The Physics Job Market: From Bear to Bull in a Decade

In their December 1993 Physics Today article, Kirby and Czujko described the job market for young physicists as bleak. What a difference eight years makes!

Kate Kirby, Roman Czujko, and Patrick Mulvey

Writing about the physics job market can be dangerous because, like the weather in New England, "if you don't like it, just wait a while." Over the past eight years, the physics job market has steadily improved, with much of the growth due to the strong economy and the burgeoning high-tech industry. There appears to be a reaffirmation on the part of business, industry, government, and academia of the important coupling of science and technology to the health of the economy. Recent statistics and a variety of indicators show the current physics job market in the US to be bullish.[1] Much of the growth has been in industry, and physicists are increasingly being lured into a variety of fields including software and consulting. As we look ahead, the physics "pipeline," particularly the number of undergraduate physics majors at US colleges and universities, is a critical issue that will affect the health of academic research in physics and ultimately the availability of highly trained physicists in the workplace.

Almost a decade ago, an extraordinary confluence of events on both global and national scales conspired to make the job market very bleak for young PhD physicists looking for employment in the three traditional physics work force sectors: academia, government labs, and industry. These events included an economic recession that affected both the hiring and retention of large research staffs at venerable industrial laboratories and the hiring at small colleges and universities. At the same time, the cold war had ended, and the national labs were undergoing a period of instability with respect to both their mission and their funding. The dissolution of the Soviet Union also resulted in a number of distinguished Russian physicists suddenly becoming available to compete for positions in US research institutes and universities. Physicists did not suffer alone during this time—so did practitioners in other scientific and technological fields.

In the early 1990s, postdocs were in "holding patterns," many taking a second, third, or even fourth postdoc appointment in hopes of eventually landing an academic or research position. A number of young physicists felt grossly misled in their employment expectations; testimony before Congress in the late 1980s, which received considerable attention in the media, had underscored projected "shortfalls" of technically and scientifically trained people and the importance of science and technology to the nation's future. The Young Scientists' Network was started by and for recent PhDs who were frustrated by their job searches. It provided an electronic forum for the exchange of concerns, news about information resources, and practical advice. Within the first two years, the network had gained 3000 subscribers, and it continued to be an important resource until 1997, when its Web presence was discontinued.

The difficult job situation spawned discussions about whether to limit the number of physics PhDs awarded by US universities. Students also received considerable encouragement—from the American Institute of Physics (AIP), American Physical Society (APS), other professional societies, and physicists employed outside of academia—to search more broadly for opportunities and to market themselves more effectively.

Recently, however, opportunities have come knocking! Recruiters are on university campuses, often successfully luring graduate students away—sometimes before completion of their PhD research—with promises of signing bonuses, stock options, and competitive salaries. Just when faculty slots are beginning to open up, due in part to an increasing retirement rate among physics professors, academic jobs may be looking less inviting in contrast to opportunities in the private sector. The number of physics PhDs awarded each year continues to decline, especially among US citizens. Thus some departments may find it increasingly difficult to fill their openings. In short, employers are looking for more physics-trained graduates as physics undergraduate and graduate departments are struggling to find enough students to enter their programs.

General physics employment trends

In the middle and late 1990s, the US economy grew at an unprecedented rate. This growth was driven to a significant extent by technological innovation and the commercial application of scientific breakthroughs in areas such as wireless communication, computing, and biotechnology, as well as by an explosion in opportunities related to

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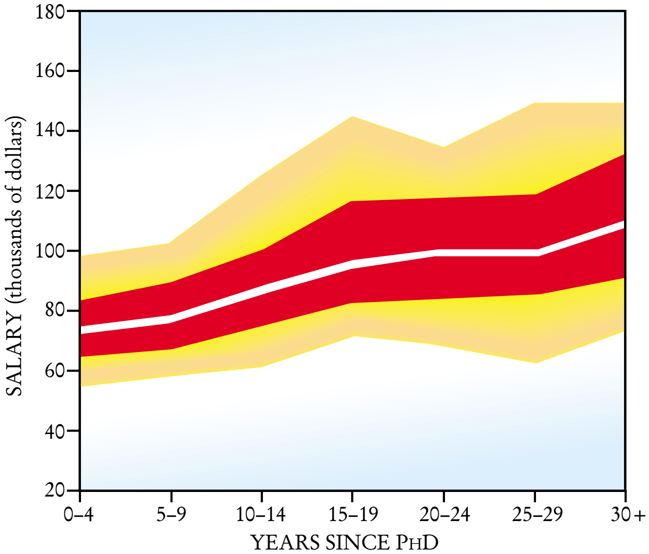


