

THE PHYSICS JOB MARKET: BLEAK FOR YOUNG PHYSICISTS

Current production of PhD physicists greatly exceeds available positions in academe, government labs and industry. Restoring a balance may depend on curtailing the number of new PhDs trained, even if more graduating physicists successfully find nontraditional jobs.

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During the past several years, many developments on both a national and global scale have greatly altered the job market for scientists and engineers in the US. The end of the cold war has meant deepening cuts in the Defense Department's research programs and at nuclear weapons facilities funded by the Department of Energy. The recession has been unexpectedly persistent, and many large corporations have eliminated tens of thousands of jobs. Pressures on state and Federal budgets combined with the continued decline in the number of Americans who are of traditional college age (18–24 years old) have affected state and private colleges and universities. Geopolitical changes, especially the turmoil in the former Soviet and East Bloc countries, have prompted a significant number of senior scientists from those countries to look for positions elsewhere—in particular the US. These changes are sending shock waves through all sectors of the physics work force and adversely affecting the availability of jobs for physicists.

Tight job markets typically affect new entrants into the labor force more severely than experienced workers, and so the current economic climate is bleak for young PhD physicists searching for permanent employment. The frustrations of recent PhD recipients have been exacerbated, however, by an expectation that there would be a strong demand for their skills. Inaccurate predictions of impending shortages of scientists and engineers received extensive press coverage several years ago, and many young physicists and graduate students have complained angrily that they were misled. Increasingly professors involved in the training of physics graduate stu-

dents have become concerned that even their best students and postdocs are facing an extremely difficult job market.

This article is an attempt to clarify the situation as it exists now with accurate up-to-date facts and figures collected by the American Institute of Physics's education and employment statistics division, the National Science Foundation and the National Academy of Sciences. (For more details from AIP, see the accompanying article by Susanne D. Ellis, page 29.) We focus on the production of physics PhDs in the United States and their accommodation in the physics work force. When possible we try to indicate trends over the last decade.

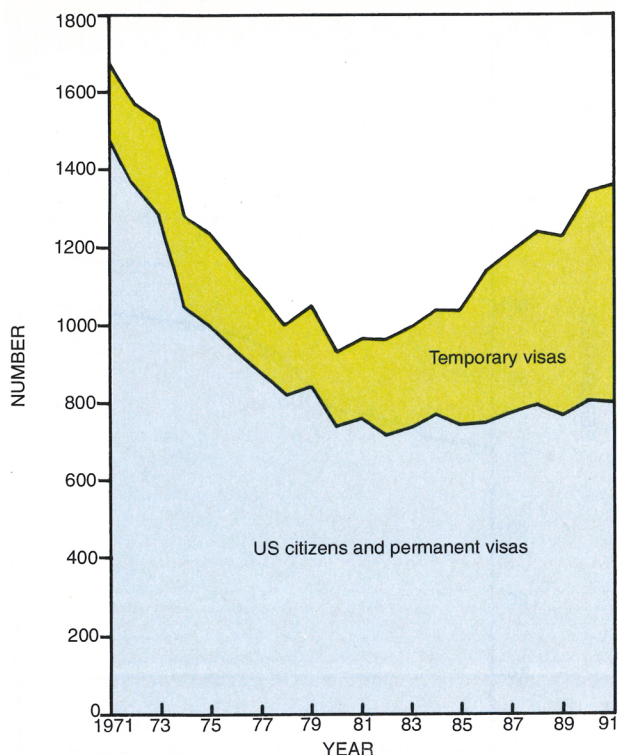
PhD production

On the supply side, US research universities produced 1346 physics PhDs in 1992. Over the last decade, the number of physics PhDs conferred each year has increased by 45%. As figure 1 illustrates, this increase is almost completely the result of growing enrollments by foreign citizens, while the number of physics PhDs awarded to US citizens has held steady at around 700 per year. Thus about 48% of the new physics PhDs in 1992 were earned by foreign citizens who were in the US on a variety of visas. Foreign citizens now represent such a large component of new PhD recipients that their career decisions can have a dramatic effect on the competition for jobs in the US.

Although about 20% of new physics PhDs on temporary visas leave the US immediately after earning their degrees, no data collection agency has accurate data on how many eventually leave after one or more postdoctoral appointments and how many change their visa types and become permanent members of the US labor force. The best educated guess among individuals who track the PhD labor force is that about half the foreign citizens stay in the US.

