Numbers You Should Know
Sources?

- American Astronomical Society
- American Institute of Physics
- NSF, NASA, other agencies
- UVa
- Literature and general media sources
- ROMEs = rough order magnitude estimates
A National Perspective on Astronomy
We're #3!
We're #3 among STEMM fields in media impact:

#1 Health & Medicine
#2 Environment
#3 Astronomy & Space
We're #1 in impact per practitioner!

Total STEMM employment: 16 million

Total astronomy & space science employment: ~20-30 thousand
AN EPIC ADVENTURE IN TIME, SPACE AND LIFE.

SUNDAY MARCH 9 ON 10 CHANNELS

COSMOS: A SPACETIME ODYSSEY

Presented by FOX, Nat Geo and National Geographic

Blog  Clips  Live Event

FOX  NATIONAL  GEOGRAPHIC  WILD  NAT GEO  mundo  FOX  life  FX  FX  FXM  FOX  UNIVERSE
"Scientist" is the #4 most prestigious profession (Harris Poll, 2014)
250,000

= Number of college students enrolled annually in elementary astronomy courses
$425,000

= National budget for astronomy per astronomer
THE NATIONAL BUDGET FOR ASTRONOMY (2016)

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<tr>
<th>Agency</th>
<th>Budget</th>
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<tbody>
<tr>
<td>NSF</td>
<td>$250M</td>
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<tr>
<td>NASA</td>
<td>$2950M</td>
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<tr>
<td>DOE, DOD</td>
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<td>Univ/Priv</td>
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<tr>
<td><strong>Total</strong>*</td>
<td><strong>$3400M</strong></td>
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<tr>
<td><strong>Number Astronomers</strong>*</td>
<td><strong>~8000</strong></td>
</tr>
<tr>
<td><strong>$/Astronomer</strong></td>
<td><strong>$425,000</strong></td>
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*Research support; excludes basic faculty salaries.

**The federal budget for astronomy is ~0.08% of the total federal budget of $4.0T or $10.09 per US citizen per year.

*** AAS membership, 2016
$425,000

= National budget for astronomy per astronomer
$425,000

= National budget for astronomy per astronomer

...Mostly in the form of *shared* observing facilities
...Mostly in the form of *shared* observing facilities
Astronomy is ~uniquely dependent on large, shared experimental facilities.

Astronomical facilities have long productive lifetimes; hard to retire them.
Kinds of Jobs for Astronomers

- **Postdoctoral**
  - Short-term (1-3 yr) research positions (mostly directed)

- **Research Scientists**
  - Mostly semi-permanent. Large range, from support to independent researchers. Universities, observatories, government labs (e.g. NRAO, NOAO, GSFC, STScI, USNO). Independent contractors (e.g. APL, SWRI).

- **University Faculty**
  - Short term contractual and permanent (tenured). Research and teaching.

- **Non-research* Government**
  - E.g. NASA, NSF, DOD, DOE, NOAA, etc.

- **Non-research* Private Sector**
  - "Beltway Bandits," computing/big data, aerospace, sensors, optics & imaging, defense, finance...
Kinds of $$$

• "Hard" money (reliable, long-term)
  – Tenured faculty
  – Civil servants
  – Tenured & senior staff at national labs

• "Soft" money (term-limited, grants & contracts)
  – Postdocs
  – "Adjunct" faculty
  – Many "research scientists"
  – Federal contractors (e.g. SWRI)
Astronomy Long-term PhD Employment Pattern Through the 1990's:

1/3 Faculty
1/3 Research Scientists
1/3 Private Sector
2% = Unemployment rate for astronomers (~ transition rate -> ~ full employment)
How many jobs?

~8000

= Membership of AAS + Nonmembers
- Non-grad degrees
How many job openings/year?

