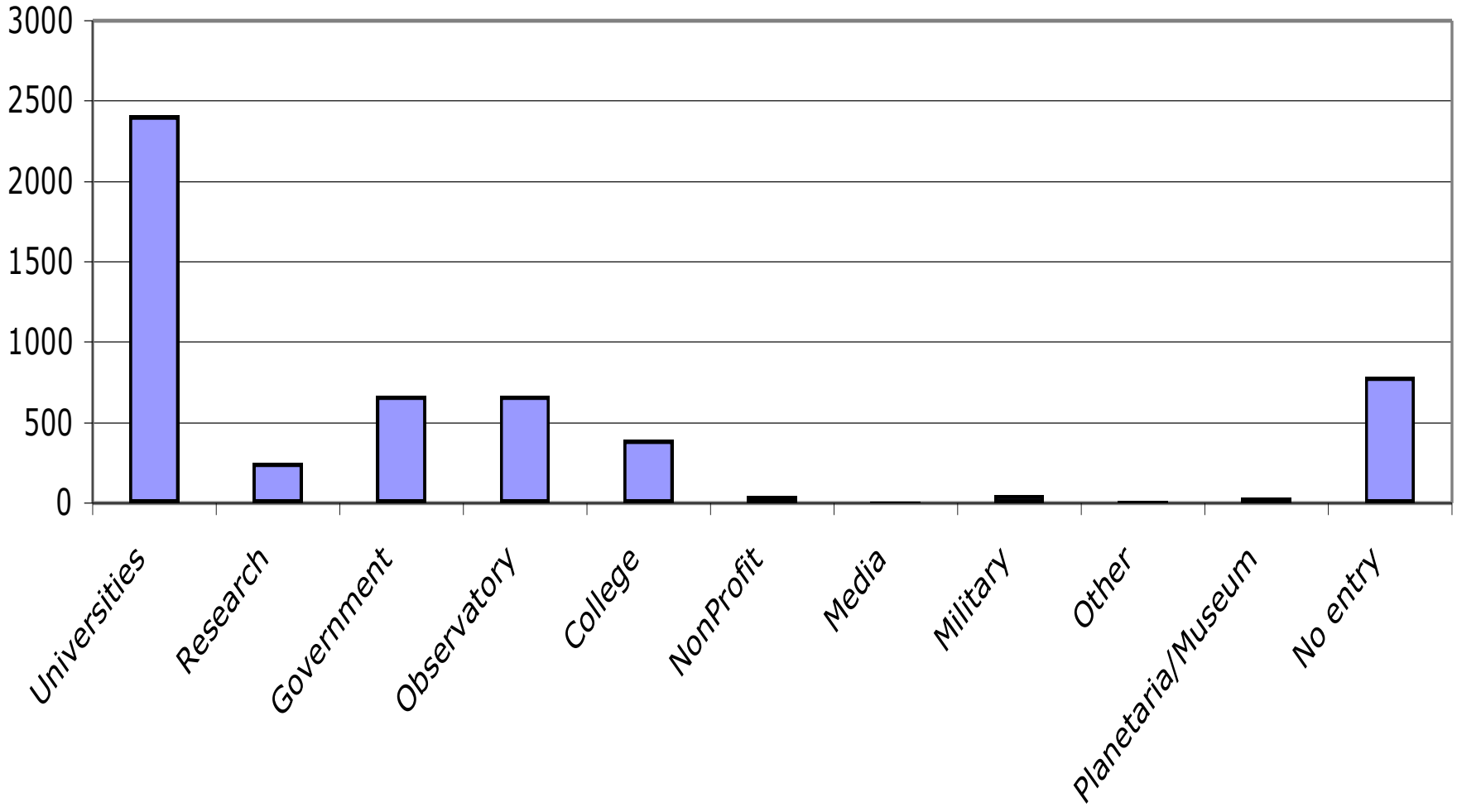
Typical academic faculty career path

- Bachelor's degree in astronomy, physics, geology or related field (4 yrs)
- Ph.D. degree in astronomy, astrophysics, physics, geology, space science or related field (4-6 years)
- Postdoctoral fellowship (2-3 years; sometimes more than one)
- Assistant professor, untenured (5-6 years)
- Associate professor, tenured (5+ years)
- Full professor, tenured (the rest)

To grad school or not to grad school: is that the question?

