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ABSTRACT

This report provides information on the size and citizenship of the incoming graduate physics and astronomy class and describes student characteristics such as gender and educational background. Data are from the American Institute of Physics Enrollments and Degrees surveys for the 1998-1999 and 1999-2000 academic years. In 1998-1999 there were 2,582 students newly enrolled in 1 of 254 graduate physics and astronomy programs, and in 1999-2000, there were 2,697 students newly enrolled in these programs. Incoming 1999-2000 physics and astronomy graduate enrollments were up about 5% from a recent low in 1997. Although their proportions are declining, students from China continue to make up the largest group (25%) of incoming international students. The percent of students from Eastern and Central Europe has risen to 22% of the incoming foreign students. Nearly all students attending PhD-granting departments received some type of financial support, but 18% of the full-time enrolled students at master's departments relied on outside employment or savings or loans to help finance their education. By the end of their first year of graduate school, more than three-quarters of all students had selected a subfield in which to specialize. The majority of students, regardless of citizenship, had a long-term goal of teaching or a research position in an academic setting. (Contains 10 tables and 5 figures.) (SLD)

Graduate Student Report: First-Year Students in 1999 and 2000

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R-207.32

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AIP REPORT

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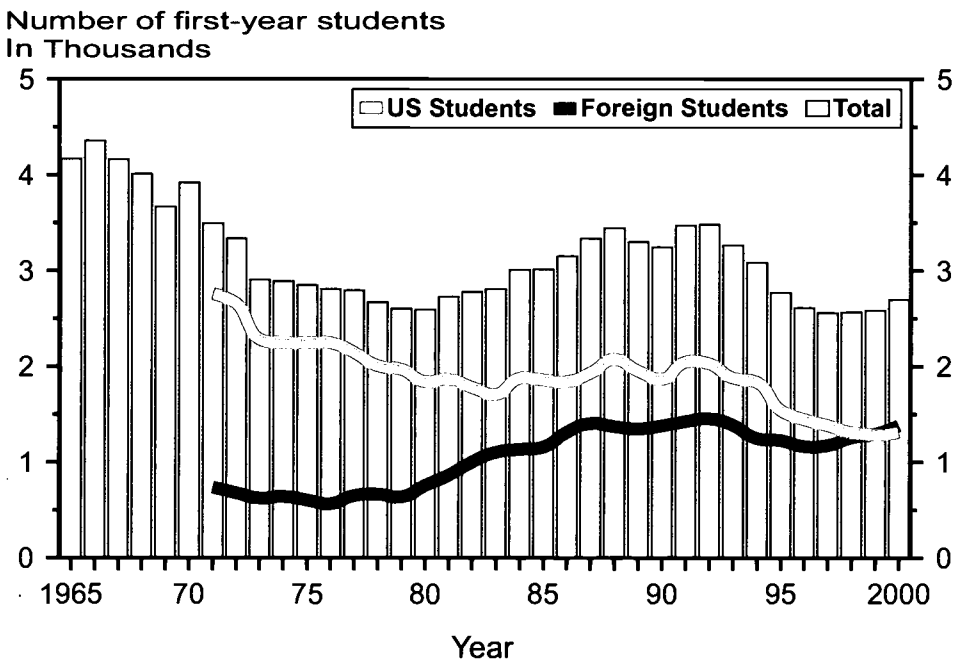


Figure 1. First-year graduate students in physics and astronomy, 1965-2000.

Note: Starting in 1995, refinement in wording may slightly raise the foreign citizen totals relative to those reported in earlier years. A citizenship breakdown of first-year enrollments is not available prior to the academic year 1970-71.

AIP Statistical Research Center, Graduate Student Report.

