Comparative Analysis of Trends in American Physics Education

Adam Tyler Crank

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Comparative Analysis of Trends in American Physics Education

By

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Abstract

The goal of this project is to research and investigate trends in the education, demographics, and career prospects of physics students at the post-secondary level across the nation. Students at the undergraduate level may sometimes feel overwhelmed in planning and deciding on their futures. By consolidation polls and statistics, conducted and gathered by the American Institute for Physics, this project seeks to alleviate such feelings, highlighting some common routes that holders of physics degrees take throughout their careers, such as trends in physics education, both nationally and at Alabama institutions, post-graduate employment by industry, and graduate school placements.
Bachelors in Physics

By Looking at U.S. trends in the number of physics bachelors conferred, particularly in the last twenty years, the total annual number of earned bachelors has risen from a relative minimum of 4,000 in the year 2000, more than doubling to an all-time high surpassing 9,000 as of 2020 (Figure 1). Per the survey conducted by the American Institute for Physics (AIP), Male physics students make up the vast majority of graduates, meaning that trends in the total number of earned degrees will closely follow the trends of male students, including the substantial dip that occurred between the mid-nineties and early 2000’s. Female physics students, by comparison, have shown a consistent increase in both the number of graduates per year and percentage of total graduates. Generally, for the past two decades, there has been a consistent increase in the number of physics bachelors awarded, and therefore, an increase in the number of Physics students across the nation.
This significant increase in Physics Bachelors graduates, however, has not corresponded to a rise in the number of Physics first-year graduate students. On the contrary, first-year placements in graduate Physics programs have remained constant over the years (Figure 2). Although rising numbers in Physics Bachelor graduates are a positive phenomenon for the future of the field, the stagnant first year graduate enrollments indicate that the number of available graduate positions is not rising to meet the influx of bachelor students. Between 2010 and 2020, the number of Physics Bachelor graduates has risen 50%, while first year graduate enrollments have functionally risen 0%. This means that the same graduate school placement in 2010 has become more competitive in 2022, or rather, that graduates are less likely to secure graduate school enrollments now than in previous years.

Figure 2

Physics Bachelors compared to Graduate Enrollments (2009-2020)
Bachelors in Astronomy

Similar to the trends found in Physics Bachelors graduates, students receiving a Bachelors in Astronomy have reached an all time high at the time of polling in 2020. Although the number of Astronomy Bachelors constitute less than one-tenth of the total Physics Bachelors, the former group has grown at much higher rate, increasing by a factor of four in the same amount of time it took Physics Bachelors to double (Figure 3). Compared to Physics, female Bachelors in Astronomy students make up a much higher percentage of graduates in 2020, around 40%, and are growing at a rate seemingly quicker than their male peers.

One factor that may have contributed to such a substantial rise in Astronomy undergraduates is the rise in Astronomy Bachelor-granting programs throughout the U.S. (Figure 4). Typically, most students pursuing Astronomy at the undergraduate level must do so through their Physics department, like UAH’s, whose Astronomy programs are entwined with. As more programs arise that offer a Bachelors in Astronomy distinct from Physics programs, it is unsurprising to see a more dramatic rise in the number of bachelor degrees conferred.
Like graduate enrollments in Physics, first year graduate enrollments in Astronomy have remained constant and have not risen to meet the constantly increasing Astronomy graduates, at least within the last decade. The number of Astronomy Bachelors conferred has increased 100% between 2010 and 2020, double the rate of their Physics counterpart (Figure 5). Thus, not only have the same Astronomy graduate positions become more competitive over the course of the last decade, but these positions have also become more competitive than their analogous Physics placements, due to the higher percentage of Graduates.