Figure 1. Salaries in industry in 2000, by years since PhD. White line is the median. The 25% to 75% percentiles are in red. The 10% to 90% percentiles are in gold.

the World Wide Web. The result was an especially strong demand for people with scientific and technological skills. Physicists certainly qualify, and they have benefited in the current employment market.

Historically, physicists have been employed in a remarkable array of different careers throughout the economy. We estimate that more than 13 000 PhD physicists are employed in academia, including physics faculty, postdocs, university research institute staff, and faculty in other departments. However, the majority of physics PhDs (about 24 000) are employed outside of academia in industry, federally funded research and development centers, federal agencies and labs, nonprofit research institutes, hospitals, and other organizations. The technology-driven growth in the economy has expanded their opportunities even further.

In the early 1990s, under pressure from stockholders interested in the bottom line and short-term profits, industrial leaders questioned their investment in and commitment to research. Over the last decade, the focus of research has shifted considerably at major companies. Still, management there has a renewed appreciation of not only the value but also the necessity of research in keeping companies competitive. In business and industry, one measure of an employee's value is salary. Figure 1 shows typical salaries for PhD physicists in industry for the year 2000 as a function of years since their degree.[2]

Academic job market

Physicists are employed throughout the economy, but the academic job market for physicists is often seen as the bellwether for the health of the entire physics workforce.

The number of openings for which departments are recruiting is up significantly from the early 1990s. For those who are searching, the number of advertisements appearing in the back of Physics Today is a good indicator of opportunities. A recent study by AIP indicates that, for the 2000–01 academic year, physics departments recruited for 510 tenured and tenure-track positions, along with more than 180 openings for visiting faculty or sabbatical replacements.[3] The combined number of openings is up by more than 50% from its 1991–92 value of 440.

Physics faculties are aging. There are now more faculty over the age of 60 than under the age of 40. The annual retirement rate, which was approximately 2% in 1990, has increased slowly over the past decade to its present value of 3.3%. During the next decade it should climb to more than 5%.

The trend in academic hiring, however, is not solely due to retirements. With increased wealth in the private sector, many colleges and universities have launched ambitious and successful capital campaigns. Because of this fundraising, departments and research institutes have grown in particular areas, many targeted toward new interdisciplinary studies involving physics, such as nanotechnology, biophysics, and quantum information and computation.

US PhDs are not the only ones who benefit from the improved job market in academia. Recruiting for professorships occurs on an international level. As shown in table 1, about 34% of the new hires in PhD-granting departments in 2000 had earned their degrees abroad.

Anecdotally, we have heard from many physics department chairs that the number of applications they have received for tenure-track openings has declined precipitously over the past several years. Around 1994, chairs told us that they had received 500 or more resumés for a single faculty opening. By 1998, they reported receiving slightly more than 100 resumés for each opening. Last year the number of resumés received was down to 50–80 for a single opening, and, during the fall of 2000, several chairs noted that they had received 30 or fewer resumés for a tenure-track position.

In a few select areas it is impossible to find any candidates. A professor at a leading research institute describes a search for a tenured professor, with a research program focused on optical fibers, that did not net any applicants. Similar news about opportunities in optical fibers comes from the world outside of academia. Ed Goldin, who managed the Placement Center at the Optical Society of America's March 2000 Optical Fiber Conference in Baltimore, reports, "184 employers posted nearly 3400 openings [at all degree levels]—great news for the 301 job seekers who attended."