Do a ROM estimate:

If 8000 jobs were all permanent and in steady state, then the rate of replacement would be

\[ \sim \frac{8000}{25-40} \]

\[ = 200-320/\text{year} \]

Actual data scarce & old!
Production of New Astronomy PhD's

Source: NSF

1970-92: baseline

92-02: bump

>2002: rise

Source: NSF
Available Jobs from 2010 Decadal Study

(Source: AAS Job Register)
Open Jobs Per New Astronomy PhD

(Metcalfe 2008)
Open Jobs Per New Astronomy PhD

PD/New PhD $\sim 1.5$

Fac/New PhD $\sim 0.5$

Other/New PhD $\sim 1.0$

(Metcalfe 2008)
Open Jobs Per New Astronomy PhD

CONCLUDE: NOT GLOOMY, NOT Flush.
TEMPERED OPTIMISM

(Metcalfe 2008)
Promise of the Next Decade

ALMA

LSST

GMT

JWST

WFIRST
Life as a Faculty Member
~ # Responsibilities of a faculty member
Job Profile of a Faculty Member

• Teaching
  – Classroom teaching (mostly undergrad)
  – Tutorial, small group instruction
  – Course, curriculum, & resource development/management
  – Student mentoring, advising, recommendations
  – Outreach

• Research
  – Personal
  – Supervising grad student & postdoc research
  – Management: lab/group direction, obtaining & administering finances (grants)

• Service/Administration
  – Local department & university administration: operations, governance, policies, personnel evaluation (recruiting, promotions)
  – Refereeing publications, proposal reviews
  – Disciplinary activities, planning, meetings, advocacy
  – National agency policy, planning, review

• Consulting
\[ \sim 55 \]

= Number of hours per week professors claim to work
UVa Faculty Senate Survey (2012)

Figure VII-1: Frequency Distribution of Hours Worked Per Week, Full Time Faculty Only.

- Non-Gaussian truncation!
- Mean: 57 hours
- 30% > 60 hours
LONG HOURS
Some 38% of Nature's readers say they work more than 60 hours a week.

Poll question:
How many hours a week do you work on average? (12,869 responses)

Avg: 55 hours/wk
LONG HOURS
Some 38% of Nature's readers say they work more than 60 hours a week.

Poll question:
How many hours a week do you work on average? (12,869 responses)

More than 60h: 38%
Scientist Survey: Hours Worked (Nature)

LONG HOURS
Some 38% of Nature's readers say they work more than 60 hours a week.

Poll question:
How many hours a week do you work on average?

EVENING & WEEKEND WORK IS REGULAR & UNAVOIDABLE
\[ \sim 90-200 \]

= Number of UG students the average professor must teach each year

= \(10 \times S/F\) (in 3-credit classes)
Student/Faculty Ratios

UC
Non-UC AAU Public (28) 17
AAU Private (26) 17
Berkeley 16
Davis 16
Irvine 19
Los Angeles 17
Merced 16
Riverside 19
San Diego 19
Santa Barbara 17
Santa Cruz 18
Illinois 19
Michigan 12
SUNY Buffalo 16
Virginia 18
Harvard 7
MIT 8
Stanford 10
Yale 6
~90-170

= Number of UG students the average professor must teach each year

= 10 x S/F (in 3-credit classes)
≈7:1

= Career averaged ratio of total teaching time to in-class time
1:1 to 3:1

= Ratio of real-time rehearsal to delivery time for a well-prepped talk

- An important class lecture
- A job talk
- A review talk
- A news conference
- etc
OPTIONAL TOPIC: "HOW TO GIVE A BAD TALK"

- An important class lecture
- A job talk
- A review talk
- A news conference
- etc
Facts of Life for New Teachers in the Astronomy Nonmajors Curriculum

by Robert W. O'Connell
University of Virginia
Received: 03/15/07, Revised: 05/22/07, Posted: 08/03/07

The Astronomy Education Review, Issue 1, Volume 6, 2007

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Abstract
This is a guide to the most pertinent or difficult practical issues that confront new teachers in the astronomy nonmajors curriculum at large colleges and universities. It covers topics such as course design and infrastructure, required effort, special considerations in nonmajors teaching, classroom performance, use of visual presentations and the Web, interactions with students, interactions with faculty research, and many details of recommended practice in the face of constraints imposed by the quality of students and the amount of institutional support.

Table of Contents

I. Introduction
II. The Astronomy Nonmajors Curriculum
III. Elements of Teaching
IV. Goals
V. Content and Texts
VI. Effort
VII. The Teaching/Research Balance
VIII. Special Effort Required in Nonmajors Teaching
IX. General Tips
X. Your Student Target Audience
XI. Interactions with Students
XII. Assignments, Innumeracy, Quantitative Work, Critical Thinking
   A. Expected Work
   B. Science Literacy and Innumeracy
MUST PLAN FOR HEAVY DEMANDS OF TEACHING ON YOUR TIME
Job Profile of a Faculty Member