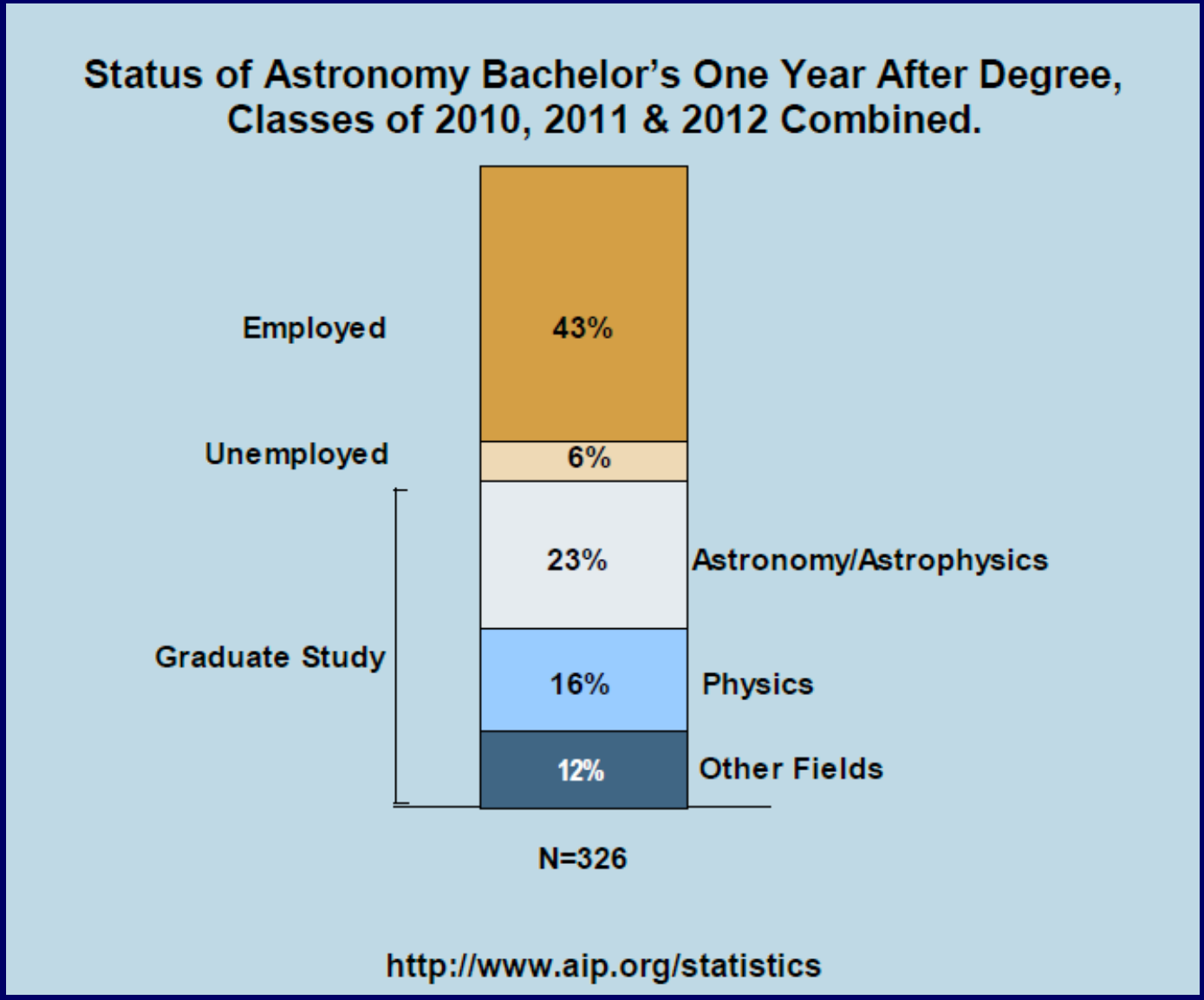
- Most graduate students in physical sciences are supported on TA-ships, GRA-ships or fellowships for 12 months/year
- Graduate courses are higher level versions of undergraduate courses; they are not easy.
- Graduate research is hard work, sometimes fun, more often frustrating (that is the nature of research).
- But, most graduate students are well-fed and adequately housed and dressed. Many have cars, big screen tv's etc.
- So, it really depends on your personal goals and motivation!

Where AAS Members Work



Source: K. Marvel, AAS

American Institute of Physics studies



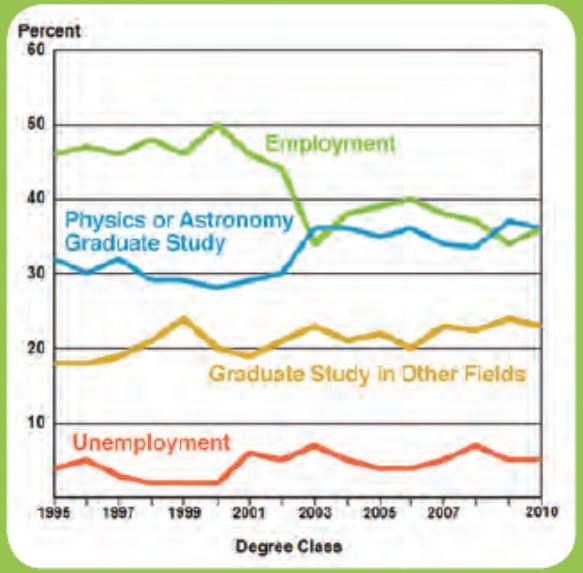
http://www.aip.org/statistics/reports/astronomy-initial-employment

American Institute of Physics studies

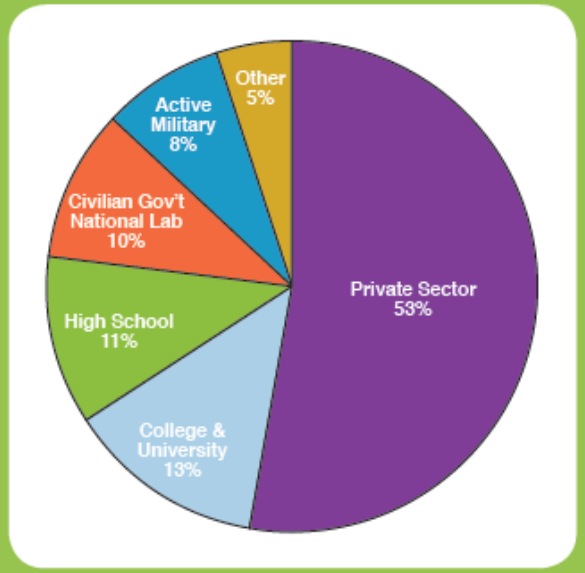
[what happens after the physics bachelor's degree?]

About 40% of graduates go directly into the workforce. Of these, more than half go into the private sector, and nearly three-fourths of those in the private sector go into STEM positions (Natural Science, Technology, Engineering, and Mathematics). Source: www.aip.org/statistics.

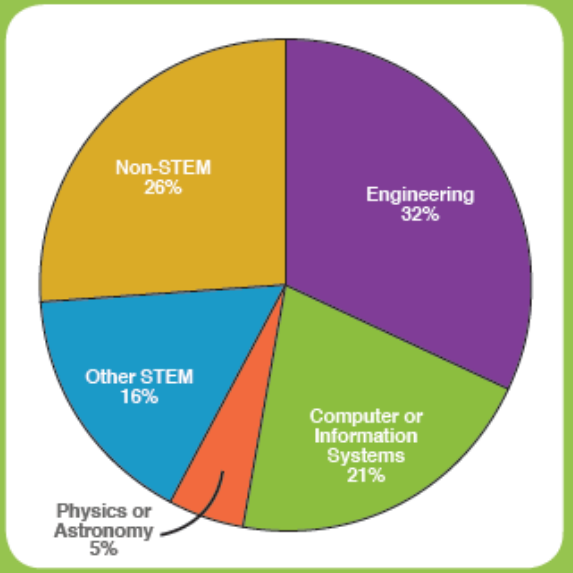
Trends in Status One Year After Earning a Physics Bachelor's, Classes 1995-2010



Initial Employment Sectors of Physics Bachelor's Classes of 2009 & 2010 Combined



Field of Employment for Physics Bachelor's in the Private Sector



STEM refers to Natural Science, Technology, Engineering, and Mathematics

http://www.aip.org/statistics/reports/fact-sheet-connecting-physics-students-career-opportunities

