Physicists and Astronomers

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Significant Points

- Scientific research and development services firms and the Federal Government employ over half of all physicists and astronomers.
- Most jobs are in basic research, usually requiring a doctoral degree; master's degree holders qualify for some jobs in applied research and development; bachelor's degree holders often qualify as research assistants or for other physics-related occupations, such as technicians.
- Applicants may face competition for basic research positions due to limited funding; however, those with a background in physics or astronomy may have good opportunities in related occupations.

Nature of the Work

Physicists and astronomers conduct research to understand the nature of the universe and everything in it. These researchers observe, measure, interpret, and develop theories to explain celestial and physical phenomena using mathematics. From the vastness of space to the infinitesimal scale of subatomic particles, they study the fundamental properties of the natural world and apply the knowledge gained to design new technologies.

Physicists explore and identify basic principles and laws governing the motion, energy, structure, and interactions of matter. Some physicists study theoretical areas, such as the nature of time and the origin of the universe; others apply their knowledge of physics to practical areas, such as the development of advanced materials, electronic and optical devices, and medical equipment.

Physicists design and perform experiments with lasers, particle accelerators, electron microscopes, mass spectrometers, and other equipment. On the basis of their observations and analysis, they attempt to discover and explain laws describing the forces of nature, such as gravity, electromagnetism, and nuclear interactions. Experiments also help physicists find ways to apply physical laws and theories to problems in nuclear energy, electronics, optics, materials, communications, aerospace technology, and medical instrumentation.

Astronomers use the principles of physics and mathematics to learn about the fundamental nature of the universe, including the sun, moon, planets, stars, and galaxies. As such, astronomy is sometimes considered a subfield of physics. They also apply their knowledge to solve problems in navigation, space flight, and satellite communications and to develop the instrumentation and techniques used to observe and collect astronomical data.

Most physicists work in research and development. Some do basic research to increase scientific knowledge. Others conduct applied research to build upon the discoveries made through basic research and work to develop new devices, products, and processes. For example, basic research in solid-state physics led to the development of transistors and, then, integrated circuits used in computers.

Physicists also design research equipment, which often has additional unanticipated uses. For example, lasers are used in surgery, microwave devices function in ovens, and measuring instruments can analyze blood or the chemical content of foods.

A small number of physicists work in inspection, testing, quality control, and other production-related jobs in industry.

Much physics research is done in small or medium-sized laboratories. However, experiments in plasma, nuclear, and high-energy physics, as well as in some other areas of physics, require extremely large, expensive equipment, such as particle accelerators. Physicists in these subfields often work in large teams. Although physics research may require extensive experimentation in laboratories, research physicists still spend much time in offices planning, recording, analyzing, and reporting on research.

Physicists generally specialize in one of many subfields: elementary particle physics, nuclear physics, atomic and molecular physics, condensed matter physics (solid-state physics), optics, acoustics, space physics, plasma physics, or the physics of fluids. Some specialize in a subdivision of one of these subfields. For example, within condensed-matter physics, specialties include superconductivity, crystallography, and semiconductors. However, all physics involves the same fundamental principles, so specialties may overlap, and physicists may switch from one subfield to another. Also, growing numbers of physicists work in interdisciplinary fields, such as biophysics, chemical physics, and geophysics.

Almost all astronomers do research. Some are theoreticians, working on the laws governing the structure and evolution of astronomical objects. Others analyze large quantities of data gathered by observatories and satellites and write scientific papers or reports on their findings. Some astronomers actually operate large space-based or ground-based telescopes, usually as part of a team. However, astronomers may spend only a few weeks each year making observations with optical telescopes, radio telescopes, and other instruments.

For many years, satellites and other space-based instruments, such as the Hubble space telescope, have provided prodigious amounts of astronomical data. New technology has lead to improvements in analytical techniques and instruments, such as computers and optical telescopes and mounts, and is creating a resurgence in ground-based research.

A small number of astronomers work in museums housing planetariums. These astronomers develop and revise programs presented to the public and may direct planetarium operations.

Work environment. Most physicists and astronomers do not encounter unusual hazards in their work. Some physicists temporarily work away from home at national or international facilities with unique equipment, such as particle accelerators. Astronomers who make observations with ground-based telescopes may spend many hours working in observatories; this work usually involves travel to remote locations and may require working at night. Physicists and astronomers whose work depends on grant money often are under pressure to write grant proposals to keep their work funded.

Physicists often work regular hours in laboratories and offices. At times, however, those who are deeply involved in research may work long or irregular hours. Astronomers may

Most jobs for physicists and astronomers are in research and usually require a doctoral degree.

need to work at odd hours to observe celestial phenomena, particularly those working with ground-based telescopes.

