Employment & Funding in Astronomy

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Prior astronomy decadal surveys have been an effective tool for defining our science program, why it is necessary, when it should be accomplished, and how it will need to be done. But it has not to date included a determination of who will be needed to do it – how many graduate students, postdocs, instrument builders, software engineers, and faculty are required[1].

By setting funding priorities, the decadal survey strongly influences the shape of employment in astronomy. For instance, the large increase in NASA funding from the Great Observatories in the 1980s and early 90s resulted in a doubling of the number of astronomy PhDs granted (see Figure 1, Metcalfe, 2008). A failure to specify the jobs that should be funded is a missed opportunity to change our field for the better. A plan for funding the astronomy workforce could help facilitate cross-agency optimization and enable us to ensure that the people with the skills that are needed to accomplish the next generation of projects are developed and retained. In the context of likely flat future federal astronomy budgets and hiring freezes at many universities, it is especially important that we set funding priorities with employment in mind.

The primary goal of this white paper is to advocate for a discussion of the astronomical employment picture in the current decadal survey. We present a current picture of astronomy employment, then consider how federal funding affects that employment. We then discuss how the current employment demographics could be changed to benefit the field. We finish with recommendations for data that the decadal survey should collect and a few suggestions to promote an effective and sustainable workforce.

(1) The Current State of Astronomy Employment

The career path in astronomy in the US typically has the following stages: (0) Undergraduate training in physics and/or astronomy for 4 years, (1) Graduate school training for 5-6 years, (2) Postdoctoral positions for 3-6 years, often at multiple institutions, ending in a (3) Tenure-track faculty, research, or service position. We examine the current demographics of 1-3 below:

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[1]We note that an analysis of the production of astronomers by Thronson (1991) was done in the context of a previous decadal survey, however, none of this work actually appeared in the panel's final report.

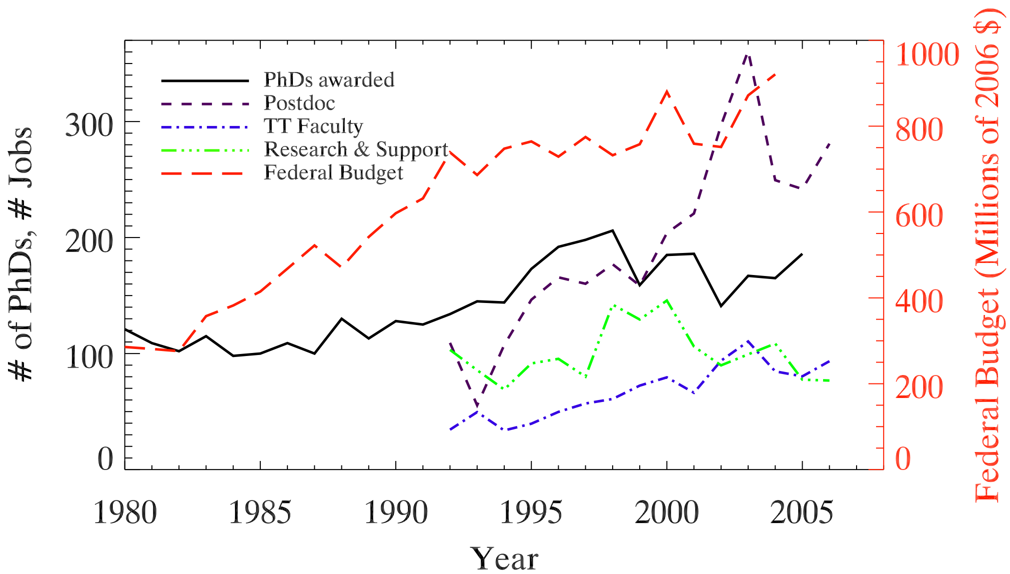

Fig. 1.— The production of PhDs in the U.S. is shown in the solid black line. Also shown are the number of ads on the AAS job register for U.S. postdoctoral, tenure-track faculty, and research & support positions. The total federal budget is shown in the red long-dashed line, with the scale being given on the right axis in millions of 2006 dollars. All data derived from Metcalfe (2008).