• Teaching
  – Classroom teaching (mostly undergrad)
  – Tutorial, small group instruction
  – Course, curriculum, & resource development/management
  – Student mentoring, advising, recommendations
  – Outreach

• Research
  – Personal
  – Supervising grad student research
  – Management: laboratory, group, administering finances (grants)

• Service/Administration
  – Local department & university administration: operations, governance, policies, personnel evaluation (recruiting, promotions)
  – Refereeing publications, proposal reviews
  – Disciplinary activities, planning, meetings, advocacy
  – National agency policy, planning, review

• Consulting

TIME MANAGEMENT IS AN ESSENTIAL SKILL
Job Profile of a Faculty Member

• Teaching
  – Classroom teaching (mostly undergrad)
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  – National agency policy, planning, review

• Consulting
Life as a Research Scientist
Job Profile of a Research Scientist

- **Research Support**
  - Observer support, training
  - Telescope time allocation
  - Software design, development, oversight
  - Data analysis pipelines, data archives
  - Instrumentation development
  - Documentation
  - Facility upgrade projects
  - Policy formulation
  - Personnel administration

- **Personal Research**
  - Allocation usually specified; typically 15-50% but wide variation
  - Grant support provides buy-outs of service time

- **General Service**
  - Refereeing publications, proposal reviews
  - Disciplinary activities, planning, meetings, advocacy
  - National agency policy, planning, review

- **Consulting**
$\sim 15\text{-}40\%$

$= \text{Typical proposal success rate for grants or observing time (NASA, NSF, NRAO, NOAO, etc)}$
Realized budgets have prevented the increase to ~$54M recommended in *NWNH*.
Realized budgets have prevented the increase to ~$54M recommended in NWNH.

UPCOMING TOPIC: "WRITING PROPOSALS"
3611 = Largest number of authors on an astronomical paper.
The Rise of Group Science

ADS Statistics on published Ast/Ap papers

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<td>&gt;5</td>
<td>3%</td>
<td>39%</td>
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</table>

Max # to date | 40 | 1187
3611

= Largest number of authors on an astronomical paper.


Abbott et all!
Multi-messenger Observations of a Binary Neutron Star Merger


(See the end matter for the full list of authors.)

Received 2017 October 3; revised 2017 October 6; accepted 2017 October 6; published 2017 October 16

Abstract

On 2017 August 17 a binary neutron star coalescence candidate (later designated GW170817) with merger time 12:41:64 UTC was observed through gravitational waves by the Advanced LIGO and Advanced Virgo detectors. The Fermi Gamma-ray Burst Monitor independently detected a gamma-ray burst (GRB 170817A) with a time delay of 1.7 s with respect to the merger time. From the gravitational-wave signal, the source was initially localized to a sky region of 31 deg² at a luminosity distance of 40 × 10^5 Mpc with component masses consistent with neutron stars. The component masses were later measured to be in the range 0.86 to 2.26 M☉. An extensive observing campaign was launched across the electromagnetic spectrum leading to the discovery of a bright optical transient (SSS17a), now with the IAU identification of AT 2017gfo in NGC 4993 (at ~40 Mpc) less than 11 hours after the merger by the One-Meter, Two Hemisphere (1M2H) team using the 1 m Swift Telescope. The optical transient was independently detected by multiple teams within an hour. Subsequent observations targeted the object and its environment. Early ultraviolet observations revealed a blue transient that faded within ~68 hours. Optical and infrared observations showed no rapid evolution over ~16 days. Following early non-detections, X-ray and radio emission were discovered at the transient’s position ~9 and ~16 days, respectively, after the merger. Both the X-ray and radio emission likely arise from a physical process that is distinct from the one that generates the UV/optical/near-infrared emission. No ultra-high-energy gamma-rays and no neutrino candidates consistent with the source were found in follow-up searches. These observations support the hypothesis that GW170817 was produced by the merger of two neutron stars in NGC 4993 followed by a short gamma-ray burst (GRB 170817A) and a kilonova/macronova powered by the radioactive decay of r-process nuclei synthesized in the ejecta.

Key words: gravitational waves – stars: neutron

1. Introduction

Over 80 years ago Baade & Zwicky (1934) proposed the idea of neutron stars, and soon after, Oppenheimer & Volkoff (1937) carried out the first calculations of neutron star models. Neutron stars entered the realm of observational astronomy in the 1960s by providing a physical interpretation of X-ray emission from Scorpius X-1 (Giacconi et al. 1962; Stiklovsky 1967) and of radio pulsars (Gold 1968; Hewish et al. 1968; Gold 1969).