Highlights

First-year student enrollments are on the rise. Incoming 1999-2000 physics and astronomy graduate enrollments are up about 5% from a recent low in 1997. **(Figure 1)**

Although their proportion is declining, students from China continue to make up the largest group (25%) of incoming international students. The percent of students from Eastern and Central Europe has risen to 22% of the incoming foreign students. This compares to less than 5% in the early 1980's. **(Table 3)**

Fifty-nine percent of the US students decided to pursue physics graduate study as an undergraduate, while almost half (47%) of foreign students made this decision prior to entering college. **(Table 5)**

Highlights Continued

The two largest influences in choosing physics and astronomy as an academic specialty for both US and foreign students were an interest in the subject and the intellectual challenge it presented. **(Table 7)**

Nearly all students attending PhD-granting departments received some type of financial support. However, 18% of the full-time enrolled students at masters departments relied upon outside employment, or savings or loans to help finance their education. **(Table 9)**

By the end of their first year of graduate school, over three-quarters of all students had selected a subfield in which to specialize. Astronomy and astrophysics were the top choice for US students, while condensed matter was the first choice for foreign students. **(Table 10)**

Fifteen percent of the incoming US students did not feel that their undergraduate education had adequately prepared them for graduate school. Foreign students had a greater sense of preparedness, with only 5% feeling underprepared. **(Figure 2)**

The majority of first-year students, regardless of citizenship, had a long-term career goal of a teaching and/or research position in an academic setting. **(Figure 4)**

Introduction

Enrollments in US physics and astronomy graduate programs have gone through some significant changes in recent years. As Figure 1 illustrates there has been considerable transformation in the number and composition of the students enrolling. Following steady declines in the early 1990s, overall enrollment totals stabilized in the late 1990s and 2000. At the same time, the proportion of students who are coming from abroad has been steadily rising. Foreign students comprise the majority of the incoming students.

Along with the size and citizenship of the incoming graduate physics and astronomy class, this report describes other student characteristics such as gender, and educational background. It examines aspects of the decision-making processes that students go through in reaching their decisions to pursue physics or astronomy study. It describes the distribution of students by subfield of study and the types of financial support they are receiving. Finally, students' intended degrees and career objectives are explored.

For over thirty years, the Statistical Research Center of the American Institute of Physics (AIP) has reported on different aspects of the physics and astronomy graduate student populations. This report focuses on the incoming student populations and combines survey data from the 1998-1999 and 1999-2000 academic years. According to the AIP Enrollments and Degrees Survey, there were respectively 2,582 and 2,697 students newly enrolled in one of the 254 graduate physics and astronomy programs in the US during these two years. About 10% of these students were enrolled at departments that only offered a master's as their highest physics degree. Surveys were sent to students in the spring of their first year of study and usable responses were obtained from about 1,950 students, representing 37% of the known departmental totals. Since some departments did not provide student lists or provided lists with poor address information, we were not able to contact an estimated 20% of our target population, raising our actual survey response rate to about 50%.

The following analysis includes students who were new to a department, but also includes some students who had transferred from another physics or astronomy graduate program. Such transferring is more prevalent among students coming from abroad, an issue discussed in greater detail in the educational

background section of this report. For the most part students enrolled at physics and astronomy departments are combined and analyzed as a group. In a few instances, the physics and astronomy students are separated for comparison purposes. In such instances, the students studying astrophysics at a physics department are grouped with the physics students. In some cases where the questionnaire changed, tables and figures are based on a single year.

Characteristics

Although much of this report combines data for physics and astronomy students, there are some distinct differences in the characteristics of these two groups (see **Table 1**). Astronomy departments enroll a larger proportion of women and US citizens than do physics departments. In the combined 1998-1999 and 1999-2000 academic years, foreign students represent the majority (52%) of the first-year students enrolling in physics departments, but represent only 29% of the students enrolling in astronomy programs. This difference will be explored later in the report.

Table 1. Characteristics of first-year physics and astronomy graduate students, 1999 and 2000.

	Physics	Astronomy
Gender*		
Male	81%	71%
Female	19	29
Citizenship*		
US	48%	71%
Foreign	52	29
Age		
US Citizens		
23 or younger	59%	70%
24-25	17	15
26 or older	24	15
Foreign Citizens		
23 or younger	36%	41%
24-25	26	23
26 or older	38	36

* Data from the AIP Survey of Enrollments and Degrees
AIP Statistical Research Center, Graduate Student Report.