1. *Graduate Student Production:* An NSF report from 2007 takes survey data completed by >90% of PhD recipients in Physics and Astronomy departments[2]. It finds that the number of astronomy & astrophysics PhDs awarded in the US from 1999-2005 was roughly constant, with ~170±17 PhDs awarded per year (see Figure 1). These numbers represent a 70% increase over the number of astronomy & astrophysics PhDs awarded in 1985, over which time the total inflation-adjusted astronomy budget has doubled. We note that the 170 PhD/year number is somewhat of an underestimate (by up to 60%) of the domestic astronomy-related PhD production due to astronomy related PhDs in other disciplines (see Metcalfe, 2008). However, it is a reasonably good estimate of the pool of people likely to desire permanent positions in astronomy & astrophysics.

2. *Postdoctoral positions:* Unlike graduate student positions, the number of advertised U.S. postdoctoral positions (Figure 1, purple line) has more than doubled from ~109 in 1992 to ~280 in 2006. Given that a typical PhD student does two postdocs, this number suggests that most (but not all) U.S. graduate students are able to find postdoctoral positions.

[2]http://nsf.gov/statistics/nsf07305/

3. *Longer-term positions:* this is a heterogeneous group of jobs that includes tenure-track faculty positions, research staff positions (e.g. at NRAO or STScI), and research support positions. We show the approximate number of U.S.-based positions advertised in the AAS job register each year in Fig. 1. The most notable trends are that the number of U.S.-based tenure-track faculty positions has experienced a growth very similar to that for postdocs, with a total of ∼94 positions advertised in 2006, up from ∼34 in 1992. This growth can at least in part be attributed to an increase in faculty retirement that peaked in ∼2000[3]. There is already evidence for a decline in the number of available positions and due to both demographic and economic reasons it is unlikely we will see continued growth in the number of available faculty jobs over the next decade. Research positions over the last decade are flat (∼63 in 2006), and the number of advertised research support positions have significantly declined (to ∼14 in 2006) perhaps replaced by less-permanent postdoctoral work. Thus the job market is currently roughly balanced between faculty and long-term research & support positions.

   The number of advertised positions significantly overestimate the number of new permanent position hires made, as many job searches are unsuccessful, get postponed, or are shuffles of senior faculty/staff. The widely used astronomy rumor wiki page for the completed job cycle 2007-2008[4] can provide some insight into this. In 2007-2008, a total of 107 U.S. based jobs were listed as "Tenure or Tenure Track Faculty/Permanent positions". Of these 58 appeared to be new hires, while 11 were shuffles of faculty or permanent staff between institutions. Six positions were listed as canceled, while 32 had no outcome listed (many of which apparently resulted in no hires). Thus only 50-85% of the available jobs resulted in new faculty hires. Assuming a pool of ∼170 PhDs/year vying for the 60-90 available positions suggests that currently 35-55% of astronomy PhDs receive permanent jobs in astronomy based on the rumor wiki data. We note that this ratio of PhD production to permanent positions is similar to what has been found previously over the past 20-30 years (e.g. Thronson 1991).

The numbers given above are very uncertain. A careful reader will have noticed that the number of jobs posted on the wiki page is ∼60% less than would be expected from the typical number of listings of tenure-track faculty and research staff on the AAS job register. The reasons for this could include that the wiki page is incomplete, that some advertised jobs in these categories aren't actually long-term positions, and a large number of other reasons. This points out that we don't currently have the data needed to compile accurate information on the employment demographics in astronomy. Nonetheless, the overproduction of PhD stu-

[3]http://www.aip.org/statistics/trends/highlite/acad06/awf06.pdf

[4]http://cdm.berkeley.edu/doku.php?id=astrojobs08/

dents relative to the available long-term employment and the huge increase in the number of postdoctoral positions are clear trends that we address in the second half of this white paper.