The proportion of foreign students remaining in the

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Physics PhDs awarded in the US have increased by 45% over the last decade. The number of foreigners earning PhDs increased 170%, and their career decisions now have a dramatic effect on the competition for jobs in the US. (Data from NSF.) **Figure 1**

US is sure to be much larger for at least a few more years, however, because of special rules applying to students from the People's Republic of China. The Chinese Student Protection Act, actually an executive order issued in November 1992, permits Chinese graduate students on temporary visas to apply for permanent visa status. The PRC is the dominant country of origin for foreign graduate students in physics, and citizens of the PRC represent nearly half of all physics students on temporary visas. Based on anecdotal data, it seems that virtually all of the PRC students are applying for permanent visa status. Thus the estimated number of new physics PhDs entering the permanent labor pool in the US in 1992 was over 1150 out of the 1346 awarded.

Initial employment

About two-thirds of new PhD physicists seeking employment in the US take postdoctoral appointments. This represents a significant increase from the early 1980s, when 40% took postdocs (see figure 2). Most new physicists follow this course without first looking for a permanent job, though some still take a postdoc as a holding pattern because they have been unsuccessful in finding a permanent situation.

Usually after one to three years in a postdoctoral position, physicists seek potentially permanent positions in academia, national laboratories and industry. A number take a second postdoc position in the hopes of improving their chances for a desirable position in the future, and some even go on to a third.

In 1991 over 1700 physicists held postdoctoral appointments in doctorate-granting institutions, one-third more than in 1980 (see table 1). These individuals, who represent a growing reservoir of talent, are competing increasingly fiercely for openings in the traditional physics research enterprise. There are another 500 physicists who have postdoc positions in national laboratories, government labs and industry. Thus the total number of

physics postdocs exceeds 2200 and is probably near its saturation point. In industry, postdoctoral positions used to be a stepping-stone to permanent staff positions. But with many major corporations downsizing and others changing their research missions away from basic research, this may be less frequently the case. More likely than not, the number of postdoctoral positions available in industry will decline.

According to a sample survey of the members of the 10 AIP member societies carried out in the spring of 1992, PhD physicists had an unemployment rate of 1.6%. This is consistent with the 1.5% found by the US Bureau of Labor Statistics for 1992 for all doctorate holders. But unemployment rates do not adequately reflect the whole situation facing physicists. While PhDs are apparently finding work, too often that work is temporary, low paying or unrelated to their training.

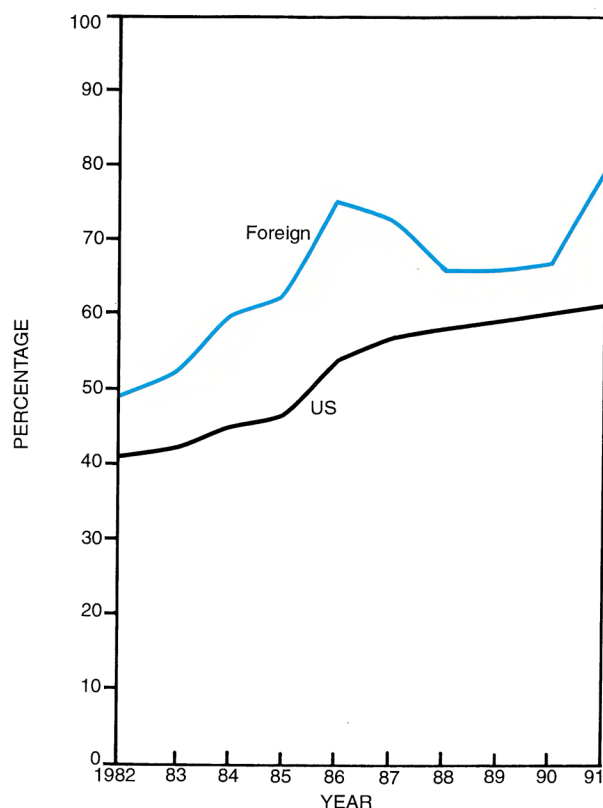
Approximately 10% of the PhD class of 1991-92 report that they are working in temporary (nonpostdoc) or part-time positions. Most were in low-paying temporary or part-time positions because they could find neither permanent nor postdoctoral positions. Some, however, received prestigious fellowships or were hired as sabbatical replacements or as research faculty, earning higher salaries than postdocs.