Age is another area where differences appear not only between physics and astronomy students but also between US and foreign students. Physics students, especially US citizens, tended to be older than those enrolling in astronomy programs. Foreign students, regardless of program, tend to be older than their US counterparts. Much of this age discrepancy is a result of the number of years foreign students study before entering US graduate programs. Delays foreign students may encounter in obtaining a visa may also contribute to the age discrepancy.

Enrollment patterns of US and foreign students also differ by the highest degree the departments offer. As seen in **Table 2**, over half of the first-year students enrolling in PhD departments were foreign citizens, while at the Master's departments, only 33% were foreign citizens.

As illustrated in Figure 1, the number of foreign students entering graduate physics and astronomy programs has been increasing. **Table 3** outlines from what parts of the world these international students are coming. Recently there has been a relatively large shift in country of origin involving students from China and students from Eastern and Central Europe. In the late 1980s and the early 1990s, the students from China represented as much as 35-45% of the incoming foreign students, while students from Eastern and Central Europe amounted to less than 5%. China now contributes only about 25% of the incoming foreign students, while Eastern and Central Europe now comprise a little more than 22%.

Table 2. Characteristics* of first-year physics and astronomy students by highest degree their department awards, 1999 and 2000.

	Institution Type	
	PhD Granting %	Master's Granting %
Gender		
Male	82%	80%
Female	18	20
Citizenship		
US	46%	66%
Foreign	54	33

* Data from the AIP Survey of Enrollments and Degrees
AIP Statistical Research Center, Graduate Student Report.

Table 3. Region/countries of origin of first-year physics and astronomy graduate students who were not US citizens, 1999 and 2000.

	Percent
Asia	
People's Republic of China	25
India	6
South Korea	5
Taiwan, Hong Kong	2
Japan	2
Pakistan	1
Sri Lanka	1
Other Asia	4
Europe	
Eastern and Central	22
Western	15
Americas	
Mexico, South and Central America	4
Canada	3
Middle East	6
Africa	3
Australia, New Zealand	1

AIP Statistical Research Center, Graduate Student Report.

Educational Background

The diversity of educational backgrounds of the students entering graduate study in physics or astronomy often makes it difficult to draw clear comparisons between the different groups of students. This is especially true of foreign students, who have come from countries whose educational systems vary greatly from each other and from our own. For this reason, much of the discussion concerning educational background will focus on the US citizens. Some citizenship comparisons will be attempted where parallels can be drawn with the US education system.

Exposure to physics in high school, while obviously not a prerequisite for enrolling in physics or astronomy graduate studies, appears to have a significant impact on whether individuals choose to pursue these fields. The vast majority of first-year US physics and astronomy students took a physics course in high school (see **Table 4**), compared with only about one quarter of all 1994 US high school seniors. Similarly, almost all foreign students said they took what they considered to be the equivalent of a high school physics course.

A second obvious filter for pursuing physics and astronomy graduate study is an individual's undergraduate major. Nearly all first-year US physics and astronomy students earned an

Table 4. Educational background of first-year physics and astronomy graduate students with US citizenship, 1999 and 2000.

Have taken HS Physics:	
All high school seniors in 1994*	25%
First-year physics and astronomy graduate students in 1999 & 2000	91%
Earned an undergraduate degree in physics or astronomy:	
All bachelors in 1999 & 2000	~.3%
First-year physics and astronomy graduate students in 1999 & 2000	90%

* Source AIP: 1997 Nationwide Survey of High School Physics Teachers

AIP Statistical Research Center, Graduate Student Report.

undergraduate degree in one of the two subjects, while less than one half of one percent of all US bachelor's degrees in recent years were awarded in physics or astronomy. The vast majority of foreign students indicated they had what could be considered the equivalent of a US bachelor's degree in physics or astronomy.