![Figure 5](image-url)
As a student of the UAH Physics Department, I was interested in what trends exist among other major doctorate-granting universities in the state of Alabama, and how our school might compare. I chose to examine data for the University of Alabama (UA), the University of Alabama in Birmingham (UAB), the University of Alabama in Huntsville (UAH), and Auburn University. Based on the data collected by AIP, I compared the available statistics per school in four categories over the past 20 years: the number of bachelors degrees awarded, the number of first year graduate students, the number of exiting masters students, and the number of PhD’s awarded. Then, making note of the fact that UA, UAB, and Auburn are all much larger schools than UAH, I normalized each curve by the number of full-faculty members in each university’s physics department. In doing so, not only are we given an estimate on trends in education across these four schools, but we are also given a comparison on the relative size of each school’s department. We make several assumptions in our normalization process. First, we assume that the number of full-time faculty is constant across our examined period. That is, full-time faculty members that leave at any department are assumed to have their position filled relatively quickly. Second, we assume that the ratio of departmental faculty members’ roles is constant across departments, e.g., the assumption that the percentage of faculty members at UAH who are solely undergraduate lecturers corresponds to a similar percentage at UAB. This assumption allows us to normalize each of the four categories examined by the same factor, the number of faculty members, as opposed to normalizing the ‘bachelors degrees awarded’ figure solely by undergraduate lecturers, versus normalizing the ‘PhDs awarded’ figure by those faculty members exclusively serving doctoral education, research, and/or advising roles at their respective universities. The third and final assumption is the number of faculty for each school. The number
of full-time faculty determined, 31 for UA, 20 for UAB, 32 for Auburn, and 12 for UAH, was based on each physics department’s website. This method does not account for potential errors on each department’s website, such as outdated information, and may have a slight effect on the data presented, though the expected error would likely be miniscule. Note that, for the remaining figures in this section, UAH did not report its Physics department data in the 2000-2001 or 2005-2006 academic years, and thus, minor gaps exist on each UAH curve.

**Bachelors Degrees Awarded in Alabama**

![Figure 6](image)

Like the national trend in physics bachelors awarded per year, the number of degrees awarded at all four examined institutions, in general, has exhibited a positive trend (Figure 6). UA and UAH have been showing a greater number of physics graduates than UAB and Auburn in recent years. Comparing it to the normalized figure (Figure 7), UAH’s curve stands out significantly.

Although UA and UAH had a comparable volume of Bachelors graduates, the number of degrees
per capita, with respect to faculty members, was substantially higher than all other schools. Until the 2019-2020 academic year, UAH was the only school that had a student to faculty ratio exceeding 1. More interestingly, the remaining three schools seemed to share a similar degree-per-faculty ratio, despite varying numbers of both. It appears that the student body of UAH’s department is relatively much larger than these other institutions.

**First Year Graduate Students in Alabama**
Examining the raw data on first year graduate students in Alabama, it is, again, unsurprising that the number of first year graduate students in Alabama has generally remained constant, on par with national trends (Figure 8). The number of first year graduate students at UAH, however, has been steadily decreasing in recent years, but remains on par with every other school examined.

Contrary to the normalized curve for bachelors degrees awarded, the normalized curve for first year graduate students, Figure 9, shows an alarming trend for UAH. In previous years, UAH had dominated other schools in its number of first year graduate students-to-faculty ratio, the seemingly inconsequential decrease witnessed in the total volume of students is much more pronounced per capita. While UAH had historically been the only institution examined to exceed a ratio of 1, UAH appears to be converging to an apparent statewide average between 0 and 0.5. UAH’s first year graduate student body is relatively approaching the same size as these other schools. Interestingly, while some of these other schools have shown similar trends of increasing
or decreasing over a small period of the previous two decades according to the raw data, they are clearly much less pronounced than changes in UAH’s department when normalized.

**Exiting Masters Students in Alabama**

An exiting master’s student is defined as a student graduating from a master’s program without intentions of pursuing further graduate study.

![Exiting Masters Students](image)

*Figure 10*

Unlike the previous figures for bachelor’s degrees and first year graduate students, all four institutions had no immediately clear trend in the number of exiting masters students. Instead, each curve was erratic, jumping between highs and lows from year to year. Two discernible features are apparent in Figure 10, however. First, UAH once again rises above other schools for one, further indicating the relative size of its Physics department compared to these much bigger schools. Second, it appears that UAB, UAH, and Auburn are potentially converging to some number of students averaging between 3 and 4, with UA, surprisingly, having no exiting Masters students in the 2019-2020 year.
When normalized, however, Figure 11 continues to follow the trend among UAH, in which the school’s student-per-faculty ratio far surpasses other comparable schools. Once again, it appears that, per capita, UA, UAB, and Auburn are relatively constant and are seemingly convergent on each other, while UAH’s Physics department takes on many students more per capita than the statewide average.
PhD’s Awarded in Alabama

