

$$m-M=5\log(d)-5$$
$$360^\circ \equiv 2 \times \pi \times 3960 \text{ miles}$$
$$F = GMm/r^2$$

$CD = \angle COD = \lambda_A - \lambda_B$
 $AB = CD \cos BD$



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MW

Astronomy Careers Beckon

It takes more than a knowledge of the night sky
to work in astronomy.

by **Marcia Bartusiak**

Ironically, childhood experience as a backyard observer — although valuable — is not a requirement in becoming an astronomer in the 21st century. At Harvard University, which has one of the top astronomy programs in the country, only a fraction of the graduate students were dedicated telescope users as youths. Advanced knowledge in mathematics, physics, and computer skills prove more important for future astronomers than a practical background in skywatching.

“That was one of my biggest surprises entering graduate school,” says Scott Ransom, now in his third year at Harvard. “The majority of astronomers don’t have a clue where the constellations are located in the sky,” says Ransom. They don’t have to. Modern astronomers instead plug in computer coordinates to find specific celestial locations.



Janice Lee's eighth-grade yearbook predicted that she would become an astrophysicist. "I didn't think of being an observer because I grew up in New York City where you can't see the sky," she says with a laugh.

In college, other interests side-tracked her. She majored in mathematics at Cornell University and worked on educational policy in Washington, D.C. After obtaining a master's degree in education and teaching physics for a year at a Long Island high school, she decided to return to her first career choice. Lee,



26, obtained a master's degree in astronomy at Wesleyan University in Middletown, Connecticut, and from there moved into the astronomy Ph.D. program at the University of Arizona.

At a recent conference, Lee was dismayed to hear a noted theorist refer to observers as "the unskilled workers of the night shift." Lee hopes to use her background

in mathematics to help bridge the chasm between theory and observation by doing a bit of both. Her current project involves looking at the spatial distribution of low-surface-brightness galaxies to see if the

overall mass of the universe is distributed differently from its light. "We can see chains of lights when looking down upon the dark Earth," she says, "but that doesn't necessarily trace where all the people are."

There may be lots of dim, dark galaxies dispersed more loosely than the bright galaxies, some of which

appear to congregate to form a spongy texture through the universe.

Lee wants her late decision to enter astronomy to serve as an example to others. "You don't have to follow a rigid formula in your career," she says. "College graduates who decide astronomy might be interesting to pursue can go back." — M.B.

Lori Stiles/University of Arizona

Longtime stargazers who plan to pursue astronomy as a course of study are often surprised at the scientific rigor required for the field. Determining how a star or galaxy forms, for example, requires a firm understanding of gravitational forces and hydrodynamics. "Astronomy is physics," stresses Valentin Ivanov, a graduate student at the University of Arizona. "But I also like to think of myself as a craftsman. Astronomy is more hands-on and practical. It's a state of mind."

A career brochure from the American Astronomical Society (AAS) highly recommends a solid foundation in physics and mathematics. It also stresses that most professional astronomy positions require a doctoral degree. Once a Ph.D. is attained, an astronomer enters an elite troop. Only 0.003 percent of all the Ph.D.'s granted annually in the United States are for astronomy. Overall, North America boasts fewer than seven thousand professional astronomers.

However, thanks to the development of new space telescopes and the construction of next-generation large optical

telescopes constructed around the world, opportunities in astronomy have increased over the last 10 years or so. In fact, the number of 6.5-meter and larger telescopes built (or being built) over the last decade exceeds that constructed over the last half century. (See "High-Tech Twin Towers" October 2000.) Launching of the Hubble Space Telescope, the Chandra X-Ray Observatory, and SOHO, as well as the many planetary fly-bys, also provide vast new vistas to analyze.



At the start of the 1990s, the United States granted about 85 Ph.D.'s in astronomy annually. Ten years later that number averages 125, a 40 percent increase (although it seems to be leveling off). While the current spurt in new telescope construction makes it appear that prospects are booming, veterans urge caution. Many new positions are based on "soft money" — provisional grants that could evaporate with a downturn in the economy.

Another factor that keeps astronomy jobs scarce is that often, when one new instrument comes on line, an older one closes down, thus keeping employment levels fixed. The

National Radio Astronomy Observatory, for example, is now participating in an international partnership to develop a large millimeter array in northern Chile. As a result, an older antenna — a 12-meter dish on Kitt Peak in southern Arizona — is being mothballed.

According to the American Institute of Physics (AIP), nearly all the new Ph.D.'s in astronomy secure some form of employment in the field at first, but usually not as assistant professors, which was the case about 40 years ago. Today, about two-thirds move into postdoctoral positions that last two or three years. Others become researchers under short-term grants. Only a tiny fraction are lucky enough to immediately obtain a tenure-track slot on a university faculty or a permanent position at a government institute involved in astronomical research.

What happens to this new pool of researchers later, though, can be shaky. By some estimates, only one-fourth to one-half go on to make astronomy their life's work. Those who are shut out gradually move into other arenas, particularly in private industry where the focus shifts from astronomy to engineering or computer software development. Other astronomy graduates end up working in planetariums, science museums, or public information.