Among new PhDs who did secure permanent employment after earning their degrees, the length of time required to find employment grew considerably during the last decade (see table 2). Over 20% of the graduating class of 1991 indicated that it took them more than six months to find potentially permanent work.

Permanent employment

PhD physicists working in physics are employed in three major workplace sectors: academia (principally in universities and four-year colleges), Federally funded research and development centers (including national labs) and industry. As table 3 indicates, a significant number of

Postdoc as holding pattern. Two-thirds of new physics PhDs now take postdocs; many take a second postdoc and some even go on to a third. The individuals in this growing reservoir of talent face increasing competition for openings in the traditional physics research enterprise. (Data from AIP.) **Figure 2**



physicists work outside the discipline, and this is not just a recent phenomenon (table 4). While the vast majority of "alternative" careers may represent successful and satisfying employment situations, prospects of such careers certainly were not usually the original motivation for obtaining a PhD degree in physics.

Young physicists continue to look mainly to academia, national labs and industry for opportunities to do physics in potentially permanent jobs. But capturing an accurate snapshot of demand for physicists in each of these sectors is a challenging problem.

Universities and colleges. Since 1986 the American Physical Society's committee on membership and the AIP statistics division have conducted four biennial surveys of physics department chairs at all US universities and four-year colleges that offer physics degrees. The purpose of these surveys is to track the hiring rate for physicists in academia, to understand the hiring problems of departments and to identify the physics subfields in which candidates are being sought.

During the 1991–92 academic year, the percentage of available openings was about 5.7% of the total professoriat in all physics departments (see table 5). This includes 225 positions for which research universities—that is, physics PhD-granting departments—recruited at the professorial level (assistant, associate and full). Another 215 positions were available in all other physics departments.

It should be noted that some positions take more than one year to fill. Thus some of the 440 positions noted in table 5 were not filled in 1992. Also, these data do not include vacancies that were left open intentionally. One out of six department chairs reported that they had faculty vacancies that they were not allowed to fill either permanently or temporarily.

Academic openings in physics research departments are filled from an international labor pool. One-sixth of

the assistant professors hired during the 1980s in physics-PhD-granting departments were trained abroad, most of them in Western Europe.

An additional factor in the 1990s has been the influx of physicists from the former Soviet Union. Preliminary analyses indicate that more than 50 physicists from the FSU were hired by physics-PhD-granting departments in the academic years 1990–91, 1991–92 and 1992–93.

Will anticipated retirements create a large number of openings in academe? At present, slightly more than a third of annual faculty turnover (2.4% of total staff) is due exclusively to retirements. With the median age of physics faculty now at approximately 52, nearly 40% of the physics professoriat working in 1990 will be 65 or older by the year 2001. Only 12% of the physics professoriat is currently under age 40. While mandatory retirement is being abolished in academe in 1994, many institutions are offering their faculty very attractive incentives not only to retire, but to retire early. Thus it is possible that the number of faculty opting for early retirement may compensate for the number deferring retirement beyond age 70.

The peak retirement rate predicted by the AIP statistics division for the end of the decade is about 6% per year—equivalent to about 275 research faculty positions or about 475 faculty positions—a significant increase from the mid-1970s, when it was less than 1% per year. But because of demographic trends and budgetary constraints, many universities and colleges probably will not retain all the positions vacated by retirements. In the meantime, the academic job market will remain tight as new PhDs continue to compete for jobs with PhDs from abroad, senior physicists from industry and the rising reservoir of postdocs.

National labs. In 1991 a companion work force survey of the physics research groups within the Federally funded research and development centers was carried

out by the AIP statistics division in conjunction with the APS committee on membership (see box at right). The total number of jobs available in this sector in 1991 was about 180, slightly more than 5% of total number of PhDs working in physics (about 3500). The median age for PhD physicists employed at FFR&DCs was 47, a full five years younger than in the academic sector. The overall growth rate in the number of jobs in 1991, excluding vacancies due to those leaving, retiring or dying, was approximately 1%—a precipitous drop from the annual growth rate of 2.5% in the 1980s.