Some students entering their current US graduate program indicated they had already received some prior *graduate-level* physics or astronomy training. About 12% percent of the US students stated they had been previously enrolled in a physics or astronomy graduate program at another department. About half of these students indicated that they had already earned a master's degree.

The educational background of foreign students is significantly different than their US counterparts. About 60% of the foreign students indicated that their educational background extended beyond the equivalent of a typical US bachelor's degree. About two-thirds of these foreign students with advanced educational backgrounds indicated that they had received the equivalent of a master's degree.

Choosing the Field and Institution

The factors that influence an individual in developing an interest in the fields of physics and astronomy vary greatly from person to person. The evolution of these interests into a decision to pursue physics or astronomy at the graduate level is a crucial turning point in a prospective scientist's educational and career path. The following section discusses why and when students first decided to pursue the field and what influenced them to choose their current institution.

Students were supplied eleven potential influences and asked to rank which influenced them most in choosing to study physics or astronomy. The data shown in **Table 5** lists these influences and shows what proportion of the students indicated a particular influence as being one of their three most important.

The two largest influences in choosing physics and astronomy as an academic specialty for both US and foreign students were an interest in the subject and the intellectual challenge it presented. Far below these two are factors that involve who introduced the subject matter to the students. A college professor or undergraduate mentor was a significant influence for a large number of US students, whereas high school teachers were a larger influence for foreign students. Knowledge about famous scientists was also a major influence for foreign students.

The timing of an individual's choice to pursue physics or astronomy is strongly related to the factors that affected the decision-making process. **Table 6** illustrates the considerable differences between US and foreign citizens in the timing of their decisions to pursue physics or astronomy graduate studies. As one might expect from the distribution of influences in Table 5, the majority of US students make the decision as undergraduates, whereas foreign students were more likely to choose their educational path prior to entering college.

Table 5. Major influences for first-year students in choosing physics or astronomy as their academic specialty, 1999 and 2000.

	US Citizens %	Foreign Citizens %
Interest in the subject matter	86	79
Intellectual challenge	79	78
College professor	32	17
Career prospects	30	22
High school teacher	20	28
Books, television, movies	15	12
Famous scientist	13	32
Family member, friend	11	20
Fellow students	5	7
Expected salary & benefits	4	2
Other	6	3

Note: Percents represent the proportion of students who listed an influence as one of their three most significant.

AIP Statistical Research Center, Graduate Student Report.

The number of graduate departments to which students applied varied somewhat by citizenship. Foreign students applied to an average of 6.2 department, while for US students the average was 4.7. This difference can be explained by the larger percent of the foreign students (15%) who applied to 10 or more departments, compared to only 6% of the US students. If you discount these students, US and foreign citizens are very similar in the number of departments to which they apply.

Many institutions now give students the option of completing a traditional paper application or submitting an electronic or web based application. Overall, about 10% of all applications were submitted electronically. It is important to note that these findings are based only on students who received acceptances and ultimately entered graduate physics or astronomy programs. Application patterns may be different for the students who applied to graduate programs but were not admitted.

Table 6. Timing of initial decision to pursue physics and astronomy graduate study, 1999 and 2000.

	US Citizens %	Foreign Citizens %
While an undergraduate	59	39
Pre-college	22	47
After working with a bachelor's degree	13	6
Other	6	8
	100%	100%

AIP Statistical Research Center, Graduate Student Report.

Students applying to physics or astronomy graduate programs have about 285 departments to which they can send their application. Departments obviously have admissions requirements that assist them in choosing which applicants to accept, but what are the factors that are used by the students in choosing which departments to apply to and ultimately attend? Choosing a graduate department can be a complex decision for many students. Most students consider several different reasons or influences before they decide. Students were given 12 factors and asked to rank which were the most influential in choosing their current department. **Table 7**, which divides the students by whether they are physics or astronomy students as well as by citizenship, lists these influences and shows what proportion of the students indicated a particular influence as one of their top three.