American Institute of Physics studies

[what a physics bachelor's degree qualifies graduates to do]

Critical thinking and problem-solving skills are the hallmarks of a physics bachelor's degree. From solving difficult theoretical constructs to collecting and analyzing data, physics majors are marketable in a wide range of professional settings. Physics bachelor's degree recipients commonly find employment in four broad areas:

- Engineering
- Computer Hardware and Software
- Research and Technical
- Education

[challenges]

- Although there are many jobs for physics bachelor's degree recipients, very few have the word "physics" in the title
- Hiring professionals may not understand what a physics student actually knows or is capable of doing
- Faculty may not understand what a physics student actually knows or is capable of doing outside of working in academia
- Students may lack self-awareness of or have difficulty articulating their strengths and capabilities
- Underdeveloped interpersonal communication skills may be a barrier to students in the job search

http://www.aip.org/statistics/reports/fact-sheet-connecting-physics-students-career-opportunities

American Institute of Physics studies

[resume writing tips for the physics undergraduate]

- Writing a skills-based resume may be the best option for physics undergraduates seeking an internship or job.
- Focus on skills and practical experience
- Translate transferable skill sets for the nontechnical reader
- Write a summary of technical qualifications
- Only highlight coursework to demonstrate knowledge of a topic
- Include GPA, overall or major
- Highlighting strong technical skills can be especially important. Consider including experience with
  - Lab equipment (mention expertise level)
  - Microsoft Office, Access
  - MatLab, LabView, or similar analytical/instrument control software
  - Programming languages (C++, SQL), technologies, and tools

*[careers too

The Careers Toolbox for
dents is a set of tools and t
physics students prepare to e
engineering, and mathematic
part of workshops presented b
resources are also available for

www.spsnational.org/career

http://www.aip.org/statistics/reports/fact-sheet-connecting-physics-students-career-opportunities

American Institute of Physics studies

[common job titles for physics bachelor's degree job seekers]

These job titles were obtained from surveys of physics bachelor's recipients from the classes of 2009 and 2010, conducted by the American Institute of Physics Statistical Research Center. They are not exhaustive or exclusive.

Computer Hardware & Software

- Analyst
- IT Consultant
- Programmer
- Software Engineer
- Systems Analyst
- Technical Support Staff
- Web Developer

Education

- High School Physics Teacher
- High School Science Teacher
- Middle School Science Teacher

Engineering

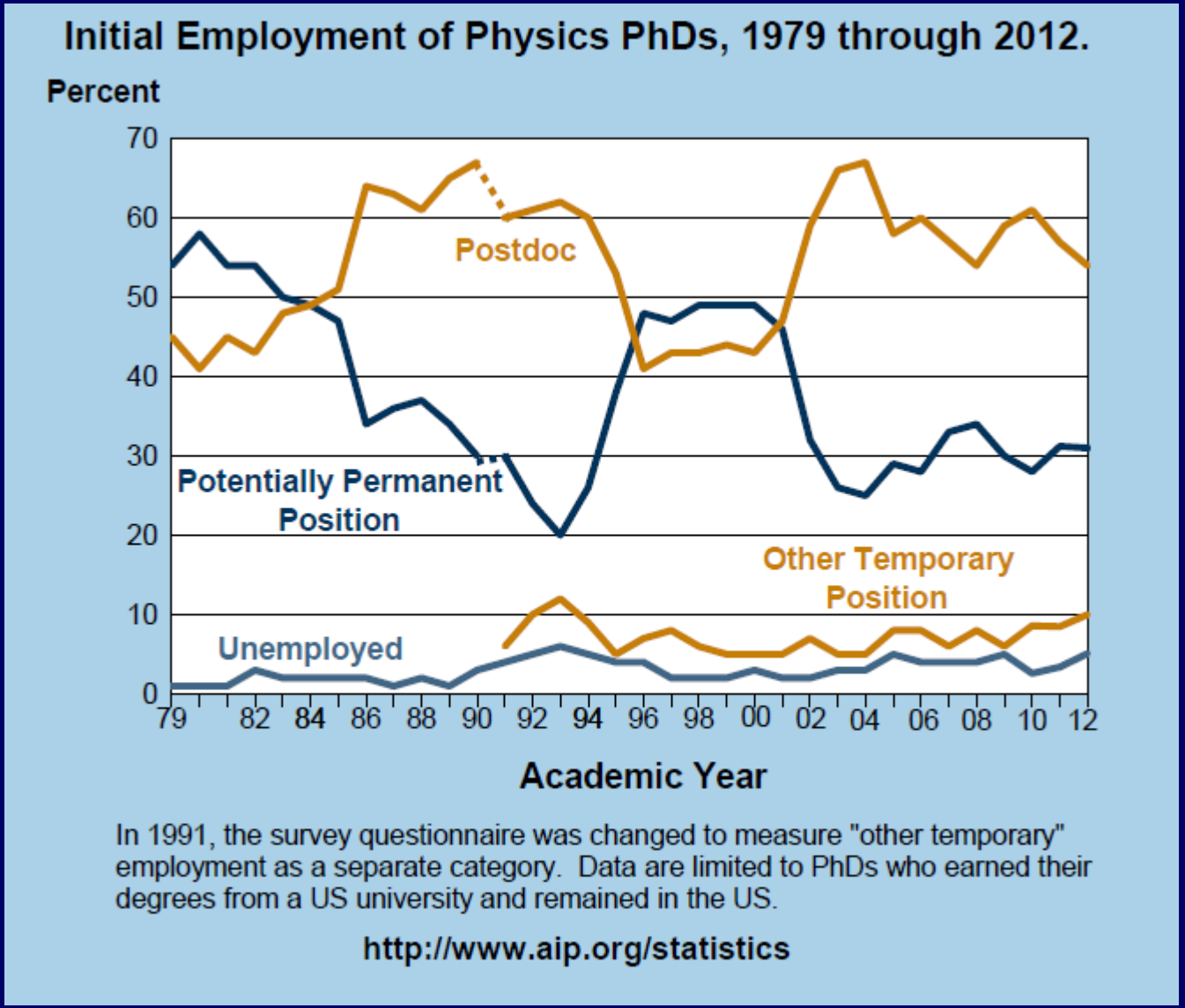
- Application Engineer
- Associate Engineer
- Design Engineer
- Development Engineer
- Electrical Engineer
- Engineering Technician
- Field Engineer
- General Engineer
- Laser Engineer
- Manufacturing Engineer
- Manufacturing Technician
- Mechanical Engineer
- Optical Engineer
- Process Engineer
- Process Technician
- Product Engineer
- Product Manager
- Project Engineer
- Research Engineer
- Systems Engineer
- Technical Services Engineer
- Test Engineer

