AMERICAN ASTRONOMICAL SOCIETY

A New Universe to Explore: Careers in Astronomy

Compiled by the Employment Committee

Introduction

Astronomy is the scientific study of the universe and of objects that exist naturally in space, such as the moon, the sun, planets, and stars. Throughout their careers, astronomers seek the answers to many fascinating and fundamental questions such as

**Is there life beyond earth? *How did the sun and the planets form?*
**How old are the stars? *What exactly are dark matter and dark energy?*
**How did the Universe begin, and how will it end?*

Thanks to the breathtaking images of the night sky from telescopes on the ground and in space, the work of science communicators as well as depictions of space in popular media, the study of the universe has captivated the imagination of many around the world. As a result, astronomy is a popular field of study. After graduation, many astronomers go on to have full-time careers in astronomy. However, as astronomy training emphasizes a remarkably broad set of problem-solving skills, many graduates also move into careers in a variety of fields such as aerospace, technology, public policy and more.

This webpage outlines the skills that are developed while pursuing a degree in astronomy or a closely related field, as well as a broad overview of some of the different career paths that are available to physics and astronomy graduates at all levels.

The landscape of astronomy research is constantly changing and evolving with new discoveries and technologies. For this reason, the National Academies of Sciences, Engineering, and Medicine conducts a decadal survey to identify scientific priorities, opportunities, and funding recommendations for the next 10 years of astronomy and astrophysics. The report from the most recent decadal survey conducted in 2020 can be found here. The results of this survey inform the priorities and overall direction of astronomy research for the upcoming decade.

Skills and Education

Many job opportunities in astronomy, such as professorships, postdoctoral research positions, leading telescope operations, or coordinating outreach efforts require a PhD degree in physics, astronomy, or a closely related field. However, a number of support positions in astronomy—for example, a telescope operator or software developer— are open to those with Bachelor's or Master's degrees.

Undergraduate education

A physics or astronomy major is the typical undergraduate stepping stone to a PhD program and eventual astronomer's position. To supplement the physics major, typical minors include math, astronomy, or computer science, although students may also choose minors from other fields. (In choosing a minor, keep in mind that some graduate programs may have specific admission requirements and/or preferences.) While a majority of those who pursue PhDs in physics/astronomy have an undergraduate degree in the same, those holding degrees in other subjects (such as engineering or computer science) also go on to obtain graduate degrees in physics or astronomy.

Typical courses for a physics or astronomy major include Introductory and Intermediate courses in Mechanics, Electricity and Magnetism, Thermodynamics, Quantum Physics, one or two lab courses, plus one or two advanced physics courses. Math courses required for the physics major typically include two semesters of Calculus, Linear Algebra, Several Variable Calculus, and Differential Equations.

While pursuing your degree, you may also be able to participate in an astronomy research program or internship designed for undergraduate students. These may be available through your department, or through separate programs such as those listed here. Such programs are often paid and can be very beneficial in gaining hands-on experience in working with data, and learning what a career in astronomy research entails. They also provide mentoring opportunities with astronomers who can provide support, advice, and write personalized letters of recommendation necessary for acceptance into most US astronomy graduate programs.

Graduate education

When considering a graduate school program, Universities might have:

1. A Physics department where some faculty work on astronomy topics. Such departments typically offer mostly physics courses at the graduate level, along with a number of elective astronomy courses.

2. A combined department of Physics and Astronomy. These are likely to have a comparable number of astronomy and wider physics faculty, with a larger number of astronomy courses being offered.

3. A separate astronomy department. Such departments typically offer many astronomy courses with the majority of the faculty working on astronomy. Such departments are likely to have access to a telescope, either in their own observatories or through a consortium with other schools.

While considering your options, the most important factor is to find a department that matches your research interests. If you have a fascination with a particular topic, or are interested in working with a specific faculty member, it might be beneficial to email them in advance of your application to see if they currently have time and funding available for new students. If you are unsure of your research interests when applying to grad schools, selecting a university with a large number of astronomy faculty may provide more opportunities for choosing a research focus.

Skills

During the course of a physics/astronomy degree, you will acquire a number of skills that will be beneficial in any career you may pursue. Some notable ones include:

1. **Critical thinking and problem solving.** Astronomers often have to interpret complex scenarios to account for multiple possibilities while trying to answer a specific research question.