Even though the number of applications is a fraction of those received a mere five years earlier, many chairs report that they are still finding excellent candidates. Over the next several years, however, it may become increasingly difficult for some departments to fill multiple openings with outstanding candidates in a single year. Faculty committees have always been careful to find the "right" candidate, and the latest data appear to indicate that committees are becoming even more selective and cautious. Part of this phenomenon may reflect the dramatic

Table 1. Backgrounds of New Physics Faculty, 2000

	Type of department	
	PhD	Bachelor's
Earned PhD in US within past 5 years	35%	60%
Earned PhD outside US, any year	34%	12%
Earned PhD in US more than 5 years ago		
Previous employer		
US academic institution	21%	22%
Industry, national lab, other	10%	6%

Table 2. University Salaries by Academic Rank, 2000

	Quartile salaries 25	Median	75	Mean salary
	(thousands of dollars)			
Professor				
9–10 month salary	70.0	81.0	100.0	87.0
11–12 month salary	90.0	108.0	134.0	114.0
Associate professor				
9–10 month salary	51.0	59.0	66.9	59.6
11–12 month salary	68.0	80.0	91.0	81.7
Assistant professor				
9–10 month salary	43.0	49.0	53.0	49.1
11–12 month salary	50.0	58.3	68.5	61.0
Research associate (11–12 months)				
Postdoctorates 0–2 years since degree	33.0	36.0	39.0	36.5
Postdoctorates 3–4 years since degree	33.0	36.0	44.0	38.0
Other research staff	48.0	56.0	74.0	62.0

increase in startup costs associated with a new faculty hire today. The committees need to feel that the huge investment is merited and will pay off. Startup packages for both theorists and experimentalists have gotten "sweeter" over the past seven years. At leading research universities, startup costs for experimentalists can be of the order of \$800 000 or more, including two years of summer salary, support for a postdoc or several graduate students for three years, and \$500 000 for research equipment. If the cost of extensive laboratory renovations is included, the total figure can easily top \$1 million.

Starting salaries in academia have not increased dramatically, perhaps because such a move would upset the existing salary structure within a department. Table 2 summarizes the salary data for university physics departments in 2000.

Employment of new PhDs

The initial employment of new PhDs reflects job availability combined with the search strategies and employment goals of job seekers. Opportunities for new physics PhDs have improved over the past eight years in all three major employment sectors. Concurrently, students are searching more broadly for opportunities, and many are marketing themselves more effectively. As a result, the current job market for new physics PhDs is the strongest we have seen in at least 10 years.

The unemployment rate and the time to find a position are two common indicators of the general health of the job market. Only 12% of new physics PhDs who secured permanent or potentially permanent positions—including staff positions in industry and government labs and tenured or tenure-track positions in academia—report that it took them more than six months to find a position. As figure 2 shows, this is the lowest level since the early 1980s. Similarly, unemployment among new PhDs is below 2% six months after degree, the lowest in nearly a decade.

Over the past several years, about half of new physics PhDs secured permanent or potentially permanent work. The majority of these positions are in the industrial sector. As figure 3 indicates, not since the early 1980s have this many new PhDs found potentially permanent positions directly after earning their degrees.

The distribution of fields of initial employment secured by the physics PhD class of 1998, shown in figure 4, reflects both the strength and the diversity of the current job market. Nearly all physicists who took postdoctoral positions are employed in physics and, in fact, the vast majority are working in their dissertation subfield. By comparison, only 43% of those who secured permanent or potentially permanent positions are working primarily in physics, although most are still employed within science and engineering. For many years, PhD physicists have been finding employment in engineering as well as in software development and applications. What has changed is the significant increase in the number of opportunities in these fields.

During good economic times or bad, experimentalists have an easier time finding work than do theorists. In part, this is because there are more theorists produced than there are opportunities. Among new physics PhDs, experimentalists outnumber theorists by roughly 2 to 1.

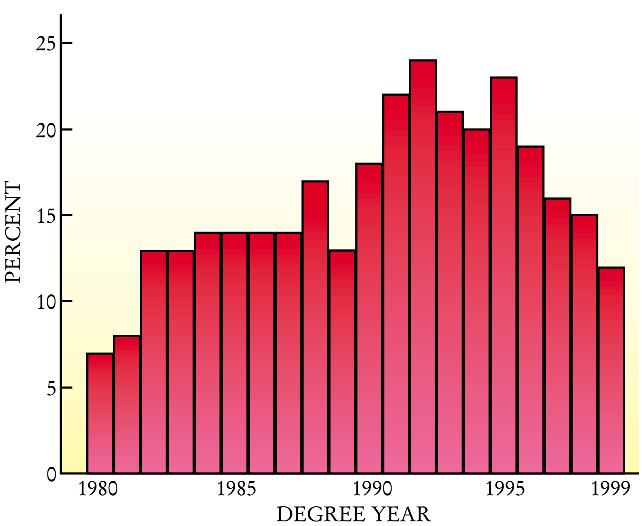


FIGURE 2. PERCENTAGE OF NEW PHYSICS PHDS finding permanent or potentially permanent employment who took more than six months to secure their position.