Research & Technical

- Accelerator Operator
- Lab Assistant
- Lab Technician
- Physical Sciences Technician
- Research Assistant
- Research Associate
- Research Technician

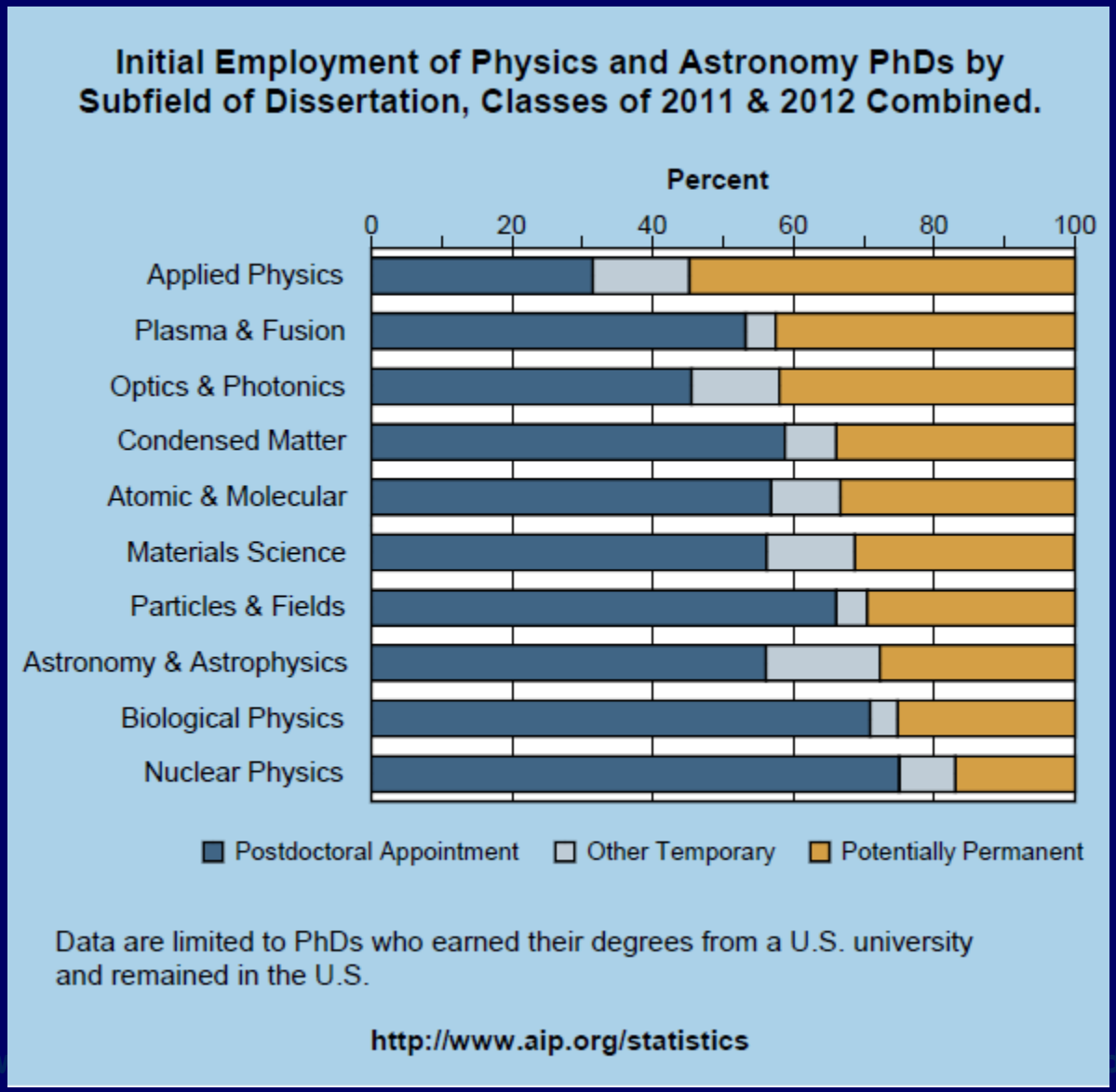
http://www.aip.org/statistics/reports/fact-sheet-connecting-physics-students-career-opportunities