Training, Other Qualifications, and Advancement

Because most jobs are in basic research and development, a doctoral degree is the usual educational requirement for physicists and astronomers. Master's degree holders qualify for some jobs in applied research and development, whereas bachelor's degree holders often qualify as research assistants or for other occupations related to physics.

Education and training. A Ph.D. degree in physics or closely related fiends is typically required for basic research positions, independent research in industry, faculty positions, and advancement to managerial positions. This prepares students for a career in research through rigorous training in theory, methodology, and mathematics. Most physicists specialize in a subfield during graduate school and continue working in that area afterwards.

Additional experience and training in a postdoctoral research appointment, although not required, is important for physicists and astronomers aspiring to permanent positions in basic research in universities and government laboratories. Many physics and astronomy Ph.D. holders ultimately teach at the college or university level.

Master's degree holders usually do not qualify for basic research positions, but may qualify for many kinds of jobs requiring a physics background, including positions in manufacturing and applied research and development. Increasingly, many master's degree programs are specifically preparing students for physics-related research and development that does not require a Ph.D. degree. These programs teach students specific research skills that can be used in private-industry jobs. In addition, a master's degree coupled with State certification usually qualifies one for teaching jobs in high schools or at 2-year colleges.

Those with bachelor's degrees in physics are rarely qualified to fill positions in research or in teaching at the college level. They are, however, usually qualified to work as technicians or research assistants in engineering-related areas, in software development and other scientific fields, or in setting up computer networks and sophisticated laboratory equipment. Increasingly, some may qualify for applied research jobs in private industry or take on nontraditional physics roles, often in computer science, such as systems analysts or database administrators. Some become science teachers in secondary schools.

Holders of a bachelor's or master's degree in astronomy often enter an unrelated field. However, they are also qualified to work in planetariums running science shows, to assist astronomers doing research, and to operate space-based and ground-based telescopes and other astronomical instrumentation. (See the statements on engineers, geoscientists, computer programmers, computer scientists and database administrators, computer software engineers, and computer systems analysts elsewhere in the *Handbook*.)

About 760 colleges and universities offer a bachelor's degree in physics. Undergraduate programs provide a broad background in the natural sciences and mathematics. Typical physics courses include electromagnetism, optics, thermodynamics, atomic physics, and quantum mechanics.

Approximately 185 colleges and universities have departments offering Ph.D. degrees in physics; about 70 additional colleges offer a master's as their highest degree in physics. Graduate students usually concentrate in a subfield of physics, such as elementary particles or condensed matter. Many begin studying for their doctorate immediately after receiving their bachelor's degree.

About 80 universities grant degrees in astronomy, either through an astronomy, physics, or combined physics-astronomy department. Currently, about 40 astronomy departments are combined with physics departments, and the same number are administered separately. With about 40 doctoral programs in astronomy, applicants face considerable competition for available slots. Those planning a career in the subject should have a strong physics background. In fact, an undergraduate degree in either physics or astronomy is excellent preparation, followed by a Ph.D. in astronomy.

Many physics and astronomy Ph.D. holders begin their careers in a postdoctoral research position, in which they may work with experienced physicists as they continue to learn about their specialties or develop a broader understanding of related areas of research. Initial work may be under the close supervision of senior scientists. As they gain experience, physicists perform increasingly complex tasks and achieve greater independence in their work. Experience, either in academic laboratories or through internships, fellowships, or work-study programs in industry, also is useful. Some employers of research physicists, particularly in the information technology industry, prefer to hire individuals with several years of postdoctoral experience.

Other qualifications. Mathematical ability, problem-solving and analytical skills, an inquisitive mind, imagination, and initiative are important traits for anyone planning a career in physics or astronomy. Prospective physicists who hope to work in industrial laboratories applying physics knowledge to practical problems should broaden their educational background to include courses outside of physics, such as economics, information technology, and business management. Good oral and written communication skills also are important because many physicists work as part of a team, write research papers or proposals, or have contact with clients or customers with nonphysics backgrounds.

Advancement. Advancement among physicists and astronomers usually takes the form of greater independence in their work, larger budgets, or tenure in university positions. Others choose to move into managerial positions and become natural science managers (listed elsewhere in the *Handbook*). Those who pursue management careers spend more time preparing budgets and schedules. Those who develop new products or processes sometimes form their own companies or join new firms to develop these ideas.

Employment

Physicists and astronomers held about 18,000 jobs in 2006. Physicists accounted for about 17,000 of these, while astronomers accounted for only about 1,700 jobs. Many physicists and astronomers held faculty positions in colleges and universities. Those classified as postsecondary teachers are not included in these employment numbers. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

About 38 percent of physicists and astronomers worked for scientific research and development services firms. The Federal Government employed 21 percent, mostly in the U.S. Department of Defense, but also in the National Aeronautics and Space Administration (NASA) and in the U.S. Departments of Commerce, Health and Human Services, and Energy. Other physicists and astronomers worked in colleges and universities in nonfaculty, usually research, positions, or for State governments, information technology companies, pharmaceutical and medicine manufacturing companies, or electronic equipment manufacturers.