2. **Coding.** A large number of astronomers use Python, a versatile programming language that is widely used in other fields as well as in non-academic roles.
3. Statistical Analysis. Astronomers often use mathematics and statistics to understand and interpret their data.

4. **Oral and written presentation skills.** Presenting scientific information in a clear and concise manner to a wide range of audiences is a key skill in astronomy and beyond.

5. **Project management.** Research projects typically have different components that need to be handled, such as budgets and deadlines. Coordination between different members of the group is also necessary.

6. **Proposing (writing technical arguments) for resources.** Astronomers often propose for observing time with telescopes and grant funding for research projects.

7. **Teaching skills.** Supporting classes as an instructor, lab supervisor or teaching assistant, astronomers typically gain hands-on experience in teaching. Some graduate schools may also have professional development and teaching certificate programs available to students in all types of graduate programs.

8. **Networking.** From attending conferences and making connections to building new research collaborations, networking is an important career skill in astronomy. The AAS holds networking events for attendees at all levels at its conferences, and regularly hosts webinars on networking.

A Typical Education and Training Path

Undergraduate Students

Undergraduate students often have opportunities to start small research projects with faculty or through academic programs. These projects often occur during the summer terms when faculty don't have teaching responsibilities. Undergraduates will typically be tasked with working directly on some research problem by writing code, analyzing astronomy data with basic programming skills or working on theoretical research problems.

Graduate Students

Graduate students pursuing a PhD in astronomy typically focus on classes the first 2-3 years of their education while slowly shifting their effort towards research with their academic advisor. Some universities require graduate students to take a qualifying exam, a test students are required to pass in order to continue towards obtaining a PhD. By the time students have finished their required classes they typically have chosen the area of expertise they wish to explore and focus on pursuing research that will eventually become their dissertation. At this stage, they spend time building professional relationships with other students, faculty and outside collaborators and learn to lead and contribute to various research projects.

Professional astronomy often requires proficient programming and technical writing skills. Graduate students will utilize these while pursuing research. Students could opt to spend time writing research proposals which are ~2-4 page technical documents asking for resources. For example, a graduate student wishing to pursue observational astronomy could request observing time using NASA's Hubble or Chandra space telescopes. A theorist could request funding or time on a super computer to perform a complex astrophysical simulation. A student focused on instrumentation could write a proposal for funding an instrument design they wish to build or test. In short, graduate students work with others and learn how to craft technical arguments as to why they need resources to pursue their research interests. Graduate students will also be expected to attend and present at local colloquia or other university events and will often have opportunities to travel to present their research at conferences. Eventually, graduate students compile, write and defend their research dissertation which, if successful, culminates in receiving a PhD.

Postdoctoral researchers

Postdoctoral researchers typically work directly with a specific faculty member or researcher that funds the postdoctoral position. Postdoctoral researchers often spend some time focusing on their own personal research interests and contribute to other projects in significant ways. This includes writing programs to analyze data, writing proposals to receive more resources (grant money, observing time, etc) and writing and publishing research papers. Unlike

undergraduate and graduate students, postdoctoral research positions are typically quite independent where the individual is responsible for contributing work on their own. However, working as a team with collaborators is still an essential part of being a postdoctoral researcher and there can be many opportunities to either lead or contribute. As a postdoctoral researcher pursuing a permanent appointment in academics, some time will be spent traveling to different conferences and presenting your work to a larger audience. Eventually, applying to permanent positions will take significant effort which needs to be pursued while continuing research.

The Academic Faculty Career Path

There are different types of colleges/universities at which an astronomer could be a professor, usually denoted by the types of degrees that are awarded by the institution: doctoral, masters, bachelors, or associate degrees. Additionally, colleges and universities may be public, private not-for-profit, and private for-profit. Some institutions have astronomy or astrophysics departments, but many other astronomers are faculty members within physics departments.

Full-time faculty members generally start at the Associate Professor level before promotion to Assistant Professor and then Full Professor. Many full-time faculty positions are tenure-track positions; this means that after an initial few years of employment at the Associate level, a faculty member may be eligible to receive tenure. Tenure offers a degree of protection and job security that is historically tied to the protection of freedom of academic speech. According to the American Association of University Professors (AAUP), "A tenured appointment is an indefinite appointment that can be terminated only for cause or under extraordinary circumstances such as financial exigency and program discontinuation." Many tenure procedures are described as "up or out" because if the candidate's record of research, teaching, and service is not strong enough to warrant tenure, the candidate loses their employment at the institution.