American Institute of Physics studies



http://www.aip.org/statistics/reports/physics-doctorates-one-year-after-degree

American Institute of Physics studies




Careers in Astronomy | America...
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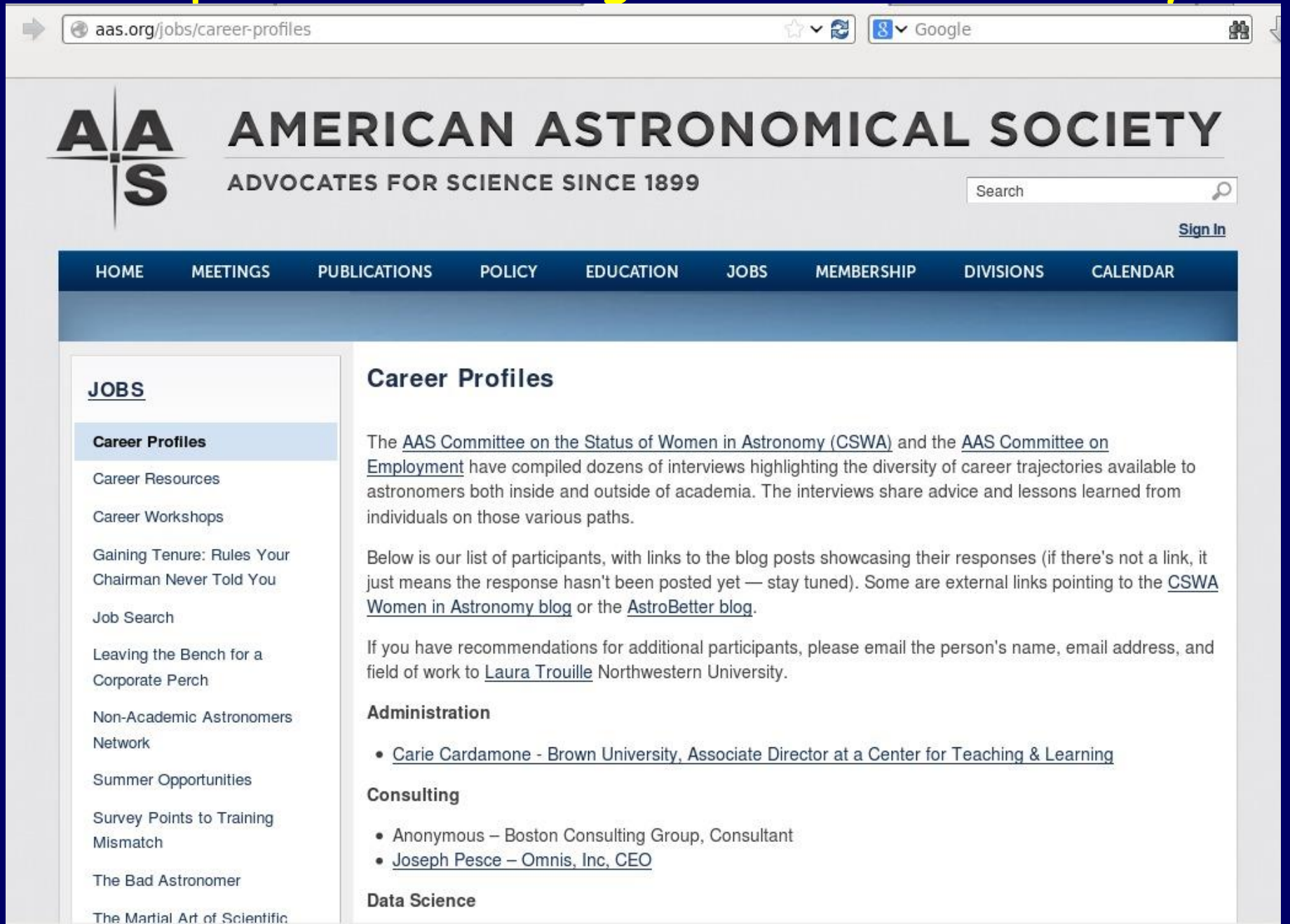
Where the Jobs Are
National Observatories and Government Laboratories
Business and Private Industry
Related Jobs
A PDF version of A New Universe to Explore: Careers in Astronomy is available. You distribute as many copies as you wish.
Where Astronomers Work
Where the Jobs Are!
Employment Potential
"Discovering new information about how our universe works is always an incredible experience, but sharing that information is also a source of satisfaction. As a planetarium director, I transport audiences to distant planets and stars daily. I am constantly rewarded by children's amazed gasps and squeals as I make the sky move, and give them their first look at the wonders of the stars. Astronomy is an excellent way of exposing young minds to the thrill of scientific discovery. Ideally, by writing articles, giving shows, and holding special events, astronomy educators are creating a world where science is not difficult or boring but is instead a key to our future."
— Christine Brunello, planetarium director, Don Harrington Discovery Center, Amarillo, Texas.
As science professions go, astronomy is a relatively small field, with about 6,000 professional astronomers in North America. Because of its size, astronomers get to know and collaborate with many colleagues across the U.S. and around the world. This can lead to an advantageous dialogue among astronomers.

Career paths of Astronomers

- Following in the footsteps of your PhD adviser
- Working on the staff of a national observatory in a support staff position
- Working as a "soft money" researcher
- Federal\agency program manager (NSF, NASA, NRC)
- Teaching at a principally-undergraduate college
- Teaching in the K-12 arena
- Teaching in the (new) distance-learning arena
- Public outreach (museums, tv)
- Journalism/science communications/press officer
- Working in industry/private sector
    - Aerospace industry
    - Financial services
    - Management consultant
    - Computer graphics/visualization
    - Many others requiring critical thinking/math-comp skills

http://www.aas.org/careers-astronomy



http://www.aas.org/careers-astronomy

Academia

- Edmund Bertschinger - MIT, Physics Department Head
- Caroline Simpson - Florida International University, Associate Professor of Physics
- Bryan Gaensler - University of Sydney, Professor of Physics; Australian Laureate Fellow; Director for the Centre of Excellence for All-Sky Physics
- Joan Schmelz - University of Memphis, Professor
- Andria Schwortz - Quinsigamond Community College, Associate Professor of Integrated Science
- Agnes Kim – Penn State Worthington Scranton, Assistant Professor of Physics
- Anonymous - Large Research 1 University, Lecturer (non-tenure track)
- Anonymous - Community College in California, Professor of Astronomy
- Meredith Hughes - Wesleyan University, Assistant Professor of Astronomy
- Douglas Arion - Carthage College, Professor of Physics & Astronomy; Professor of Entrepreneurship; Director of Carthage Institute of Astronomy; President of Galileoscope LLC
- Anonymous - Small Liberal Arts College, Associate Professor of Physics
- Anonymous - Small Liberal Arts College, Assistant Professor of Physics
- Anonymous - Smithsonian Astrophysical Observatory, Astrophysicist (retired)
- Christine Jones - Smithsonian Institution, Senior Astrophysicist; Director of Smithsonian Consortium on Unlocking the Mysteries of the Universe
- Anonymous - University & Observatory, Associate Professor & Project Scientist

National Labs

- Neil Gehrels – NASA Goddard Space Flight Center, Chief of Astroparticle Physics Laboratory

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Data Science

- Jessica Kirkpatrick - Director of Data Science at InstaEDU
- Alicia Oshlack - Murdoch Children's Research Institute, Head of Bioinformatics
- Stephanie Gogarten - University of Washington, Research Scientist in Statistical Genetics

Defense

- Anonymous - Federally Funded Research and Development Center, Research Staff
- Eileen Chollet - Center for Naval Analyses, Research Analyst
- Eric Rubenstein – Image Insight, Inc., President

Finance

- Melissa Nysewander - Fidelity Investments, Principal Data Scientist
- Anonymous – Large American Bank, Researcher
- Anonymous - Small Hedge Fund, Researcher

Government

- Sethanne Howard - US Naval Observatory, Chief of the Nautical Almanac Office (retired)
- Cara Rakowski - US Patent and Trademark Office, Patent Examiner
- Anonymous - European Union, Policy Analysis

Industry

- Andre Wong – Teledyne Imaging Sensors, ASIC Design Engineer
- James Marshall – INNOVIM, Senior Staff Scientist