Examining the number of PhD’s awarded at these four schools over the last 20 years, like exiting masters students, the un-normalized curves in Figure 12 are erratic, with no clear pattern emerging. Interestingly, though, is that the UAH and UAB align, for the most part, very closely in shape and number, although UA and Auburn have generally been awarding more PhD’s per year over the last two decades. Because Auburn and UA share a comparable number of faculty members, both exceeding UAH and UAB, this isn’t unexpected at the doctoral level.
Once again, a normalized view of PhD’s awarded (Figure 13) indicate that UAH has, in previous years, far exceeding the numbers produced by UA, UAB, and Auburn. Like the number of first year graduate students, most schools appear to be converging to some state-wide average between 0.2 and 0.3 PhD’s awarded per faculty member, indicating a falling trend overall in the number of PhD’s awarded by UAH across this period.

**Trends in Employment**

**Bachelors in Physics**

According to an AIP poll of bachelor’s in physics students, one year after graduation (Figure 13), 48% of bachelors holders were pursuing graduate studies, 29% of which were pursuing graduate studies specifically in the fields of Physics or Astronomy. 46% of graduates responded that they were employed in any sector, and 6% reported that they remained unemployed, a number nearly twice the national average. By breaking down these responders’ fields of both graduate study and employment sector, we seek to gain an understanding of what students are accomplishing with a bachelor’s degree in physics.
Of those bachelor’s holders pursuing graduate study, 65% reported entrance into a physics or astronomy graduate program, continuing their undergraduate studies. Of the remaining 35%, nearly half pursued graduate engineering programs, while 18% of students pursued a field outside of these. Thus, the overwhelming majority of students remained in STEM.

Meanwhile, of those bachelor’s holders who entered into the workforce, a majority, 59%, entered into the private sector, which constitutes employment controlled by private citizens and their enterprises, uncontrolled by the state. A substantial portion of graduates, collectively 24%, found employment in academic settings, either at the college and university level (18%) or in high
schools (6%), while 10% of employed graduates reported employment in the public sector, with 7% in civilian government positions and 3% as active military. The remaining 7% of respondents reported employment as other than these listed.

Within the Private sector, bachelor holders held a myriad of job types. According to figure 16, the majority of bachelor’s in physics holders in the private sector worked in the fields of engineering (35%) or computer science (24%), and 15% reported as remaining in stem excluding physics or astronomy, engineering, or computer science. A surprisingly high portion of private sector employees did not work STEM jobs, totaling 22%, while a surprisingly low portion worked in physics or astronomy, at only 4%.
AIP also collected data regarding initial salaries for employed bachelor’s in physics graduates (Figure 17). According to the data, private sector STEM jobs had the highest median starting salary of $65,000. Civilian government positions followed closely behind, with a median starting salary of around $59,000. On the contrary, private sector non-STEM positions that rarely involve solving technical problems, as well as college or university positions, had the lowest median starting salaries, both less than $40,000. Meanwhile, private sector, non-STEM positions that do...
involve solving technical problems had the widest distribution of starting salaries, with a higher maximum pay compared to private sector STEM positions. However, private sector STEM positions have much higher and much more frequent outliers than any other position or sector measured by AIP, meaning that private sector STEM has the highest potential for a high-paying initial salary.

**Bachelors in Astronomy**

![Figure 18](image)

Like bachelor’s in physics graduates, for graduates holding a bachelors in Astronomy, over half (53%) have entered or attempted to enter into the workforce across all employment sectors, with 7% of them remaining unemployed but seeking employment one year after graduation. The remaining 47% of respondents reported pursuing graduate study, 35% of whom remained in physics or astronomy, while 12% branched into other fields (Figure 18).
Of those students pursuing graduate studies, nearly half (47%) of astronomy bachelor’s holders again pursued astronomy in graduate school, while over a quarter (28%) were admitted to non-astronomy physics programs. In total, 89% of bachelor’s in astronomy graduates remained in STEM programs, with only 11% pursuing non-STEM.