For US students enrolled in a physics department, a department's location, a positive visit and the financial support offered were the three most important influences. US astronomy students also indicated that a positive visit and location were important, but additionally took into account the department's reputation and facilities. The major influences affecting foreign students in choosing an institution were the financial support they were offered and the department's reputation.

Preparation

Students were asked how well they felt their undergraduate education prepared them for graduate study in physics or astronomy. The majority (91%) felt adequately prepared or better.

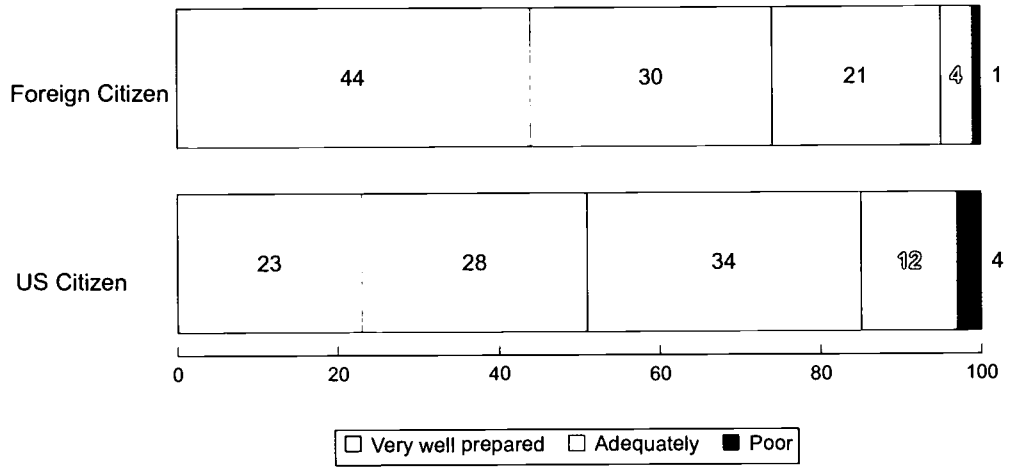
Table 7. Major influences for first-year physics and astronomy students in choosing their current institution, 2000.

	Physics Students		Astronomy Students	
	US %	Foreign %	US %	Foreign %
Location of institution	52	36	39	16
Positive university / departmental visit	41	9	55	12
Financial support offered	37	51	21	36
Department's reputation	32	46	55	76
Facilities in a particular subfield	31	36	39	28
Department's atmosphere (e.g. Class size)	24	15	27	24
Personal reasons	22	21	11	12
To study with a particular professor	19	28	16	32
Overall reputation of the University	14	36	9	32
Attended University as an undergraduate	12	2	4	0
Only acceptance received	9	15	11	16
Other	10	6	13	16

Note: Percents represent the proportion of students who listed an influence as one of their three most significant.

AIP Statistical Research Center, Graduate Student Report.

Figure 2. Perception* of undergraduate preparation for graduate school by citizenship for first-year physics and astronomy graduate students, 1999 and 2000.



* Rated on a 5-point scale.

AIP Statistical Research Center, Graduate Student Report.