Management

- Doris Daou - NASA Lunar Science Institute, Associate Director
- Kim Nilsson – Pivigo Recruitment, Managing Director
- Bernadette Rodgers – Gemini Observatory (South), Head of Science Operations

http://www.aas.org/careers-astronomy

Museums

- Doug Roberts – Adler Planetarium, Astronomer & Associate VP for Digital Technologies
- Anonymous - Science Museum, Curator

Science Communication/Writing/Publishing

- Leslie Sage - *Nature*, Senior Editor
- Rick Fienberg - AAS, Press Officer
- Lisa Frattare - STScI, Master Image Processor & Summer Student Program Coordinator
- Monica Young - *Sky & Telescope*, Web Editor

Software

- Patrik Jonsson - SpaceX, Software Engineer
- Amy Nelson - Disney Interactive Worlds, Software Engineer

Teaching & Learning

- Andy Cantrell - Blake School, Mathematics Teacher

Soft Money

- Anonymous - Senior Scientist - Soft Money

Change of topic….

Career paths of Astronomers

- Following in the footsteps of your PhD adviser
- Working on the staff of a national observatory in a support staff position
- Working as a "soft money" researcher
- Federal\agency program manager (NSF, NASA, NRC)
- Teaching at a principally-undergraduate college
- Teaching in the K-12 arena
- Teaching in the (new) distance-learning arena
- Public outreach (museums, tv)
- Journalism/science communications/press officer
- Working in industry/private sector
    - Aerospace industry
    - Financial services
    - Management consultant
    - Computer graphics/visualization
    - Many others requiring critical thinking/math-comp skills

Applying to Grad School

General advice:

- Talk with faculty friends/mentors about you(!).
- Talk with grads/postdocs about their experiences.
- Leave yourself enough time to write good applications.
- For the physics GRE: practice, practice, practice!
- Explore options in astronomy/physics/Earth science.
- Don't apply to all the same schools that your friends are.
- Apply to 6-8 schools in 3 categories: certain/good/hope.

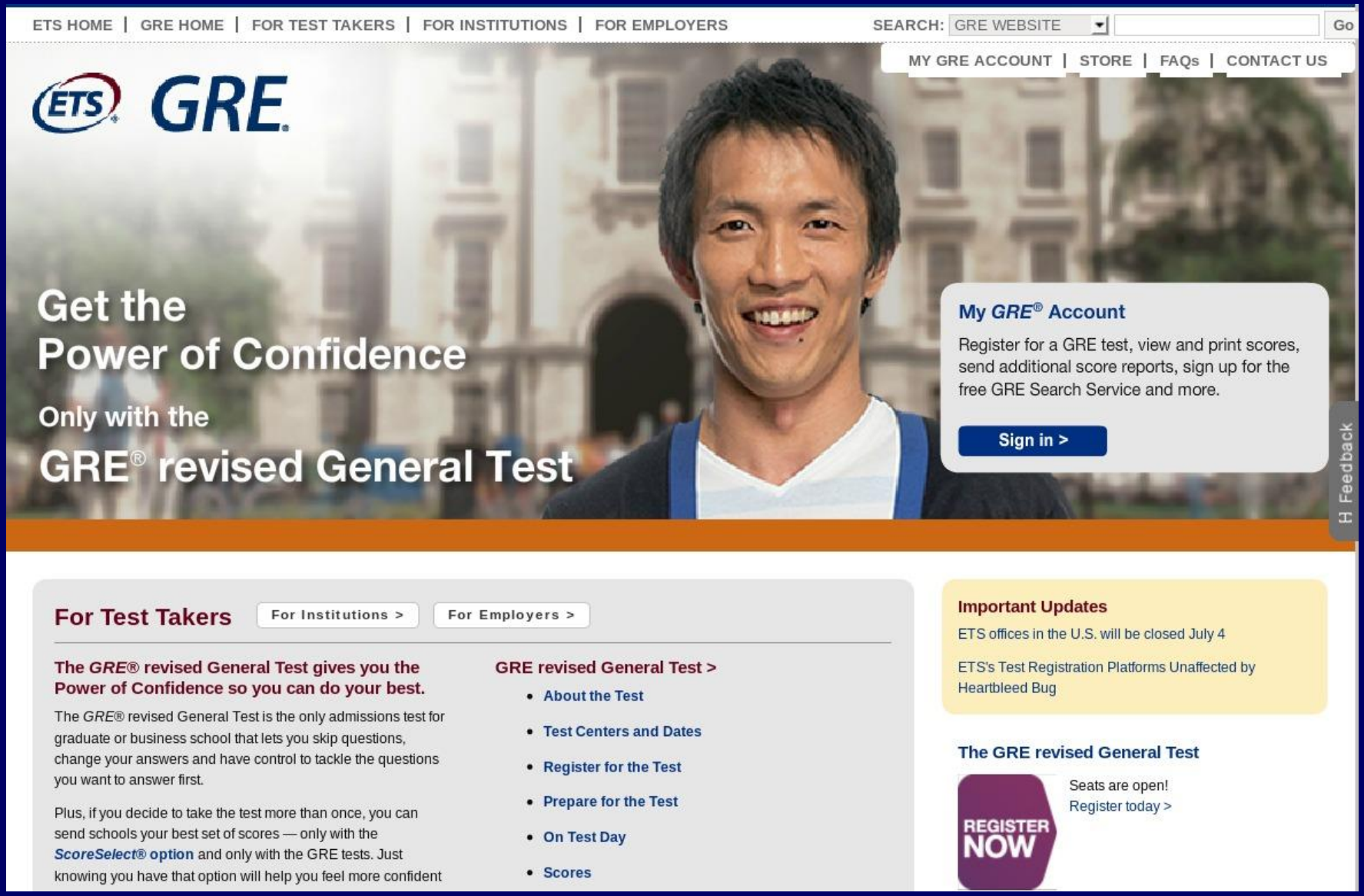
The Grad School Experience

- There is a spot for you somewhere!
- You probably don't have to pay tuition and you probably get a stipend as a fellow, TA or RA.
- You probably will take courses for 1-2 years; they will be tough.
- Having a TA-ship early on is not a bad idea.
- Most grad students work hard but have a good time.
- Getting a job afterwards is not easy, but
    1. It is far from impossible and
    2. That's a long way off…

Senior Year Timeline: I.