This employment picture is also highly incomplete and leaves out many non-traditional astronomy jobs. Specifically, it doesn't include soft-money employment, a sector that anecdotally appears to be on the rise. In addition to research faculty at existing universities paid primarily or entirely through soft money, there are a number of institutions (e.g. Eureka, Space Science Institute) which are based solely on soft-money, and have researchers working both on and off site. These institutes employ >175 people, and the number of soft-money researchers at universities is likely to be on a similar scale. We strongly suggest that the decadal committee collect complete and accurate information on astronomy employment of all types (see §4).

(2) Where the Money Goes

The decadal survey has considerable influence over the allocation of federal money that is the dominant funding source for graduate students, postdocs, and research positions. It has considerably less influence over the spending of private and state money that is the source for much of the tenure-track faculty positions. The total federal budget for astronomy from 1999-2004 was ∼\$800 million (in 2006 dollars), of which 75% comes from NASA (Metcalfe 2008). We feel it is critical to understand where, how, and on whom this money is spent. Below we give an example of the type of analysis needed – what is given is a rough and incomplete picture of astronomy employment funding, but is nonetheless informative.

Since NASA is the dominant federal funding agency in astronomy, we have attempted to look at where NASA money is spent in terms of employment. A 2007 study of NASA research centers conducted by the National Research Council[5] finds a total yearly budget of \$206 million for four science centers (CXC, STScI, IPAC/SSC, and HEASARC), representing about 1/3rd of the total NASA astronomy budget. Of this money, \$10 million is spent on EPO activities, and \$80 million is spent on grants including observer, PI, and fellowship funding. The rest of the money goes to employing 676 full-time employees (FTEs) at the science centers. An equivalent of 61 full-time employees at these centers are dedicated to research, while another 101 are employed in administration; the remainder of the jobs are in flight operations, engineering and support. This suggests a total outlay for research employment at the centers of ∼\$12 million dollars, about 5% of their total funding. A total of 61 fellow Hubble, Spitzer, and Chandra fellows are also employed.

We have also estimated the total amount of money spent in the U.S. on graduate student and postdoctoral positions. For grad students assuming a total cost (including overheads) of \$50,000 per year, an average time to PhD of 6 years and 170 PhDs/year, we find that ∼\$50 million is spent on graduate students. The cost is likely quite a bit higher as only about half

[5]http://www.nap.edu/catalog.php?record_id=11909

of those that enter astronomy graduate school achieve a PhD (Mulvey & Nicholson 2008). For postdocs, assuming $100,000 per year, postdoc duration of 3 years and 280 positions filled yearly, ~$84 million is spent on postdocs. This money allocated to younger researchers is on a similar scale to the total federal grant resources – in total NASA provides $80 million of grant funding, while the NSF senior review[6] lists an NSF grants budget in 2006 of $50 million.

(3) What are the optimal employment demographics?

This is precisely the question the authors would like the decadal committee to consider. Answering this question requires both (1) having a good knowledge of the current state of astronomy jobs and how they are funded, and (2) deciding what jobs are needed to sustain and improve the field. As with science priorities, opinions on employment priorities will differ; we give our opinions below and argue that we should attempt to balance our employment demographics by increasing funding for long-term positions relative to temporary positions for younger workers.

There are two notable trends from the numbers presented in sections 1 and 2 that point to an imbalance in the employment demographics resulting, at least in part, from funding choices made during the last couple decades. First, a significant fraction of trained PhD astronomers end up leaving the field or working in temporary positions over a long period of time. Second, over the past 15 years we have vastly increased the funding of postdoctoral positions, while longer-term research positions have been stagnant.