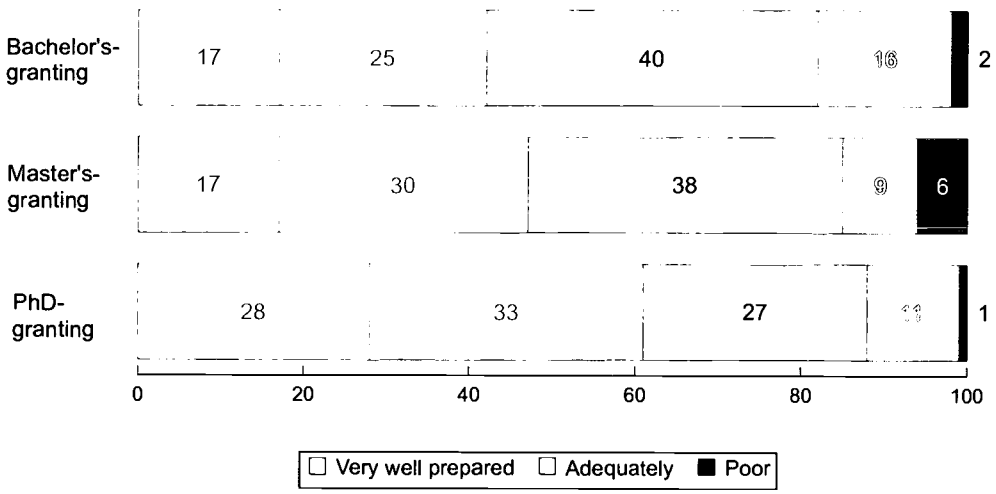
It's important to note that the survey only asked the students about their subjective opinion concerning their undergraduate education; the survey did not have any way of directly evaluating the actual level of preparation.

A difference in perceived preparation emerges when students are separated by citizenship, with foreign students feeling more prepared than US students (see **Figure 2**). Almost three-quarters of the foreign students and about half of the US students felt better than adequately prepared. This difference could be partially attributed to the differences in educational backgrounds discussed earlier in this report.

A student's undergraduate degree field also has an influence on his/her sense of preparation for graduate school. More than half of US students with a physics bachelor's degree felt more than adequately prepared, while only 39% of the students with an undergraduate major other than physics or astronomy shared that sentiment.

Looking at only the US students whose educational background included a physics bachelor's degree, some differences in preparation emerged depending on the type of undergraduate department they attended. As **Figure 3** illustrates, 61% of US students who attended PhD-granting institutions as undergraduates felt more than adequately prepared compared to the 42% of those who attended a 4-year college. The preparation data for students coming from master's-granting departments is very similar to that of the 4-year colleges. These results are consistent with those from past years. It is not clear whether the greater research orientation at doctoral-granting departments better prepares students for the academic demands of graduate study, or whether such departments attract more academically- orientated undergraduates in the first place, or a combination of both applies.

Figure 3. Perception* of undergraduate preparation by type of undergraduate department for first-year physics and astronomy graduate students with an undergraduate degree in physics, 1999 and 2000 institution.



Note: Includes only US citizens. * Rated on a 5-point scale

AIP Statistical Research Center, Graduate Student Report.

Enrolled Students: Status, Source of Support, and Subfield

As we saw in figure 3, the type of department students attended as undergraduates had an influence on their perceived preparation for graduate studies. There are also differences in the characteristics and educational experiences of first-year students by whether the graduate program they are currently enrolled in offers a PhD or a master's as its highest degree. Table 2 showed the difference in the representation of foreign citizens by department type, where **Table 8** illustrates the difference in educational experience. Only 2% of the students attending PhD-granting institutions indicated they were enrolled on a part-time basis, whereas 17% attending master's-granting institutions were part-time. The vast majority of these part-time students attending master's institutions are US citizens. Many of the US students enrolled at master's-granting institutions simultaneously hold full- or part-time non-departmental employment.

Almost all of the students at PhD-granting departments desired a PhD as their highest degree. Interestingly, over half of the students enrolled at master's institutions aspired to transfer to another institution and eventually earn a physics or astronomy PhD. This is especially true for the foreign citizens. The students enrolled at departments with the master's as the highest degree offered were more likely to have delayed entry into a graduate program after receiving their bachelor's degree and were subsequently considerably older.

Physics students have been traditionally well supported. Nearly all students entering a graduate program in 1999 and 2000 received some type of external financial support (see **Table 9**). The one exception is the students who were enrolled on a part-time basis. About half of such students relied upon funds from non-departmental employment, family members, savings, or loans.

Table 8. Educational characteristics of first-year physics and astronomy students by highest degree that their department awards, 1999 and 2000.

	Institution Type	
	PhD-Granting %	Master's-Granting %
Study status		
Full-time	98	83
Part-time	2	17
Highest degree desired		
PhD	92	54
Master's	8	46

AIP Statistical Research Center, Graduate Student Report.