- Summer/early Fall of Senior year:
  - Check out GRE website (**www.ets.org/gre**)
  - **New questions/format** introduced in 2011; read the most up-to-date material! Includes (1) verbal reasoning; (2) quantitative reasoning; (3) analytical writing.
  - Start practicing for (1) general and (2) subject test – practice, practice, practice!
  - Consider taking general GRE test (computer based) sooner rather than later to get it over with!
  - Check out where nearby sites are.
  - Start checking out school web sites
  - Start asking advice on school programs/options

General GRE info



General GRE info

Structure of the Computer-delivered Test

Measure	Number of Questions	Allotted Time
Analytical Writing (One section with two separately timed tasks)	One "Analyze an Issue" task and one "Analyze an Argument" task	30 minutes per task
Verbal Reasoning (Two sections)	20 questions per section	30 minutes per section
Quantitative Reasoning (Two sections)	20 questions per section	35 minutes per section
Unscored[1]	Varies	Varies
Research[2]	Varies	Varies

[1]An unidentified unscored section that does not count toward your score may be included and may appear in any order after the Analytical Writing section. Questions in the unscored section are being tried out either for possible use in future tests or to ensure that scores on new editions of the test are comparable to scores from earlier editions.

[2]An identified research section that does not count toward your score may be included in place of the unscored section. The research section will always appear at the end of the test. Questions in this section are included for ETS research purposes.

The Analytical Writing section will always be first. The Verbal Reasoning, Quantitative Reasoning and unidentified/unscored sections may appear in any order; therefore, you should treat each section as if it counts toward your score.

General GRE info

Test Design Features

The advanced adaptive design of the GRE revised General Test allows you to freely move forward and backward throughout an entire section. Specific features include:

- Preview and review capabilities within a section
- "Mark" and "Review" features to tag questions, so you can skip them and return later if you have time remaining in the section
- The ability to change/edit answers within a section
- An on-screen calculator for the Quantitative Reasoning section

To experience the test design features of the computer-delivered test, download *POWERPREP® II* software.

See also:

- Test Preparation Materials
- Test Centers, Test Dates and Seat Availability

Senior Year Timeline: II.

- September/October of Senior year:
  - Talk with local adviser about process, schools, letters of reference, experiences of grads of your school
  - Check out fellowship websites (NSF, Zonta, etc)
  - Register for subject(=physics) GRE test (Sep or Oct!)
    - Sept 17th, 2016, register by Aug 12th
    - Oct 29th, 2016, register by Sep 23rd
      - Register earlier to get site choice!
  - Take the general GRE test early (summer before?).
  - Gather application materials

What Are the Subject Tests?

The *GRE*® Subject Tests are achievement tests that measure your knowledge of a particular field of study.

Show what you know about a specific subject and graduate schools will take notice. The Subject Tests can help you stand out from other applicants by emphasizing your knowledge and skill level in a specific area.

Each Subject Test is intended for students who have an undergraduate major or extensive background in one of these seven disciplines:

- Biochemistry, Cell and Molecular Biology
- Biology
- Chemistry
- Literature in English
- Mathematics
- Physics
- Psychology

Note: The GRE Computer Science Test was discontinued following the April 2013 administration. Scores will continue to be reportable for five years.

Who Takes Them?

Prospective graduate school applicants take the Subject Tests. Applicants come from varying educational and cultural backgrounds and the GRE Subject Tests provide a common measure for comparing candidates' qualifications.

GRE Subject Test scores are used by admissions or fellowship panels to supplement your undergraduate records, recommendation letters and other qualifications for graduate-level study. Some Subject Tests yield subscores that can indicate the strengths and weaknesses in an individual student's preparation and may also be useful for guidance and placement purposes.

Subject test (physics) GRE info

Physics Test

Overview

- The test consists of approximately 100 five-choice questions, some of which are grouped in sets and based on such materials as diagrams, graphs, experimental data and descriptions of physical situations.
- The aim of the test is to determine the extent of the examinees' grasp of fundamental principles and their ability to apply these principles in the solution of problems.
- Most test questions can be answered on the basis of a mastery of the first three years of undergraduate physics.
- The International System (SI) of units is used predominantly in the test. A table of information representing various physical constants and a few conversion factors among SI units is presented in the test book.
- The approximate percentages of the test on the major content topics have been set by the committee of examiners, with input from a nationwide survey of undergraduate physics curricula. The percentages reflect the committee's determination of the relative emphasis placed on each topic in a typical undergraduate program. These percentages are given below along with the major subtopics included in each content category. In each category, the subtopics are listed roughly in order of decreasing importance for inclusion in the test.
- Nearly all the questions in the test will relate to material in this listing; however, there may be occasional questions on other topics not explicitly listed here.

Content Specifications

1. **CLASSICAL MECHANICS — 20%**
   (such as kinematics, Newton's laws, work and energy, oscillatory motion, rotational motion about a fixed axis, dynamics of systems of particles, central forces and celestial mechanics, three-dimensional particle dynamics, Lagrangian and Hamiltonian formalism, noninertial reference frames, elementary topics in fluid dynamics)
2. **ELECTROMAGNETISM — 18%**
   (such as electrostatics, currents and DC circuits, magnetic fields in free space, Lorentz force, induction, Maxwell's equations and their applications, electromagnetic waves, AC circuits, magnetic and electric fields in matter)
3. **OPTICS AND WAVE PHENOMENA — 9%**
   (such as wave properties, superposition, interference, diffraction, geometrical optics, polarization, Doppler effect)
4. **THERMODYNAMICS AND STATISTICAL MECHANICS — 10%**
   (such as the laws of thermodynamics, thermodynamic processes, equations of state, ideal gases, kinetic theory, ensembles, statistical concepts and calculation of thermodynamic quantities, thermal expansion and heat transfer)
5. **QUANTUM MECHANICS — 12%**
   (such as fundamental concepts, solutions of the Schrödinger equation (including square wells, harmonic oscillators, and hydrogenic atoms), spin, angular momentum, wave function symmetry, elementary perturbation theory)
6. **ATOMIC PHYSICS — 10%**
   (such as properties of electrons, Bohr model, energy quantization, atomic structure, atomic spectra, selection rules, black-body radiation, x-rays, atoms in electric and magnetic fields)
7. **SPECIAL RELATIVITY — 6%**
   (such as introductory concepts, time dilation, length contraction, simultaneity, energy and momentum, four-vectors and Lorentz transformation, velocity addition)
8. **LABORATORY METHODS — 6%**
   (such as data and error analysis, electronics, instrumentation, radiation detection, counting statistics, interaction of charged particles with matter, lasers and optical interferometers, dimensional analysis, fundamental applications of probability and statistics)
9. **SPECIALIZED TOPICS — 9%**
   Nuclear and Particle physics (e.g., nuclear properties, radioactive decay, fission and fusion, reactions, fundamental properties of elementary particles), Condensed Matter (e.g., crystal structure, x-ray diffraction, thermal properties, electron theory of metals, semiconductors, superconductors), Miscellaneous (e.g., astrophysics, mathematical methods, computer applications)