There has been considerable speculation about the future of the national labs. While some individuals are saying that one or more of the labs may be closed by the end of the century, there is also an effort to adapt the missions of the labs to civilian applications, such as environmental cleanup and energy. The critical issue is whether the Federal government will allocate sufficient funds to these areas in light of other demands on the budget. Due to the change in mission and priorities at the FFR&DCs as well as the uncertain funding picture, it is likely that the number of the staff members at some labs will be reduced while the number at other labs may increase. Thus it appears prudent to assume that all opportunities in this sector will be due to turnover with no increase in the number of physicists employed—that is, a balance between new positions added and positions that are cut during the near term.

The most recent data available from the Department of Energy bear out our no-growth scenario. At nine laboratories funded by DOE, the number of scientists decreased from 9628 in 1991 to 9440 in 1992, while the number of engineers increased from 9583 to 10 273. Lawrence Livermore and Los Alamos National Laboratories have each retired hundreds of scientists in the last couple of years. And while an early retirement program at Lawrence Berkeley Laboratory, similar to that at the University of California (PHYSICS TODAY, September, page 59), may open some new jobs, LBL director Charles Shank expects that there will be a net decrease in positions and that the decrease will be larger than average in physics.

Private sector. For the last two decades industry has been an important source of employment opportunities for physicists. Since around 1989, however, industrial employment has been affected by a persistent recession, increased international competition, the end of the cold war, shifts in R&D spending and downsizing at major corporations. In 1989 there were nearly 11 000 physicists working in the private sector; about 3500 were engaged in physics and another 7300 were involved in a broad range of areas, including product development, engineering and emerging technologies such as communications, networking and computing.

Major restructuring of research in the physical sciences has occurred at large corporations such as IBM, where the number of physicists working in physics was slated to be cut this year by about one-third, and at AT&T, where basic physics research as traditionally defined has been deemphasized in favor of applied research and computer science (PHYSICS TODAY, June 1993, page 75, and June 1991, page 97). Senior physicists, many with international reputations, have taken early retirement options, or in some cases have managed to obtain professorships at research universities.

No numbers regarding openings for physicists in industry are currently available. Assessment of the industrial work force via an AIP survey, analogous to the academic and FFR&DC work force surveys, is extremely difficult. In the industrial sector, physicists are often not identified as “physicists,” but instead are part of a larger

Federally Funded Research and Development Centers Surveyed

The Aerospace Corporation
Ames Laboratory
Argonne National Laboratory
Battelle Pacific Northwest Laboratories
Brookhaven National Laboratory
Center for Naval Analysis
Fermi National Accelerator Laboratory
Francis Bitter National Magnet Laboratory
Westinghouse Hanford Company
High Altitude Observatory
EG&G Idaho, Inc.
Institute for Defense Analysis
Jet Propulsion Laboratory
Knolls Atomic Power Laboratory
Lawrence Berkeley Laboratory
Lawrence Livermore National Laboratory
Lincoln Laboratory
Los Alamos National Laboratory
Mitre Corporation
EG&G Mound Applied Technologies, Inc.
Oak Ridge National Laboratory
Princeton Plasma Physics Laboratory
The Rand Corporation
Sandia National Laboratories
Westinghouse Savannah River Company
Solar Energy Research Institute
Space Telescope Science Institute
Stanford Linear Accelerator Center

scientific and technical staff generally designated as “engineers” or “scientists.” In fact, many managers may not know (without reading through personnel files) who on staff has a physics PhD. In addition, appropriate managers who would be in a position to respond to a survey must be identified. However, the AIP statistics division is developing plans to survey this sector of the physics work force.

To provide a rough estimate of employment prospects within industry for physicists, we have assumed that there will be no increase in the number of physics positions in the private sector for the near future and a 5% turnover among the 3500 PhD physicists who are working in physics, representing about 175 openings. Even after

Table 1. Increase in physics postdocs

Year	Number
1991	1721
1990	1678
1989	1578
1988	1548
1987	1527
1986	1342
1985	1320
1984	1350
1983	1326
1982	1445
1981	1398
1980	1287

Number of physicists holding postdoctoral appointments in doctorate-granting departments, 1980–91. Source: NSF report 93-302.

Table 2. New PhDs taking more than 6 months to find permanent jobs

Year of degree	Percent
1991	22
1990	18
1989	13
1988	17
1987	14
1986	14
1985	14
1984	14
1983	13
1982	13
1981	8
1980	7

Percent of employed new PhD recipients who took more than 6 months to secure permanent positions, 1980–91. Source: AIP statistics division.

the recession ends, the number of openings may not increase significantly, as a number of the major industrial labs that have traditionally employed physicists have changed their missions and downsized over the past five years.