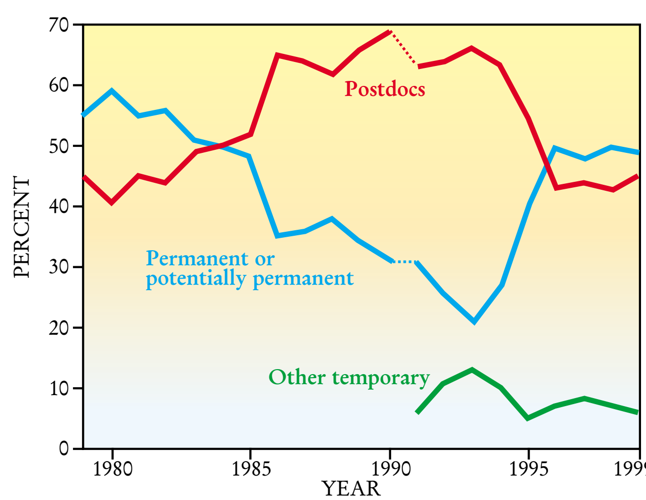


FIGURE 3. TYPE OF EMPLOYMENT secured by new physics PhDs. In 1991, the survey questionnaire was changed to measure "other temporary" employment as a separate category.

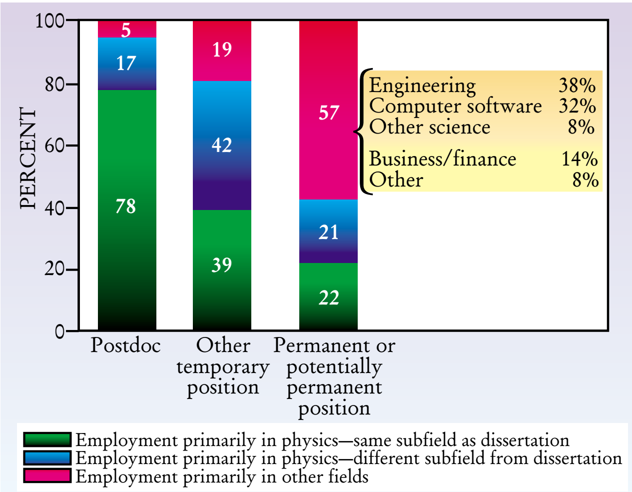


FIGURE 4. PRIMARY FIELD OF EMPLOYMENT secured by physics PhDs in the class of 1998.

Interestingly, this mirrors the ratio between experimentalists and theorists on university physics faculties. However, the ratio grows to about 3 to 1 for physicists in government labs, and is far larger still for physicists employed in industry.

The employment options for new physics PhDs are related, to some extent, to their areas of specialization. As indicated in figure 5, most PhDs in fields such as astrophysics, astronomy, and elementary particle physics tend to spend their early careers in postdoctoral positions. By contrast, most PhDs in optics, atomic and molecular physics, and condensed matter physics have gone directly into permanent or potentially permanent positions.

Additional evidence of the vitality of the job market for physicists can be seen in the opinions expressed by new physics PhDs about their initial employment. The vast majority report that their positions are professionally challenging and intellectually stimulating. New physics PhDs expressed similarly positive opinions about the level of problem solving and analytical thinking involved in their current positions, and very few thought that they were underemployed.

However, the job market for new PhDs is not perfect. Some, especially among those who were employed in industry, question whether their jobs were appropriate in light of their PhD training. And 13% of new physics PhDs working in related fields say their positions are not challenging. It is unclear whether such dissatisfaction reflects a weakness in the job market or disappointment on the part of some PhDs who were unable to continue in basic research.