Teaching assistantships continue to be the dominant source of support for first-year students, with about two-thirds of the students receiving them. Not surprisingly, teaching assistantships are even more prevalent (71%) among the students who have not yet selected an area of specialization. Although fellowships were rare for first-year students at master's-granting departments, they were the second most frequently obtained source of support for students entering PhD-granting departments. As a group, first-year astronomy students held the most fellowships with 28% of the students listing it as their primary source of support. Sources of financial support only varied a little by citizenship. A larger proportion of the US students indicated having a fellowship, while foreign students had a slightly greater proportion holding teaching assistantships.

Table 9. Primary sources of support by highest degree of department enrolled for first-year physics and astronomy students, 1999 and 2000.

	PhD-Granting %	Master's-Granting %
Teaching assistantship	63	65
Research assistantship	18	3
Fellowship	14	14
Savings or loans	1	11
Non-Dept. employment	0	7
Other	4	0
	100%	100%

Note: Table only includes full-time enrolled students.

AIP Statistical Research Center, Graduate Student Report.

Choosing a subfield and an advisor are important steps for first-year graduate students. About three-quarters of the students indicated they had selected a subfield of specialization by the end of their first year. Half of all students had selected an advisor, which often occurred when they decided upon a specialty. Students with an educational background that included physics training beyond the bachelors level were more likely to have chosen a specialty than those who did not. Twelve percent of the students who desired only a master's degree were enrolled in programs that did not require them to choose a subfield.

Table 10 lists the major subfields potential PhD students intended to pursue. A higher proportion of US than foreign students chose to specialize in astronomy and astrophysics, while foreign students were more likely to choose condensed matter. Almost an equal proportion of US and foreign students were undecided about which field to specialize in at the end of their first year of study.

Table 10. Major subfields of first-year students who have plans to receive a PhD and are enrolled in a physics and astronomy graduate program, 1999 and 2000.

	US Citizens %	Foreign Citizens %
Undecided	25	21
Astronomy / Astrophysics	19	8
Condensed Matter	14	22
Particle and Fields	9	13
Nuclear	4	5
Atomic and Molecular	3	4
Relativity and Gravitation	3	1
Optics and Photonics	3	5

AIP Statistical Research Center, Graduate Student Report.

The Future

At the time the survey was conducted, nearly all (93%) of the respondents expected to continue studying physics at the same department the following year. About 4% of all respondents expected to continue studying physics but were transferring to a different institution. The majority of the latter students were foreign citizens, which included a large group of German students returning home to study after completing a year-long exchange program. The remaining students (3%) indicated that they would not be continuing physics graduate study the following year. It is important to note that this survey was conducted toward the end of the academic year. Students who left their department during their first semester of study most likely did not receive a questionnaire. Thus, the above figures almost certainly underestimate total first-year graduate student attrition.

The majority of the students aspiring to a PhD believe it will take 5 full-time equivalent years to earn their degree. There was no difference in this anticipated length of study between men and women or between physics and astronomy students. Foreign students thought it would take less time than US students. However, this difference was not surprising, since many more foreign students entered their current graduate program having already obtained some graduate level training. In reality, 6 full-time equivalent years of study is the most common interval for physics and astronomy PhDs to obtain their degrees, with over one-third taking even longer.

Students were asked to indicate their primary long-term career goals by choosing from a list of broad choices. As in the past, over half of all students desired a research/teaching position at a college or university. Students were also asked if they planned to pursue these goals in the United States. Basically all (99%) of the US students and three-quarters (74%) of the foreign students indicated plans to remain in the US. Focusing on the career goals of the US students, we see only a little difference in career aspirations between men and women. A slightly higher proportion of men desire positions in an industrial setting (20% vs. 14%), while women were a bit more inclined to aspire to a position with the government (18% vs. 12%). Overall, long-term objectives were similar for men and women.

