Physicists and Astronomers

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Significant Points

- Scientific research and development services firms and the Federal Government employ 3 out of 5 physicists and astronomers.
- Most jobs are in basic research and development, usually requiring a doctoral degree; master's degree holders qualify for many jobs in applied research and development, while bachelor's degree holders may qualify as technicians or research assistants.
- Ph.D. graduates will face competition for basic research jobs.

Nature of the Work

Physicists explore and identify basic principles governing the structure and behavior of matter, the generation and transfer of energy, and the interaction of matter and energy. Some physicists use these principles in theoretical areas, such as the nature of time and the origin of the universe; others apply their physics knowledge 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, telescopes, mass spectrometers, and other equipment. Based on observations and analysis, they attempt to discover and explain laws describing the forces of nature, such as gravity, electromagnetism, and nuclear interactions. Physicists also find ways to apply physical laws and theories to problems in nuclear energy, electronics, optics, materials, communications, aerospace technology, and medical instrumentation.

Astronomy is sometimes considered a subfield of physics. *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. 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. Physicists who conduct applied research 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. This equipment often has additional unanticipated uses. For example, lasers are used in surgery, microwave devices are used 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.

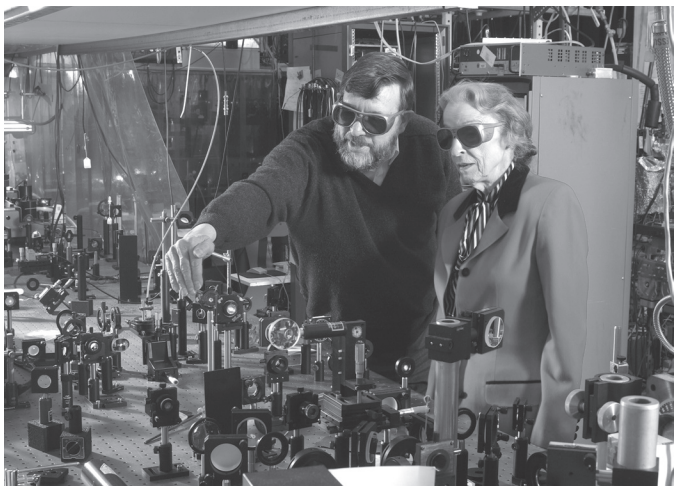
Much physics research is done in small or medium-sized laboratories. However, experiments in plasma, nuclear, and high energy and in some other areas of physics require extremely large, expensive equipment, such as particle accelerators. Physicists in these subfields often work in large teams. Although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

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- 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 tremendous amounts of astronomical data. New technology resulting in improvements in analytical techniques and instruments, such as computers and optical telescopes and mounts, is leading to 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.

Physicists generally specialize in one of many subfields—elementary particle physics, nuclear physics, atomic and molecular physics, physics of condensed matter (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.

Working Conditions

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. Most 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 using ground-based telescopes may spend long periods in observatories; this work usually involves travel to remote locations and may require long hours, including nightwork.



Most physicist and astronomer jobs are in basic research and development, usually requiring a doctoral degree.

Physicists and astronomers whose work depends on grant money often are under pressure to write grant proposals to keep their work funded.

Employment

Physicists and astronomers held about 14,000 jobs in 2002. Jobs for astronomers accounted for only 7 percent of the total. Nearly one-third of physicists and astronomers worked for scientific research and development services firms. The Federal Government employed 29 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.

Besides the jobs described above, many physicists and astronomers held faculty positions in colleges and universities. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

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

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. 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 do 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 specifically prepare students for physics-related research and development that does not require a Ph.D. degree. These master's degree programs teach students specific research skills that can be used in private industry jobs. A master's degree may suffice 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. Some may qualify for applied research jobs in private industry or nonresearch positions in the Federal Government. Some become science teachers in secondary schools. Astronomy bachelor's or master's degree holders often enter a field unrelated to astronomy, and they are 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; environmental scientists and geoscientists; computer programmers; computer systems analysts, database administrators, and computer scientists; and computer software engineers, elsewhere in the *Handbook*.)

More than 500 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.

About 180 colleges and universities have departments offering Ph.D. degrees in physics. More than 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 70 universities grant degrees in astronomy, either through an astronomy, physics, or combined physics/astronomy department. Currently, more than 30 departments are combined with the physics department and nearly 40 are administered separately. With fewer than 40 doctoral programs in astronomy, applicants face considerable competition for available slots. Those planning a career in astronomy should have a very strong physics background. In fact, an undergraduate degree in either physics or astronomy is excellent preparation, followed by a Ph.D. in astronomy.

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.

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 specialty and develop ideas and results to be used in later work. Initial work may be under the close supervision of senior scientists. After some experience, physicists perform increasingly complex tasks and work more independently. Those who develop new products or processes sometimes form their own companies or join new firms to exploit their own ideas.

Job Outlook

Employment of physicists and astronomers is expected to grow more slowly than the average for all occupations through 2012. Federal research expenditures are the major source of physics-related and astronomy-related research funds, especially for basic research. Although these expenditures are expected to steadily increase over the 2002-12 projection period, resulting in some growth in employment and opportunities, the limited research funds available still will result in competition among Ph.D. holders for basic research jobs. The need to replace physicists and astronomers who retire or otherwise leave the occupation permanently will account for most expected job openings.

Although research and development budgets 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, persons with a physics background continue to be in demand in the areas of 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, engineer, and systems developer, rather than physicist.

Through the 1990s, the number of doctorates granted in physics was much greater than the number of job openings for physicists, resulting in keen competition, particularly for research positions in colleges and universities and in research and development centers. Competitive conditions have eased somewhat because the number of doctorate degrees awarded has been dropping for several years, in line with declining enrollment in graduate physics programs. Recent increases in undergraduate physics enrollments, however, may again lead to growth in enrollments in graduate physics programs, meaning that, toward the end of the projection period, there may be an increase in the number of doctoral degrees granted that will intensify the competition for job openings.

Opportunities may be more numerous for those with a master's degree, particularly graduates from programs preparing students for 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.

Persons with only a bachelor's degree in physics or astronomy are not qualified to enter most physicist or astronomer research jobs but may qualify for a wide range of positions related to engineering, mathematics, computer science, and environmental science. Those who meet State certification requirements can become high school physics teachers, an occupation in strong demand in many school districts. Most 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, individuals with a physics degree at any level will find their knowledge of science and mathematics useful for entry to many other occupations.

Earnings

Median annual earnings of physicists were $85,020 in 2002. The middle 50 percent earned between $66,680 and $107,410. The lowest 10 percent earned less than $50,350, and the highest 10 percent earned more than $129,250.

Median annual earnings of astronomers were $81,690 in 2002. The middle 50 percent earned between $53,390 and $106,230; the lowest 10 percent, less than $40,140, and the highest 10 percent more than $126,320.

According to a 2003 National Association of Colleges and Employers survey, the average annual starting salary offer to physics doctoral degree candidates was $55,485.

The American Institute of Physics reported a median annual salary of $95,000 in 2002 for its full time members with Ph.D.'s (excluding those in postdoctoral positions); the median was $87,000 for those with master's degrees, and $78,000 for bachelor's degree holders. Those working in temporary postdoctoral positions earned significantly less.

The average annual salary for physicists employed by the Federal Government was $95,685 in 2003; for astronomy and space scientists, it was $100,591.

Related Occupations

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

Sources of Additional Information

General information on career opportunities in physics is available from:

➤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**

➤The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844. Internet: **http://www.aps.org**