Postdoctoral appointments

Postdoctoral appointments are intended to provide new PhDs with continued education and training in research. They are usually a prerequisite for obtaining a tenure-track position at research universities and the top-tier four-year colleges. However, as shown in figure 3, the likelihood of new PhDs taking postdoc appointments has varied over time. Whereas 70% of new physics PhDs in 1990 took postdoc positions and 30% found potentially permanent positions, only 45% of new PhDs took postdoc positions in 1999. As the physics PhD production has been dropping by 3–4% per year over the past five years, the decline in interested and available candidates is even more precipitous than the percentages alone indicate.

It is not surprising that there is considerable discussion among leaders of research groups in both industrial labs and academia about the difficulty in finding good candidates for funded postdoctoral positions. In many cases, postdocs are leaving their positions early, before their projects are completed, to take positions in high-tech startups, in small industrial and manufacturing labs, and even on physics faculties. While this is welcome news for many recent PhDs, it has left many funded research projects critically understaffed. This situation highlights the essential role played by postdocs in the nation's research enterprise.

In a report issued in September 2000, the Committee on Science, Engineering, and Public Policy of the National Academies of Sciences and Engineering and the Institute of Medicine expressed concern over the treatment and lack of institutional support for postdoctoral fellows at research institutions in the US.[4] Postdocs in the physical sciences and mathematics make up less than one-fourth of the total US postdoc population. But for postdocs in all fields, the report documented some overarching concerns, including low pay, lack of benefits such as sick leave and vacation time, and job insecurity. Although the position of postdoc is viewed universally as an "apprenticeship" that enhances the credentials of a new PhD for a good position in research or teaching, the negative aspects loom large in a hot job market.

The physics pipeline

The employment prospects for new physics PhDs, while

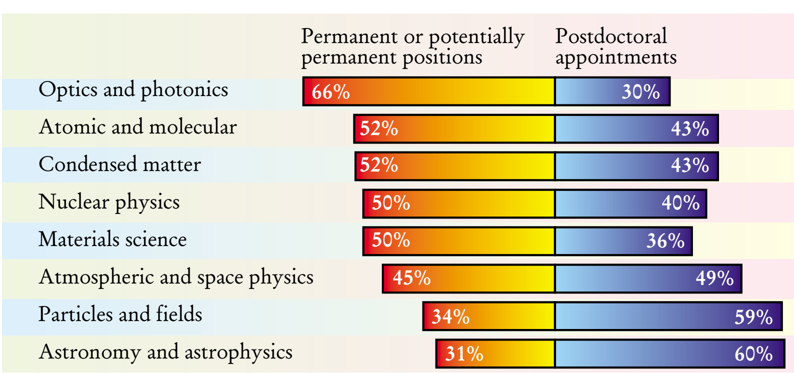
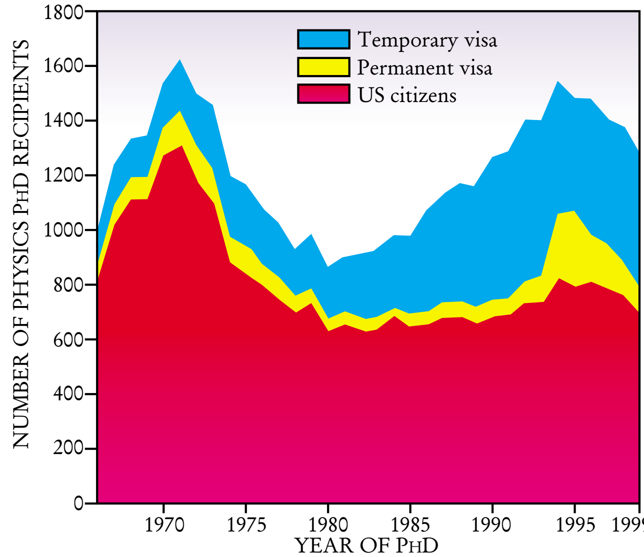


FIGURE 5. INITIAL EMPLOYMENT by subfield for physics PhD classes of 1997 and 1998. (PhDs who accepted other temporary positions or were unemployed six months after earning their degree are not included.)

FIGURE 6. NUMBER OF PHYSICS PHD RECIPIENTS by US citizenship status. The width of each color band is the number of PhDs of that status. The top of the blue curve gives the total number of new physics PhDs. Astronomy and astrophysics are not included. (Data collected by NSF.)



not perfect, are the best we have seen in more than a decade. Despite all of this positive news, however, physics enrollments at both the undergraduate and graduate levels continue to decline.