A net assessment. In 1992 the total number of openings in academe, national labs and industry for PhD physicists working in physics was approximately 800 (440, 180 and 175, respectively). At least 1150 new PhDs and probably more, taking the graduates from the PRC into account, entered the physics labor pool that year.

It is inappropriate, however, to simply compare the number of openings with the number of new physics PhDs produced in the US because there also are other sources of physicists. Many positions are being filled by PhDs from abroad or by senior physicists from national labs and industry. Many of the senior physicists taking those jobs are leaving positions that are being eliminated. And while US physicists displaced by foreign applicants can look abroad for jobs, because of even more adverse conditions found in almost all industrial countries, the net immigration of job takers undoubtedly will be into the US.

Thus supply and demand in the market for physics PhDs are seriously out of balance, and the situation is bleaker than the numbers indicate. Even after the recession is over, the prospects for young physicists may not markedly improve in the short term.

Looking into the future

It is extremely difficult, if not impossible, to predict either the supply of or demand for physicists. Accurate data exist on the size of the graduate student population in

physics, but it is likely that students will drop out of graduate school at a greater than usual rate as they see the difficulty that recent PhDs are having finding employment. In addition, over 40% of all physics graduate students are foreign citizens, and the number of such students who are able to apply to US graduate programs is affected by political developments on an international scale. Furthermore, the number of foreign citizens who are actually accepted in graduate programs in this country is based on the decisions of individual PhD-granting departments.

The number of openings and the number of physicists competing for those jobs will depend, in part, on how the US and the rest of the industrialized world emerge from the current economic recession. The number of jobs for physicists will also depend on the funding priorities of the Federal and state governments and of industry in the US. Although it is possible to make educated guesses about each of these factors, none can be projected accurately even in the short term. It is imperative, however, that physicists openly discuss and debate those issues over which they do have some control, to arrive at the best possible strategies for dealing with these difficult, changing times.

The current situation and the outlook for the future raise a number of challenging issues. Several of these involve the graduate education process itself and are therefore particularly difficult to address in a community in which academic physics plays a leading role.

Limit supply? It appears that the system of physics graduate education still is set up to replicate itself, even as the market has reached saturation. The nature of physics graduate education, in which a student works as an apprentice with a research adviser, too often leads the graduate student to expect the same kind of position as the adviser. Given the current job market, that expectation is unrealistic for the majority of physics PhD students today.

The paucity of openings is exacting a heavy toll on young people after their years of specialized training, and so the academic community might do well to consider some form of "birth control." Students currently emerging from the apprenticeship with a PhD degree, typically after five or more years, find that almost no job opportunities exist in their areas of expertise. They are absolutely justified in questioning the value of the long hours invested and the years spent at minimal pay. Perpetuation of the system in the current climate could be labeled exploitative at worst and irresponsible at best.

Although many physics departments willingly grow, few voluntarily contract. During the first part of the last decade there was significant growth in the number of PhD-granting physics departments in the US. Colleges and universities have been eager for the overhead dollars that sponsored research brings in. State legislatures, hoping to attract high-technology companies, supported the build-up of physics PhD programs at state universities to create a more scientifically and technically trained local work force. Given the current job market, it is amazing that five institutions *started* PhD-granting departments in physics during the 1992–93 academic year.

To justify their existence, new PhD departments need to produce a constant stream of students. Concurrently, physics professors in research oriented departments have a vested interest in encouraging the flow of PhD graduate students through the department, as their research careers and scientific stature are often based on the number of students they train and the skilled labor those students provide as research assistants. Unfortunately, the negative consequences of PhD overproduction are experienced

Table 3. Employment of physics PhDs, 1989

Employment sector	Physics	Non-physics	Total
University or 4-year college	8 900	2 600	11 500
Industry	3 500	7 300	10 800
FFR&DC	3 500	1 400	4 900
Other	2 100	2 100	4 200
Total	18 000	13 400	31 400

Source: National Academy of Sciences, unpublished data.

Table 4. Employment of physics PhDs by field, 1973–89

Year	Physics (percent)	Nonphysics (percent)	Total number
1989	57	43	31 400
1985	59	41	29 500
1981	60	40	27 000
1977	60	40	24 000
1973	68	32	19 900

Source: National Academy of Sciences, unpublished data.

by the students but seldom by the departments or faculty.