Those taking the test should be familiar with certain mathematical methods and their applications in physics. Such mathematical methods include single and multivariate calculus, coordinate systems (rectangular, cylindrical and spherical), vector algebra and vector differential operators, Fourier series, partial differential equations, boundary value problems, matrices and determinants, and functions of complex variables. These methods may appear in the test in the context of various content categories as well as occasional questions concerning only mathematics in the specialized topics category above.

Prepare for a *GRE*® Subject Test

Free, official test preparation materials for the *GRE*® Subject Tests are available to anyone who visits this website. If you register for a Subject Test, you are encouraged to download the free practice book for the specific Subject Test you plan to take. If you have a disability or health-related need and require test preparation material in an alternate format, contact ETS Disability Services.

Subject Test Materials

Each Subject Test practice book contains a full-length test and answer key, test-taking strategies, and information to help you understand how the test is scored. You may download them here:

- Biochemistry, Cell and Molecular Biology (PDF)
- Biology (PDF)
- Chemistry (PDF)
- Literature in English (PDF)
- Mathematics (PDF)
- Physics (PDF)
- Psychology (PDF)

See also:

- Test Content and Structure
- Student fair schedule

Taking the Physics GRE

- 100 multiple choice (5 possible answers) questions in 150 minutes, covering a broad sweep of undergrad physics; some grouped in sets.
- You get penalized for a wrong answer (negative points) and get no points if you skip a question.
- Ira Wasserman (my colleague; theoretical astrophysics) took the (downloaded) test in 2003 (as an experiment). He answered only 66 questions but got only 8 wrong. He scored in the 91st percentile!
- You need to PRACTICE (…PRACTICE… PRACTICE) when to skip and when to guess.
- **Practicing the best strategy can really help**!

Don't try to answer all 100 questions!

Senior Year Timeline: III.

- October/November of Senior year:
  - Start applications for fellowships
  - Talk with other reference letter writers
  - Talk with postdocs, grad students
  - Begin to narrow your choices
  - If you are not an "A" student:
    - Apply to a range of schools
    - Understand your chances/choices
    - Don't apply only to the "usual suspects"

Choosing Letter Writers

- PhD's who know you!
- At least one who taught you in an upper level course in physics/math/astro
- Talk to each one about your goals and aspirations; ask each for his/her advice.
- Make sure you provide each of them with your latest information about classes, grades, test scores, research experience, career goals

Personal statement: keep it professional

Focus on your "career" as a scientist, e.g. research experience, educational background, scientific interests

Support for a graduate student per year includes:

- Tuition at Cornell that is about $31K
- Stipend at Cornell that is about $38K
- Other at Cornell, health insurance is about $2K

~ $70+K total (plus meetings, travel, computers etc)

So: "*WHY YOU SHOULD INVEST $350K+ IN ME*"

Personal statement: keep it professional

Focus on your "career" as a scientist, e.g. research experience, educational background, scientific interests

- Limit discussion of non-professional activities except where they show development of leadership, intellectual breadth, discipline
- Give some details, e.g., write a paragraph about what research (or other relevant experience) you are doing this summer/did recently:
  - *My project was focused on assessing the impact of environment on galaxies in the region of the rich group ZwCl1400.4+0949. In addition to examining the large scale structure and establishing group membership, I evaluated the published methods of deriving stellar masses from optical (SDSS) and UV (GALEX) photometry (e.g. Bell et al.; MPA-JHU compilation, etc) and how the astrophysical assumptions behind them may (or may not) apply to HI-based galaxy samples. I developed code in python and IDL and accessed and analyzed public databases using VO tools including TOPCAT.*

"Statement of Purpose"

- Write professionally!
- Summarize your education and especially your research experience, less so other extracurricular activities unless they are exceptional (Olympics, etc)
- Address any "rough spots" in your academic record.
- State what your career objectives are (professor, research scientist, observatory staff, etc). Theory? Observation? Numerical simulations? You will **not** be held to whatever you write here!
- Mention some research area(s) of interest. You do not have to choose, but show that **something** is really interesting to you.
- In describing your research experience or scientific interests, be as specific as you can. Provide some scientific details to show that you know what you are talking about.
- Make sure it is clear why the school to which you are applying is a good match to your background and goals.
- Mention individual faculty at the school whose research is interesting to you.

Senior Year Timeline: IV.

- Late October/Nov/Dec of Senior year:
  - Draft application
    - "Statement of purpose"
    - Vita/résumé (even if not required)
  - Give each letter writer a "package"
    - List of schools with addresses, deadlines, on-line/paper forms/no form [Help your writers search their emails…]
    - Addressed, stamped envelopes for paper submissions (few these days)
    - Your résumé, transcript, scores, statement

Senior Year Timeline: V.

- December/January of Senior year:
  - Submit applications
    - Do not wait until the last minute unless you have a good reason
    - Check with schools for missing items!
    - New: don't be surprised if you get a request for a SKYPE interview. This is becoming a more common "feature".

Senior Year Timeline: VI.

- Feb-Mar of Senior year:
  - Start receiving offers (or …)
    - Visit schools you still seriously consider
    - Investigate financial aid offer, living expenses, academic program, "karma"
    - Notify schools you do not intend to attend as soon as you can, so that they might offer your spot to someone else.
- 15 April: it's all over….

Taking a year off

- Apply now anyway!
  - It is always easier to apply when you are still at your undergraduate school.
  - You may change your mind once you have received an offer.
  - If you are accepted, you can then ask for your admission to be deferred.
    - Do not discuss deferral until you are accepted.
    - A scientific/educational experience will be viewed more favorably than a vacation.
    - ~half of "deferrees" end up not attending the grad school which deferred them (so anticipate some skepticism…)