The discovery of a radio pulsar in a double neutron star system by Hulse & Taylor (1975) led to a renewed interest in binary stars and compact-object astrophysics, including the development of a scenario for the formation of double neutron stars and the first population studies (Flannery & van den Heuvel 1975; Massevitch et al. 1976; Clark 1979; Clark et al. 1979; Dewey & Cordes 1987; Lipunov et al. 1987; for reviews see Kalogera et al. 2007; Postnov & Yungelson 2014). The Hulse-Taylor pulsar provided the first firm evidence (Taylor & Weisberg 1982) of the existence of gravitational waves (Einstein 1916, 1918) and sparked a renaissance of observational tests of general relativity (Damour & Taylor 1991, 1992, Taylor et al. 1990; Wex 2014). Merging binary neutron stars (BNSs) were quickly recognized to be promising sources of detectable gravitational waves, making them a primary target for ground-based interferometric detectors (see Abbott et al. 2010 for an overview). This motivated the development of accurate models for the two-body, general-relativistic dynamics (Blanchet et al. 1995; Buonanno & Damour 1999; Pretorius 2005; Baker et al. 2006; Campenni et al. 2006; Blanchet 2014) that are critical for detecting and interpreting gravitational waves (Abbott et al. 2016a, 2016b, 2016c, 2017a, 2017c, 2017d).

GROUPS, not people
- 62 collaborations
  - (Can't fit in AstroPH author display)
- 3611 authors
- Author list is 10 pages long
  - (Normal ApJL total length is 4 pgs)
- 953 institutional affiliations
- Acknowledgements take 6 pgs
- 4 authors are already dead
1980

... The year that determined the demographic profile of the current tenured faculty. A time lag of 38 years!
Tenured Cohort

- Age at tenure: \( \sim 35 \)
- Age at retirement: \( \sim 70 \)
- Median age (assuming steady state)

\[ = 35 + 0.5 \times (70 - 35) = 52 \]
Prospective scientists must get on no later than the start of high school, i.e. at age 14, or 38 years younger than the median tenured professor.
2018 – 38 = 1980

The demographic profile of the median tenured faculty member reflects US society as of 1980.
1980

- **Mirada by Dodge**: Everything that made personal cars personal in the first place. Wrapped up in one dramatically new car.

- **Carter & Reagan**: October 28, 1980

- **The Blues Brothers**: Universal Pictures

- **Star Wars: The Empire Strikes Back**: The Star Wars Saga Continues

- **Laverne & Shirley**: A TV show from 1976-1983 featuring Laverne DeFazio and Shirley Feeney, played by Geri Jewell and Cindy Williams.
1984
Money Matters

Can you make a decent living as an astronomer?

YES
Money Matters

• Salaries
• Saving for retirement
Salaries in Astronomy?

Starting Salaries for Physics PhDs, Classes of 2013 & 2014 Combined

Potentially Permanent Positions

- Private Sector
- University & 4-year College
- Postdocs
- Government Lab
- University & UARI

Typical Salaries in Thousands of Dollars

R1 universities
Depends on COL
Postdocs: **12 month** salaries
   Incidental support (travel, publications, etc) provided; may be discretionary
Faculty: **9 month** salaries
   Can use grant funds to cover add'l 3 months
   Incidental support by department
New hires normally offered a "Startup Package" for 3-5 years; covers research support and incentives. ($100K-1000K)
Saving for Retirement?

It's never too soon to start!

Famous thought experiment: "the twin brothers"
The Twin Brothers

#1  Saves for ten years after college, then stops

#2  Goes to grad school, then saves for whole career
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TWINS PROBLEM: 8% RETURN
CONSTANT CONTRIBUTION
(Units: $K)
The power of compound interest

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Total contribs: $10,000 $35,000
Total earnings: $204,189 $137,317
## Twins Problem: 8% Return
### Constant Contribution
(Unit: $K)

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Total contribs: $10,000 $35,000
Total earnings: $204,189 $137,317
Homer's Retirement
Savings Advice

Save 15% of your salary over & above Social Security*

Start soon

*SS: 7% of salary plus 7% from employer
Average Net Worth of Astronomy PhD's at Retirement?

~$1-3 M (if you're prudent)

Maximum @ UVa?

~$500M!