At present several government funding agencies, NSF in particular, strongly encourage each grantee to have an "educational component" within his or her research budget. Grantees often respond by supporting graduate students to work on the proposed research. Agencies have been known to balk at funding postdoctoral researchers on a grantee's project for more than two years. The physics community should question the wisdom of perpetuating these policies, which were initiated four or five years ago. In particular, the community should examine whether at this time money is better spent training more students, supporting more postdocs or providing more career opportunities for young physicists.

Deemphasize the PhD? Does American industry really want to employ PhD physicists? Richard Freeman, head of advanced lithography at AT&T Bell Laboratories, Holmdel, New Jersey, cites a failure on the part of physics graduate schools to provide industrial employers with well-trained master's degree physicists. He bemoans the demise of the terminal master's degree in physics at leading institutions. Increasingly, a terminal master's could be a valid and valuable degree for those heading to positions in industry. At present, however, a terminal master's degree is often a mark of failure within PhD-granting departments—reserved for those students who have been judged incapable of successfully pursuing a PhD.

While one hears a number of success stories regarding PhD physicists who have achieved satisfying employment in alternative careers, the community should discuss the value, costs and benefits of the PhD for those individuals. Would those physicists have achieved their success outside the traditional physics work force earlier if they had been on a more direct path, without the detour for a PhD? Could the physics curriculum in graduate school be modified to make it easier for new PhDs to apply their skills in a changing technological labor market?

Many of the questions raised here cannot be answered definitively. But fear of what the answers might be and of the resultant necessity for change should not keep the physics community from exploring these issues.

Near-term initiatives

A number of physics departments are starting to discuss curtailing graduate student enrollments. In the 1992–93 academic year, first-year physics graduate school enrollment declined for the first time in 15 years. The 8% decrease in first-year enrollment was accomplished by a few large departments drastically reducing the number of incoming graduate students.

In October 1993, Kurt Gottfried, the chair of the physics department at Cornell University, sent a letter to other physics department chairs describing measures

Table 5. Physics faculty size and openings

Highest degree offered	Professorial staff in 1991 (number)	Openings in 1992 (number) (percent)	
PhD	4400	225	5.1
Master's	895	55	6.1
Bachelor's	2430	160	6.6
Overall	7725	440	5.7

Size of physics faculty and number of openings by type of department. Source: AIP statistics division.

that Cornell was instituting to deal with the diminished employment opportunities for young physicists. Cornell is planning to employ about a half-dozen research associates (PhD physicists) as part-time lecturers to perform teaching duties now borne by graduate students. Funding for these positions will come partly from research grants and partly from the department. A simultaneous decrease in the number of graduate students admitted to the department will also take place. An added bonus of this plan is that young physicists will gain important additional teaching experience. (Lack of such experience on the part of applicants for professorial positions has been decryd by the chairs of physics departments at four-year colleges.)

When there has been a balance between physics PhD production and employment opportunities, new PhDs often got jobs based on recommendations from their advisers, the strength of their training in physics and their potential as physics researchers. They did not have to give a great deal of thought to marketing themselves. Clearly, the employment situation has changed, and new PhDs are now faced with acquiring the job search and interviewing skills needed to compete for positions outside the traditional research enterprise.

In response to the growing concern about employment on the parts of both young and more senior physicists, the American Physical Society and the career planning and placement division of AIP have organized, sponsored and encouraged a variety of different programs aimed at helping new PhD physicists to evaluate their career directions and their particular skills, and to market themselves successfully.

In October 1992 a pilot program was held at Fermi National Accelerator Laboratory for approximately 20 early-career physicists, cosponsored by Fermilab and APS. A similar career assessment workshop was held at the University of Texas, Austin, in January 1993. The success of these workshops has prompted APS to offer to sponsor approximately eight more such workshops, with costs to be shared by physics departments at major universities. Other kinds of programs conducted recently include a symposium on nontraditional technical career opportunities held at the April 1993 APS meeting in Washington, DC, and a symposium on student employment held at the May 1993 meeting of the APS division of atomic, molecular and optical physics.

If programs focusing on career opportunities for young physicists continue to be enthusiastically received, we hope that physics departments at major universities will begin to take a more active role in educating their students about these issues. At the very least, members of the physics community—and physics professors in particular—need to be very honest with students about the current employment situation. ■