From an economic standpoint, graduate students and postdocs are commonly thought to produce astronomical work for less money than older researchers. However, these younger researchers typically need to be advised and supported, an activity which currently consumes much of the research activity of senior astronomers. Furthermore, younger researchers' lack of knowledge in the field may yield lower quality work and their temporary positions are mismatched to the 10-20 year timescales for most large scale astronomy projects. Thus increasing the funding of senior positions relative to junior positions could result in significant scientific benefits.

The unbalanced employment demographics also have a negative affect on the field as a result of the lifestyle required to work in astronomy. The long-hours, frequent moves, and long-term job uncertainty associated with working in astronomy discourages talented young people from entering or staying in the field. This problem is compounded by the fact that many young astronomers have working spouses. The difficult lifestyle has been shown to disproportionately affect women in academia[7]. The oversubscription of grant proposal applications makes it difficult for young researchers who do achieve tenure track positions to secure funding once they

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[6] http://www.nsf.gov/mps/ast/ast_senior_review.jsp

[7] http://chronicle.com/jobs/news/2009/01/2009012701c.htm

get there. Many postdocs envision battling through several cycles of failed job hunting seasons before managing to land a tenure-track position, only to have to continue fighting to win grants, either for their own salary or to achieve tenure. This picture discourages many promising young astronomers. If we want to diversify the field and attract and retain the brightest people, we need to change the lifestyle required by the current employment path. Increasing funding for permanent jobs and new faculty would significantly ameliorate this problem.

Finally we note that the length of the 'training' period in astronomy has extended to roughly 12 years after an undergraduate degree. This is a far longer period than most other careers. It is our view that this is caused in large part by our investment in early career temporary jobs at the expense of longer-term positions.

(4) What should be done?

We split this section into two halves. First we address the type of data that needs to be gathered in order to have an accurate view of employment in astronomy. Second, we make a few specific suggestions for what might be changed in the upcoming decade to create a more sustainable, productive astronomy workforce.

Data Gathering: Data on employment and funding in astronomy should be obtained both as part of the decadal survey and regularly in the future to best understand what is happening in our field. As part of the decadal survey we suggest:

(A) A complete analysis of employment demographics including both the different levels of employment (grad student, postdoc, long-term) and types of employment (faculty, support, software development etc).

(B) An analysis of what funds support each type of employment focusing especially on federal funds (NASA, NSF, & DOE) over which the decadal committee has the most influence.

(C) A survey of future hiring plans in astronomy institutes. Most universities and institutes have 5-10 year plans. Trying to ascertain their hiring plans will help the decadal survey plan for the employment in astronomy over the next decade.

In addition, a more long-term goal is to regularly determine and disseminate job statistics in the field. Currently, our statistics on jobs in astronomy are determined primarily from advertised jobs, but our examination of the rumor wiki shows this provides an inaccurate picture of the actual number of jobs available. One relatively inexpensive way of collecting accurate data would be to have the AAS job register follow up with institutions that have posted jobs to determine the outcome of the posted jobs.

Employment Suggestions: We discuss here a few suggestions on graduate student training, changes to postdoctoral positions, and ways to increase the number of long-term postions.

I. Rethink Graduate Student Training: We suggest that graduate programs should make an effort to present a clear picture of the job market in astronomy to their students (assisted by the more easily available employment data suggested above). When first-year graduate students were surveyed by the AIP, 87% of them hoped to end up in academic positions (Mulvey & Tesfaye, 2006), a clear mismatch with the realities of the job market. Since nearly all graduate students are trained by faculty at research universities this mismatch of expectations with reality is understandable. But the effect on the field is harmful because it means that graduate students aren't being trained for the jobs they are going to fill (see Eric Huff's 'Training the Next Generation of Astronomers' white paper). Expanding alternative training programs and career paths among graduate students will require the support of faculty mentors. We suggest a few specific possibilities:

(A) Provide more training opportunites for graduate students that involve the national observatories and labs. For example expanding the NASA GSRP program to also include other research institutions such as NOAO. Also, encourage students towards existing programs in government labs and industry.