The number of US applicants for physics graduate programs has been dropping steadily since 1991. Figure 6 shows the citizenship status of physics PhD recipients over the past four decades. Many departments have received so few applications from qualified US students that they have admitted fewer graduate students than they have money to support. Recruitment of foreign graduate students has increased, and, for the first time in history, Americans represent the minority of entering first-year students, only 47% in 1999–2000. By 2003, fewer than 500 US citizens will earn physics PhDs each year, the lowest number since the early 1960s. As US physics graduate students are drawn almost exclusively from the pool of undergraduate physics majors, more attention must be paid to attracting the best and brightest college students into physics and exciting them about the opportunities for interesting and rewarding careers.

The number of bachelor's degrees awarded in physics declined throughout the 1990s and, as shown in figure 7, is now down to levels last seen in the late 1950s. The decline during the 1990s in physics bachelor's degrees was steeper at departments that offer a PhD than at departments that offer a bachelor's as their highest physics degree.

At the same time, the total number of bachelor's degrees awarded in the US has gone up. During the mid-1950s, 10 out of every 1000 bachelor's degrees awarded in the US were in physics. Today, only 3 out of every 1000 bachelor's are in physics. The decline is not unique to physics. In 1998, engineering departments reported that they awarded their lowest number of bachelor's degrees in 17 years. Similarly, the bachelor's class in computer science in 1997 was the smallest in 11 years.

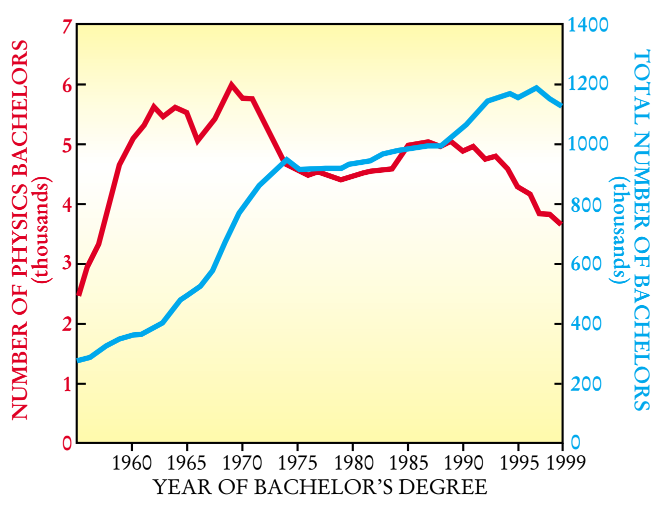
If the economy is being driven to a large extent by technology, why are these fields losing students? The answer is complex. Among the many possible causes for this apparent paradox is an explosion in opportunities in science and technology.

Today, more than ever, individuals of typical college age are presented with a remarkable array of career options. They have to choose whether to continue their education, for how long, and in what area to immerse themselves. They are presented with options that provide intellectual challenge, personal satisfaction, financial reward, or some combination of all three. Concurrently, many new fields have emerged over the last several decades, often at the interface between existing fields: Medical physics, bioinformatics, and computational linguistics are just a few examples. Thus, in today's competitive environment, physics departments can no longer sit back and expect the best students to come to them; they must actively recruit new students, provide curricula that meet the students' needs, and develop mechanisms for helping students continue through their undergraduate programs.

There are striking examples of effective programs for attracting and retaining excellent physics undergraduates. The highly successful efforts at Lawrence University are described in the box on page 41. At the College of the Holy Cross in Worcester, Massachusetts, which has a student enrollment of 2700 undergraduates, Janine Shertzer, chair of the physics department, notes that over the last five years her department has increased the number of physics majors from an average of 7 per year to 10. She attributes this increase to changes in the physics curriculum, including a new course, "General Physics in Daily Life," which integrates interactive demonstrations into the lectures; a new schedule of required courses that, while not reducing the number of courses, more readily accommodates students who decide late to major in physics or want to take a junior year abroad; and new advanced courses in experimental solid-state physics and astrophysics, which have been very popular with physics majors.

The Laser Teaching Center at SUNY Stony Brook is another example of an innovative program that is attracting students and exciting them about physics. The Laser Teaching Center is a new, permanent facility within the

FIGURE 7. PHYSICS BACHELOR'S DEGREES and total bachelor's degrees awarded in the US. (Total bachelor's data from the National Center for Education Statistics's *Digest of Education Statistics*.)