Academic faculty salaries can vary depending on faculty rank as well as the type of institution. Generally, PhD-granting institutions will have higher salaries on average than bachelors-granting institutions. The American Institute of Physics statistical research center frequently publishes salary ranges of physics/astronomy faculty.

Securing a full-time, tenure-track faculty position in astronomy is very competitive because there are many more PhD graduates in astronomy per year than faculty positions open. This is the nature of the design of academia; each faculty member will mentor many PhD students over the course of their faculty career. For example, according to the American Institute of Physics (AIP), 155 PhDs were awarded in astronomy in 2020, but there were only 54 faculty

recruitments in astronomy departments in the 2018-2019 academic year. These numbers do not count astrophysics-related PhDs awarded in physics departments, nor astronomy faculty recruitment in physics departments.

The expectations for an academic faculty astronomer depend heavily on the type of institution. Generally, any faculty member divides their time among teaching, research, and service. Service may include service to the campus community, such as by serving on university committees, and service to the professional community.

At doctoral-granting institutions, faculty members are expected to mentor and financially support graduate students and postdoctoral scholars with external grants and publish new research results frequently in academic journals. Their teaching responsibilities may be minimal and not heavily weighted in decisions for tenure and promotion. A significant amount of time is spent managing a large research team of students and postdocs. Some doctoral-granting institutions may have a separate type of faculty track with more extensive teaching requirements and lower expectations for research productivity, but these positions do not always carry the same job security as tenure-track faculty.

Colleges and universities that do not award PhDs in physics/astronomy will likely have reduced expectations for research productivity, but heavier teaching loads and higher expectations for service and for quality, innovative teaching methods. While faculty members may still be expected to involve students in an active research program, there may be fewer resources available to support their programs.

Careers at National Labs and Telescopes

Research facilities supported by large, stable grants and programs that employ astronomy graduates can be found in the US, Europe, and Asia. Examples include dedicated mission support for telescopes or exploration programs, as well as large scale or multi-site experimental projects. Although centered around observation or instrumentation, these facilities place subject experts alongside operations personnel to maximize scientific output and support. This provides a unique opportunity to support independent research time with part-time service/support work, rather than the traditional teaching or individual grant funding path associated with university settings. Scientists/astronomers in these facilities tend to spend 50-80% of their time in service, with generally more “regular” and predictable hours than research faculty, although these can shift when institute-wide priorities are forefront (ie. during the commissioning of a mission or instrument).

The size of these scientific support staff can be an advantage for the research atmosphere compared with a traditional university department. An additional advantage is that facility

researchers have a comparatively easy timeshifting service roles and promotional tracks compared to academic institutions. The service portions of staff positions are usually determined based on company need, although the employee typically has some input. Students are rare in such positions, although postdoctoral opportunities are common. Salaries are competitive with academic positions but are typically for all 12 months of the year, rather than separating summer work. As a result, such positions are typically much less dependent on individual grant funding than research groups.

These facilities also include career paths that are 100% functional/service work, for example science support analysts, archive scientists, or flight operations engineering. Many such positions are advertised on the AAS Job Register, which is updated as new positions are available. The job requirements for technical positions vary, requiring anywhere from a bachelors degree to a PhD in astrophysics, computer science, or related engineering fields, or sometimes in other areas like communications or technical writing, or primary management roles. In general, working at a research facility feels like a hybrid between a corporate and an academic environment. However, unlike traditional faculty positions which offer tenure, employees at national labs and telescopes often depend on the success and duration of the mission for employment. Over the course of a career, astronomers in these positions may switch roles or find new positions at other institutions more frequently than tenured faculty.

Public Policy

Science policy careers cover a wide range of arenas, and can describe positions that support, use, or promote publicly funded science. There are many government agencies, non-profits, think-tanks, media, and lobbying groups that want to inform their policy decisions based on the science, or, alternatively, that directly work to support science and science funding itself. These groups require staffing and support, and they do not necessarily require a PhD. Policy positions often require data analysis and synthesis, problem solving, and public communication skills.

The policy world is often fast-paced and reacts quickly to current events. Astronomers in policy will often be working with people from a wide variety of backgrounds and who do not have scientific training. Being able to convey complex information succinctly and clearly and having the flexibility to change approaches based on the audience are extremely valuable skills in these careers.