(B) Increase the accessibility of cross-departmental and education training. William Waller's 'Workforce Development' white paper has suggestions in this regard.

(C) Increase awareness and usage of the AAS non-academic astronomer's network[8], which seeks to provide people with career templates outside the academic norm. Also, encouraging departments to track and stay in touch with students that leave the field; these people can serve as a resource for existing students.

(D) Consider the creation of more Masters degree programs in astronomy that could produce non-academic astronomers and help meet our country's demand for scientifically literate people. This would reduce the inefficiency of training large numbers of PhD students in skills they don't need, and would get these students into the workforce at a younger age.

II. Create Longer-Term Postdoctoral Positions: The typical astronomer moves at least twice during their years as a postdoc. The applying for jobs, moving, and settling in a new place takes up a large fraction of postdocs time and energy during a period when they are supposed to be producing at their peak. Furthermore, moving requires many postdocs to repeatedly solve 2-body problems. One way to reduce this inefficiency and increase the quality of life for postdocs would be to recognize that most people are in the postdoc stage of their career for >3 years, and increase the length of the postdoctoral positions accordingly, with the goal of having people do just a single postdoc before finding a more permanent position. This is effectively already being done by postdocs combining multiple prize fellowships. We think the wider postdoc community would benefit from this as well. Clearly, it is difficult for individual investigators to fund 5-year positions in the current system, but if the prize positions were made to be longer, this would encourage others to also lengthen their postdoctoral postions. In a similar vein, Spergel (2009) recently proposed the creation of 6-year "Advanced" fellowships similar to those in the UK that

[8]http://aas.org/career/nonacademic.php

would require commitment from universities to provide a portion of the funding. Such positions may encourage the continued growth of faculty at universities even in these difficult economic times.

III. Invest in New Permanent Positions: We have shown above that over the past 15 years, an increasing amount of federal money has been spent to support postdoctoral positions, while the number of research staff positions at most federally-funded institutions (NASA institutes, NOAO, NRAO, SAO) has not increased. Looking at section 2, the amount of money spent on research at the NASA institutions is a small fraction of the budget for grants (or the total budget). We recommend increasing hiring of long-term staff at federal institutions and believe that it could be done within existing budgets by reducing funding that goes to earlier career jobs. These positions could greatly help the field by targeting people working on software development and other needed technical skills (see Michael Strauss's 'Wide-Field Astronomical Surveys in the Next Decade' White Paper) and giving these people the independence to work on problems that interest them.

IV. Streamline the Application Process: The job application process is very inefficient. Job applications and recommendation letters are written, sent, and read, and such work is duplicated many times as graduate students and postdocs each apply for dozens of jobs. This process could be simplified significantly by creating a common job application web site, perhaps hosted by the AAS. Employers would indicate on their job ads that they are using the common job application, and applicants and recommenders could submit single applications through the website, with cover letters tailored to the specific job sent directly to the institution to indicate an applicant's interest. This would work best at the postdoctoral level where most job applications are quite similar, but could also be extended to graduate school and faculty applications if successful.

In conclusion, we hope that the decadal survey will explicitly consider the employment implications of their scientific proposals and provide guidance to funding agencies on how money should be spent in the next decade. Gathering data on astronomy employment is crucial to this process. We believe that shifting funding priorities from early career temporary positions towards more long-term employment will create a more sustainable, equitable, and productive astronomy workforce.

References:

Metcalfe, T., 2008, *PASP*, v. 120, p. 229

Mulvey, P. J. & Nicholson, S. 2008, AIP Pub. Number R-151.43

Mulvey, P. J. & Tesfaye, C. L. 2006, AIP Report R-207.35

Spergel, D., 2009, *Science Magazine*, v. 175 #5, p. 32

Thronson, H. A., 1991, *PASP*, v. 103, p. 90