As for those students who were successfully employed at the time of polling, 54% were employed in the private sector, a figure comparable to their physics-degree-holding peers, with
35% employed in STEM positions, and 19% in non-STEM. 20% of respondents were employed in the academic sector at various universities and colleges, and 11% were employed in the civilian government sector, which includes national laboratories. The remaining 15% reported employment in a sector other than private, public, or academic (Figure 20).

Figure 21 details initial salary distributions for new bachelors of astronomy graduates from the classes of 2014, 2015, and 2016. Reported salary distributions for new astronomy bachelors were measured for private sector STEM positions and Academic sector positions. The median starting salary for private sector STEM positions was $55,000, with a reported minimum of $29,000 and
a maximum salary of around $77,000. The median starting salary for academic sector positions was $33,000, with salaries distributed between $22,000 and $48,000.

**Masters in Physics**

![Employment Distribution of Exiting Physics Masters One Year After Degree, Classes of 2016, 2017, & 2018 Combined](image)

Resembling trends in employment for bachelors holders, the majority of employed exiting master’s degree graduates, almost 60%, found employment in the private sector, followed by 20% of graduates employed at the college or university level (Figure 22). The remaining (approximately 24%) of employed graduates were equally distributed between high school, civilian government or national labs, or some other employment sector position.
Figure 22, though not delineated by sector of employment, highlights the field of employment of exiting masters students. Interestingly, nearly equivalent portions of physics masters graduates worked in engineering or computer science as their bachelors counterparts. Additionally, a significantly larger portion of masters students worked in the fields of physics or astronomy, forming the largest field of employment among polled masters graduates. Very few graduates were employed in non-STEM fields.
Initial Salary polls of exiting masters students were, like those of bachelors in astronomy graduates, not quite as comprehensively delineated by position type as that of bachelor’s in physics students (Figure 23). However, the combined median salary for private sector positions was $70,000, slightly higher than that of private sector STEM salaries for bachelor holders. Both the minimum and maximum reported salaries were higher than that of a bachelor’s holder’s initial salary distribution. Additionally, the private sector maximum was almost $20,000 higher, at $130,000. This trend is replicated in that of academic positions, in which the distribution of reported salaries for masters holders is similar in shape but slightly higher when compared to bachelors.

Because there are so few programs that grant masters in astronomy degrees distinctly from physics programs (Figure 4), AIP had very little data to discern any reasonable conclusions regarding exiting masters graduates.

**Doctorate in Physics**

![Initial Employment of Physics PhDs, 1980 through 2020](image)

*Figure 24 (AIP)*
Employment of Physics Doctoral graduates is generally divided between Postdoc placements, at 50% of polled doctorate holders’ initial employment, and potentially permanent positions, which include private, academic, and public sectors, at 39% of graduates. 6% of PhD holders reported holding other temporary positions, and 5% reported being unemployed (Figure 24).

<table>
<thead>
<tr>
<th>Sector of Employment</th>
<th>Initial Employment Type</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Postdoc %</td>
<td></td>
</tr>
<tr>
<td>Academic</td>
<td>73</td>
<td>49</td>
</tr>
<tr>
<td>Private</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>Government</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Examinining the sector of employment of PhD holders (Figure 25), the overwhelming majority of the 809 respondents who were initially employed in postdoc positions, 73%, are in the academic sector, while 23% of postdocs are government based. Meanwhile, of the 650 doctorate holders with potentially permanent positions, 70% hold positions in the private sector, while 20% are
employed in academia. Like postdoc positions, doctorate holders who reported holding other temporary positions are concentrated largely in academia (62%) and the private sector (30%).

**Starting Salaries for New Physics PhDs, Classes of 2019 & 2020 Combined**

![Diagram showing starting salaries by sector and position type]

Data represents only US-educated PhDs who remained in the US after earning their degrees. The full starting salary range, excluding outliers, is represented by the lines extending to each side of the box. The box represents the middle 50% (25th to 75th percentile) of the salaries. The vertical line within the box represents the median starting salary for the sector. The dots outside of the bars are statistical outliers. Government Lab includes federally funded research and development centers, e.g., Los Alamos National Laboratory. UARI is university affiliated research institute. The data for PhDs holding potentially permanent positions in academia include salaries based on 9-10 and 11-12 month commitments and have not been adjusted. Data are based on respondents holding potentially permanent positions in the private sector (192) and in universities and 4-year colleges (37), postdocs in government labs (105), and universities and UARIs (277), and "other temporary positions" in universities and 4-year colleges (17).