A wide range of salaries can also be expected across policy careers. Non-profits may have limited funding and therefore limited salaries; however, a well-funded agency or group may be more competitive. Federal careers have high job security and salary tiers and benefits are

publicly available. Working directly for or with a government agency as a policy advisor or researcher often requires US citizenship, however.

For astronomers interested in policy careers, there are a growing number of policy fellowships both at the state and federal levels. Fellowships such as the AAS John Bahcall Public Policy Fellowship and the AAAS Science & Technology Policy Fellowships are good pathways for Astronomers who already have PhDs who are interested in policy careers. Both of these programs are designed to get scientists directly involved in government, public policy, and science communication. It can also be useful to get involved with local community groups on a smaller scale.

Careers in Tech

The mathematics, coding, and analytical thinking skills gained while obtaining degrees in astronomy and physics have proven to be incredibly valuable in industries outside of academia. A substantial portion of undergraduate and graduate degree recipients in astronomy pursue careers in the private sector.

Careers in technology - especially in data science and software engineering - have been increasingly common outcomes for astronomy graduates. These careers are in high demand, can be very lucrative, and present unique problem solving opportunities outside of astronomy.

An astronomy graduate has a wide array of career options outside of the worlds of academia and tech. Astronomers have found careers in aerospace, journalism, finance, public policy, and a litany of other careers. Check out our career profiles page for detailed descriptions of a variety of jobs real astronomers have pursued.

If you are interested in understanding careers outside of academia, consider attending a career panel or Astronomers Turned Data Scientists splinter meeting at the next annual AAS meeting. We also have additional nonacademic career resources.

Careers in Aerospace

Aerospace includes the branch of technology and industry concerned with both aviation and space flight, with commercial, industrial, and military applications. The work of aerospace companies is to research, design, manufacture, analyze, test, and operate aircraft, spacecraft, rockets, and more. Aerospace projects are diverse and can include working on everything from space telescopes, to new propulsion systems, to missile guidance technologies, to the control and analysis software for all of the above.

Careers in aerospace can be had at federal government facilities, traditional aerospace companies, and a wide variety of "new space" companies and startups. Aerospace work does not require a PhD — all your technical skills from astronomy can come into play: math, physics, problem solving, understanding complex systems, data analysis, coding, proposal writing, and project management. Aerospace is frequently project-based and therefore the work can vary based on the lifecycle of a project. Careers in aerospace include: engineers, technicians, project managers, cost estimators, business development professionals, technical communications experts, and more.

The aerospace industry in the US is typically well funded by the US government for aviation, defense and civil space purposes; add to this the commercial aviation industry and the blossoming commercial space sector — aerospace careers are in high demand and have higher than average salaries. Citizenship is often required, and depending upon the nature of the work, defense related jobs in the US are likely to require ability to obtain a security clearance.

If you're interested in a career in aerospace and have the opportunity, internships can be a great way to get your foot in the door. Many astronomers start in aerospace as systems engineers, working on either software for calibration/analysis, or for those with hardware experience, on assembling, integrating, and testing systems. To find out more, go up to one of the aerospace booths at an AAS meeting and chat with the employees who work there or network with aerospace representatives at a career hour held at each winter meeting.

Family & Astronomy

Pursuing a career in astronomy, while rewarding, can complicate one's family life, occurring, as it does, during the period of life most people settle down and start families. If you do not have outside support, and having a family is very important to you, then pursuing academic astronomy, while possible, will present severe challenges that should be honestly evaluated.

The basic academic career path after undergrad starts with a long, circa 6 year period of high stability but low pay. Graduate school pay scales will likely make it difficult to support or contribute to a family after graduating from college, particularly in high cost of living areas. Raising a child will also complicate what is, in essence, a competition against your co-workers for prestigious postdoctoral positions.

After the stability of graduate school comes a period of, likely two postdoctoral positions. The good news is that postdoctoral pay is significantly higher than graduate student pay, although still much lower than in non-academic roles with more than 6+ years of experience. On the other hand, post-docs move to wherever their new job is, assuming that one is obtained in

the first place. This can strain marriages or partnerships, particularly if your partner helped support you in graduate school; and the two-body problem, where two academics try to find jobs in the same general location, is infamous. The short time frame of post-docs, and the need to publish to win the next position, is in severe tension with having children in this phase of academic life.

Postdoctoral positions have widely varying standards of family leave, disability, remote work possibilities, and benefits. These can vary wildly by region and institution (or type of institution). It is important to ask explicitly about these benefits and restrictions when accepting any position, but postdoctoral positions are particularly variable. Additionally, country (and state) laws can significantly affect what is offered to postdocs (or graduate students), particularly in terms of health insurance, retirement, leave, and office location.