Although physicists and astronomers are employed in all parts of the country, most work in areas in which universities, large research laboratories, or observatories are located.

Job Outlook

Physicists and astronomers should experience average job growth but may face competition for basic research positions due to limited funding. However, those with a background in physics or astronomy may have good opportunities in related occupations.

Employment change. Employment of physicists and astronomers is expected to grow at 7 percent, about as fast as the average for all occupations during the 2006-16 decade. The need to replace physicists and astronomers who retire or otherwise leave the occupation permanently will account for many additional expected job openings.

Federal research expenditures are the major source of physics- and astronomy-related research funds, especially for basic research. Although these expenditures are expected to increase over the 2006-16 projection period, resulting in some growth in employment and opportunities, the limited science research funds available still will result in competition for basic research jobs among Ph.D. holders. However, research relating to biotechnology and nanotechnology should continue to see strong growth.

Although research and development expenditures in private industry will continue to grow, many research laboratories in private industry are expected to continue to reduce basic research, which includes much physics research, in favor of applied or manufacturing research and product and software development. Nevertheless, people with a physics background continue to be in demand in information technology, semiconductor technology, and other applied sciences. This trend is expected to continue; however, many of the new workers will have job titles such as computer software engineer, computer programmer, or systems analyst or developer, rather than physicist.

Job prospects. In recent years the number of doctorates granted in physics has been somewhat greater than the number of job openings for traditional physics research positions in colleges and universities and in research centers. Recent increases in undergraduate physics enrollments may also lead to growth in enrollments in graduate physics programs, so that there may be an increase in the number of doctoral degrees granted that could intensify the competition for basic research positions. However, demand has grown in other related occupations for those with advanced training in physics. Prospects should be favorable for physicists in applied research, development, and related technical fields.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Astronomers and physicists	19-2010	18,000	19,000	1,200	7
Astronomers	19-2011	1,700	1,700	100	6
Physicists	19-2012	17,000	18,000	1,100	7

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

Opportunities should also be numerous for those with a master's degree, particularly graduates from programs preparing students for related work in applied research and development, product design, and manufacturing positions in private industry. Many of these positions, however, will have titles other than physicist, such as engineer or computer scientist.

People with only a bachelor's degree in physics or astronomy are usually not qualified for physics or astronomy research jobs, but they may qualify for a wide range of positions related to engineering, mathematics, computer science, environmental science, and some nonscience fields, such as finance. Those who meet State certification requirements can become high school physics teachers, an occupation in strong demand in many school districts. Some States require new teachers to obtain a master's degree in education within a certain time. (See the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.) Despite competition for traditional physics and astronomy research jobs, graduates with a physics or astronomy degree at any level will find their knowledge of science and mathematics useful for entry into many other occupations.

Despite their small numbers, astronomers can expect good job prospects in government and academia over the projection period. Since astronomers are particularly dependent upon government funding, Federal budgetary decisions will have a sizable influence on job prospects for astronomers.

Earnings

Median annual earnings of physicists were 94,240 in May 2006. The middle 50 percent earned between $72,910 and $117,080. The lowest 10 percent earned less than $52,070, and the highest 10 percent earned 143,570.

Median annual earnings of astronomers were $95,740 in 2006. The middle 50 percent earned between $62,050 and $125,420, the lowest 10 percent less than $44,590, and the highest 10 percent more than $145,600.

According to a 2007 National Association of Colleges and Employers survey, the average annual starting salary offer to physics doctoral degree candidates was $52,469.

The American Institute of Physics reported a median annual salary of $80,000 in 2006 for its members with Ph.D.'s (excluding those in postdoctoral positions) who were employed by a university on a 9-10 month salary; the median was $112,700 for those who held a Ph.D. and worked at a federally funded research and development center; and $110,000 for self-employed physicists who hold a Ph.D. Those working in temporary postdoctoral positions earned significantly less.

The average annual salary for physicists employed by the Federal Government was $111,769 in 2007; for astronomy and space scientists, it was $117,570.

Related Occupations

The work of physicists and astronomers relates closely to that of engineers, chemists and materials scientists, atmospheric scientists, environmental scientists and hydrologists, geoscientists, computer systems analysts, computer scientists and database administrators, computer programmers, mathematicians, and engineering and natural sciences managers.

Sources of Additional Information

Further information on career opportunities in physics is available from the following organizations:

- American Institute of Physics, Career Services Division and Education and Employment Division, One Physics EllipSE., College Park, MD 20740-3843. Internet: **http://www.aip.org**
- American Physical Society, One Physics EllipSE., College Park, MD 20740-3844. Internet: **http://www.aps.org**