*Figure 26 (AIP)*

When examining initial salaries of doctorate holders from the 2019 and 2020 classes, we notice a similar trend in figure 26 found in both bachelors and in the masters of physics salaries. As expected, the private sector offers degree holders the highest paying initial salaries, with a median initial salary of $120,000, substantially higher than the previous two physics cohorts.
Potentially permanent positions at 4-year universities offered the next highest quartile distribution, though with a significantly lower median salary than private sector positions with any level degree. All reported postdoc salaries had extremely tight salary distributions, with government postdocs offering higher salaries than their university counterparts. Temporary university positions offered the lowest minimum, median, and maximum starting salaries of all reported positions.

**Doctorate in Astronomy**

![Initial Employment Type](image)

*Figure 27: Corresponds to the Astronomy PhD classes of 2014, 2015, and 2016 combined.*

The majority of employed graduates holding a doctorate in astronomy, 62%, found initial employment through postdoc positions, a larger percentage than physics doctorate graduates, whereas the remaining 38% of employed astronomy PhDs found other, potentially permanent employment (Figure 27).
Like the postdocs of physics PhDs, most astronomy PhD postdocs were in the academic sector (72%), namely universities, and the public sector (23%), namely in civilian government or national labs. Since postdoctoral positions are typically heavily research-based, it is hardly surprisingly that very few postdocs in either field occur outside of these two sectors.

Figure 28: Corresponds to the Astronomy PhD classes of 2014, 2015, and 2016 combined.

As with every other degree examined, the majority of those who entered the workforce found employment in the private sector. Similar to doctorates in physics, employment in the academic sector dominated the non-private initial employment of astronomy PhDs (Figure 28).
The median initial salary of astronomy PhDs employed in the private sector was around $105,000, with a distribution ranging between $50,000 and $175,000. Potentially permanent academic positions had a median salary of around $65,000, with a reported minimum of $42,000 and a maximum of $90,000. Government postdocs had a very tight initial salary distribution, with reported salaries ranging between $58,000 and $80,000, and a median salary of $65,000, aligning with that of potentially permanent academic sector positions. Academic postdocs had the lowest reported minimum ($40,000), median ($59,000), and maximum ($70,000) compared to every other sector, similar to academic postdoc initial salaries for physics PhD holders.
Conclusions

In conclusions, to highlight some of the more substantiative trends:

- The number of bachelor’s in physics and bachelor’s in astronomy awarded each year are steadily rising and consistently reaching all-time highs
- The number of graduate study placements have not increased in the decades, meaning the same positions in programs are more competitive now than they were 10, 20, or even 30 years ago.
- Across bachelors and masters students from both fields, roughly half entered the workforce immediately after graduating.
  - Physics bachelors graduates worked primarily in the private sector, primarily in the fields of engineering or computer science
  - Exiting masters students followed a similar trend, but a plurality was concentrated in physics or astronomy fields, followed by engineering and computer science.
  - Similar percentages of private sector employees from both a bachelors and masters of physics background worked in engineering or computer science
- Physics and Astronomy PhDs both tended to take postdoc positions as initial employment, though a larger percentage of astronomy PhD’s took postdocs than their physics counterparts
- Across every degree, private sector employment offered the most lucrative positions
- PhD holders in both the private sector and in potentially permanent academic positions made significantly more than their bachelor-holding counterparts
- Both physics bachelors and PhDs had larger initial salary distributions than their astronomy counterparts for the same type of positions across all sectors of employment.
- Physics masters degree holders reported salary distributions that were generally very similar to their bachelor degree counterparts.

- Between four of the major universities in the state of Alabama, UA, UAB, UAH, and Auburn, UAH conferred comparatively high numbers of physics bachelor’s degrees, and for many years, had the highest number of exiting masters students.

- By normalizing each school by the number of their full-time physics faculty, we learn that UAH has had a far larger physics department per capita than these other, much larger Alabama universities in nearly every category measured.
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