An Undergraduate Physics Success Story

Lawrence University in Appleton, Wisconsin, is nationally recognized as a leading small liberal arts college. Within this institution of only 1300 undergraduates, one quarter of whom major in music, physics is thriving. Lawrence graduates an average of 10 physics majors and several minors each year. More than half of the physics majors go on to graduate programs in physics and related fields, placing Lawrence well ahead of other primarily undergraduate institutions.

John Brandenberger, chair of the Lawrence physics department, attributes this success to the faculty's belief that an effective undergraduate physics program must embrace far more than a curriculum. The five physicists on the faculty thus support several activities outside the classroom, including an aggressive recruitment program focusing on high-school seniors interested in physics; student involvement in faculty research; a steady stream of prominent physicists who make extended visits to the department; and a broad range of interactions among students, faculty, and visitors, including colloquia, teas, retreats, conferences, and planning sessions.

The department offers recruitment workshops, which currently focus on computational physics, laser physics, plasma physics, and x-ray diffraction. The weekend workshops attract 30–35 high-school seniors from around the nation. Travel to the workshop is subsidized by the university, and the attendees stay overnight with physics majors. Roughly one-third of the attendees matriculate at Lawrence. The workshops depend heavily on the participation of current physics majors, thereby giving students a role in sustaining the livelihood of the department.

Attracting students is only half the battle. To retain them, Lawrence focuses on high-quality teaching and a contemporary curriculum that provides opportunities for advanced projects and individual electives in the senior year. For the summer, students are encouraged to work with Lawrence faculty and to seek research experiences elsewhere at major laboratories. Recent physics majors have spent summers with research groups at CERN, JILA, NASA, IBM, national observatories, and various large research universities around the world. The department also supports a chapter of the Society of Physics Students and a Women of Physics group that endeavors to bring women physicists to speak about their research and to meet with women and men students.

Sustaining an undergraduate program with this breadth requires a major commitment by faculty and students, but those who are involved in the physics enterprise at Lawrence believe the extra efforts are justified. To reverse the current downward trends in physics enrollments nationwide, it may be necessary for more physics departments, both large and small, to broaden the range of their offerings, activities, and outreach to undergraduates.

department of physics and astronomy that sponsors instructional programs that attract local high-school students and undergraduates at Stony Brook. Under the leadership of Harold Metcalf and John Noé, a range of hands-on research opportunities in optical physics and laser technology is offered, and many of the students supported through the center have gone on to participate successfully in national science competitions.

Physics in high school

Increased science requirements for high-school graduation since the mid-1980s, combined with the efforts of many groups within the physics community, have borne positive results for high-school physics. Between 1987 and 1997, the proportion of high-school graduates who took physics rose substantially,[5] from about 20% to 28%. In fact, a higher proportion of high-school graduates now takes physics than at any time since World War II. High-school enrollments in general have also grown, thus this higher percentage is based on a larger number of students. More than 800 000 high school students took physics during the 1996–97 academic year.

These increased enrollments have occurred across different types of physics courses, including conceptual physics, the regular physics course, honors physics, and advanced placement physics. Anecdotal feedback leads us to believe that this growth has continued since 1997. One trend fueling the increase in physics enrollments is the growing participation of girls, who now make up nearly half (47%) of all high-school physics students.

Opportunities and challenges

The opportunities for physicists in our rapidly evolving technological society are many. Several recent trends represent good news, especially for new graduates looking for stimulating and financially rewarding career opportunities. Trends in graduate and undergraduate physics enrollments represent bad news, especially for physics departments that are struggling to find students or new faculty in a very competitive environment. Reversing the decline in the physics pipeline presents a challenge to undergraduate physics programs to aggressively encourage and promote the study of physics.

As stated eloquently by Myriam Sarachik, newly elected vice president of the APS,

> We need to be more effective in explaining the pleasures that a career in physics can bring, the satisfaction garnered from teaching, and the excitement of research and discovery. At the same time, we must continue to make as strong a case as possible to our legislators and the public that it is essential to the health and future of the nation to invest in the science that produces major discoveries which seed the technology of the future.[6]

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