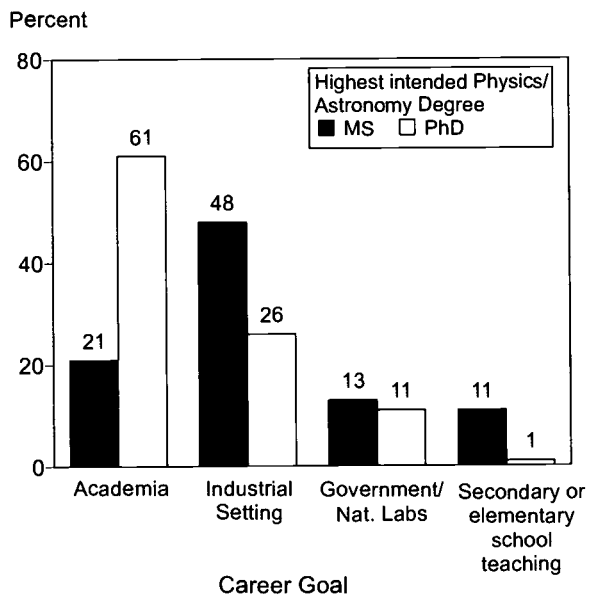
Career goal differences surface when we separate US students by their highest intended degree (see **Figure 4**). About half of the students aspiring to a master's degree anticipate working in the private sector which traditionally hires the bulk of new physics masters recipients. Also, a greater proportion of the master's students plan to pursue teaching at the high school or elementary school level. In contrast, and consistent with previous findings, the majority of PhD students aspire to a position at a college or university.

Figure 5 shows the distribution of career goals for US and foreign students who have the intention of obtaining a PhD. The results for the foreign students are separated by whether they currently intend to pursue these goals in the United States or abroad, and may differ from their ultimate course once they receive their degrees. Almost two-thirds of the US doctoral students aspire to a position in a college or university setting and about a quarter plan to work in the private sector. Although the majority of foreign students hope to work in an academic setting, a greater proportion of those not planning to stay in the US aspire to such a position.

The focus on an academic career was even more accentuated among US students pursuing PhDs at astronomy departments. The vast majority (88%) of US astronomy students aspired to research or teaching positions at a university or college compared to 59% of US physics students. Concomitantly, a much larger fraction of US physics students set their sights on working in an industrial setting. This is not surprising given the far greater range of industrial career options available to physicists as compared to astronomers.

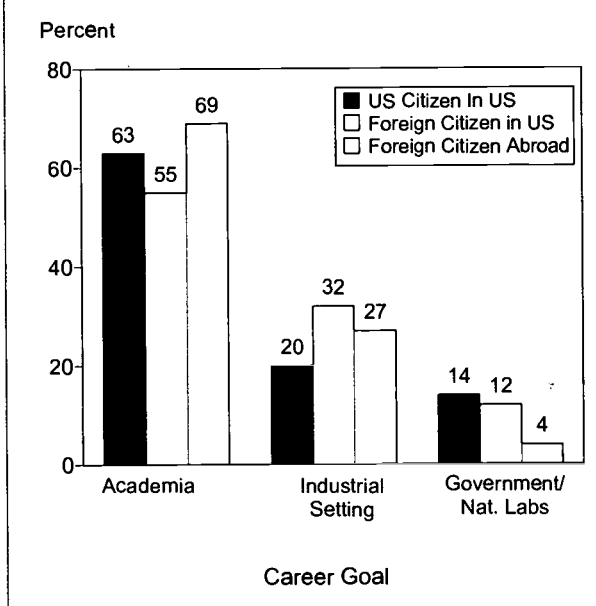
This report was prepared with the help of Michael Kabran.

Figure 4. Career goals by intended highest degree of first-year physics and astronomy graduate students, 2000.



AIP Statistical Research Center, Graduate Student Report.

Figure 5. Career goals by citizenship and location of desired employment of first-year physics and astronomy graduate students who intend to pursue a PhD, 2000.



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