To complicate things further in recent years, US federal and state laws have changed with surprising frequency, even during a single postdoctoral term. Family leave, for example, can be as little as zero official days or up to the supervisor; however states like Maryland currently (as of 2022) guarantee 12 weeks of (unpaid) leave, which impacts postdoctoral researchers in those states.

Finally, if (and it is a big if) you win a faculty position, you will need to move to wherever that position is: perhaps in a big city, perhaps in a small college town in the middle of nowhere without any real job prospects for your partner. Stability returns, and the pay scale will likely be comfortable. Here at last, in your mid to late 30s (assuming a traditional career path), you will be both relatively free and financially secure enough to support a family.

In sum, the academic path is the most straightforward for those who are driven and with relatively few responsibilities, financial or familial, but poses challenges that should be weighed carefully otherwise. There are certainly those who have made it work; but there are also many who found that they had to leave after striving for years.

From Student to Professional Astronomer: An Example Timeline

While a career in astronomy can be very rewarding, it requires a serious commitment and financial sacrifice if your goal is to pursue a full-time role at an academic institution. We recommend that you consider your individual financial situation, family commitments and personal preferences, along with career opportunities (both academic and non-academic) available to you at each stage. A career path starting from a PhD program in graduate school to a tenured faculty position at a research institution typically takes 10+ years and

requires relocating several times to work at various institutions. The majority of that time (5-7 years) is spent in grad school where students that are accepted into US PhD programs typically have tuition costs waived but earn a very limited stipend. For example, first year physics/astronomy grad students at US institutions between the 2014-2016 academic years earned a stipend of ~$25,000 per year. Some students may opt to leave a PhD program without graduating or focus exclusively on obtaining a masters degree in astronomy. While a masters degree can provide some minor additional career opportunities compared to a bachelor's degree, a PhD is required for most academic positions. If a graduate student wishes to pursue a career focused on astronomy research (e.g., faculty, research scientist, postdoc) then they would typically apply to academic postdoctoral positions the same year they plan to graduate with a PhD.

After graduating with a PhD, it is typically for an astronomer to spend 2-4 years at postdoctoral positions. All postdoctoral positions are located almost exclusively at academic institutions around the world and thus will require relocation for each ~2 year long position. The median US postdoctoral research salary in 2018 was ~$63,500. Postdoctoral position opportunities are often specific to a type of research and obtaining one may depend on the field of research the graduate student has pursued (e.g., exoplanets, galaxies, stars, etc). It is typical for an astronomer to apply for permanent academic positions while they are a postdoc. Securing a full-time, tenure-track faculty position in astronomy is very competitive because there are many more PhD graduates in astronomy per year than faculty positions open. That being said, while it may take 10+ years from starting grad school before applying for a permanent position at a university, there are options along the way if one decides a career in academic astronomy is not for them. For example, there are many career opportunities for people who obtain a PhD in astronomy or a related field.

Astronomy around the world

International students from many countries come to the US to enroll in undergraduate, masters and PhD programs to pursue astronomy as a career. In order to do so, you will have to enter under a F-1 student visa to be able to enroll. Universities typically have an international students office that can help you coordinate paperwork after acceptance.

There are many postdoctoral positions and fellowships in astronomy that do not have a citizenship requirement. Some grants, such as some offered by the National Science Foundation, are restricted to US citizens. Similarly, many positions at national centers or labs, such as NASA centers, the Naval Research Lab, Los Alamos, might be restricted to individuals with US citizenship or permanent residency. However, many prize fellowships, such as the NASA Hubble Fellowship, are open to international applicants. Postdoctoral positions at universities are also usually open to applicants from around the world.

There are also many opportunities for astronomers from the US to study or work abroad. The duration of the PhD and funding availability for foreign students vary from country to country. For example in many European countries, a separate masters degree is required before enrollment in a PhD program, resulting in a shorter (3-4 years) timeline for obtaining a PhD. Due to the varied expectations, it is recommended that you talk to someone who is based in that location before applying. The length of postdoctoral positions is typically the same around the world.

Astronomy research is often international, and it is quite common for research groups and collaborations to have members of different nationalities and/or from institutions around the world. Traveling both domestically and internationally for conferences is also likely to be a part of your career in astronomy.

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