"There is a small turnover of positions each year and, therefore, strong competition for positions," cautions the AAS. "Only those with a quality education, ability, and passion for the subject are likely to find a permanent position." For many, astronomy is a field that's more of a calling than a career, and passion for the subject becomes the engine that powers it. Money is certainly not the motivator.



Chris Gottbrath | Cosmic Simulations

"I like to build toy universes inside my computer and smash things together," says Chris Gottbrath, a third-year graduate student at the University of Arizona. He's hoping that this fascination with numerical simulations of the cosmos will eventually lead to a teaching position at a smaller college, where, although access to big telescopes may be difficult to obtain, he can continue his computer-modeling studies.

Gottbrath's thesis involves calculating how pre-galactic building blocks in the early universe merged and evolved into ellipticals and grand-spiral galaxies. In order to facilitate this research, he is setting up a special cluster of parallel-processing computers to handle the immense number crunching required for such a simulation.

For Gottbrath, 26, a valuable asset for an astronomer is having "a physical sense of what is reasonable and what is not." He also believes it's wise not to specialize too much so that you don't miss other career opportunities that may arise. "For instance, if you work on galaxies, you can't afford to ignore stellar

astronomy," he says, "since star formation has an effect on galaxy formation. You have to keep up with a variety of papers and concepts."

Unlike some of his colleagues at Arizona, Gottbrath didn't initially choose astronomy as a career. "Astronomy



was a cool science, but music was also a draw," he says. While a trombone player in his high school band in northern Indiana, Gottbrath considered becoming a band director. But a summer job at the Kitt Peak National Observatory in Arizona changed his mind.

That's where he was in 1994 when the 20-plus fragments of Comet Shoemaker-Levy slammed into Jupiter. The big telescopes initially had their domes closed, due to the threat of rain. Gottbrath, though, found a small 8-inch telescope tucked away in one of the observatories and quickly set it up outside. He was the first person at Kitt Peak to see the dark impact spots. "It was a unique moment," he recalls. "It came closest to my childhood fantasy of what being an astronomer would be like." — M.B.

Initial salaries start around \$35,000 and currently rise to an average of \$70,000 for a senior astronomer. With their technical skills, astronomers could easily earn more in the corporate world. Nearly all the respondents to an AIP survey indicated that they chose astronomy because of their fondness for it, not because of financial opportunities. But there are perks. In his fourth year in the graduate program at Harvard, Saurabh Jha has already traveled to Chile, Hawaii, and Australia in connection with his research.

About two-thirds of the students entering graduate programs acknowledged in the AIP survey that they aspired to an academic career — a professorship at a college or university. But after a few years in school, they become very aware that the odds are against them. “You don’t go into astronomy these days without doing the statistics,” says Chris Gottbrath, a graduate student at the University of Arizona.

In order to beat the odds, Harvard astronomer Alyssa Goodman advises students to choose their thesis topic carefully. Good astronomers do their homework, stay alert to the

questions being asked within the community, and then seek out the tools needed to answer those questions. A thesis that just fills in details of a problem already broadly understood — while valuable and needed — does not necessarily advance a career.

In the end, says Goodman, “it’s best to be known for something,” whether it’s building a new instrument, attacking a problem with several techniques, or emerging as the world authority on a particular issue. For example, at Case-Western Reserve University in Cleveland, Ohio, Ph.D. candidate John Martin is studying the chemistry of high galactic B stars, a less sexy topic than extragalactic astronomy, the most competitive arena in the field. “But it gives you a chance to stand out when applying for a job,” he notes.

New astronomers also benefit by becoming good communicators. While a tiny fraction of astronomers succeed solely on the sheer brilliance displayed in their publications, it’s a rare achievement. The majority must learn to network among their colleagues and at conferences. “Jobs are often



John Martin | Speaking “Computerese”

John Martin’s family credits his interest in space to the many hours his father spent calming him down as an infant while watching *Star Trek* reruns. Now Martin has the unique distinction of being the lone graduate student at Case-Western Reserve University in Cleveland, Ohio — home of the smallest astronomy department in the United States to offer a Ph.D. Martin is currently finishing up his third year of the program.

His first exposure to astronomy occurred during his teen years. In a summer job at the U.S. Naval Observatory in Washington, D.C., he worked on cataloging astrometric stellar positions. Later, as an undergraduate at the University of Virginia, he got involved in parallax measurements using photographic plates. “My advisor spent weeks gathering the pre-CCD-era plates from the East Coast,” he recalls.

Earlier work with one of the three full-time professors at Case-Western led to Martin’s Ph.D. research.

The research involves using the 82-inch telescope at McDonald Observatory in Austin, Texas, to study the chemistry of some unusual stars outside the plane of the Milky Way. These objects look like young, massive B stars but could be older stars in a later stage of stellar evolution. The spectra Martin gathers at the telescope may tell the tale.

The one thing Martin has learned as a Ph.D. candidate, he says, is the importance of networking. “You have to build up contacts,” he notes. Martin was also surprised by the amount of time he spends on the computer. “Fortunately, I have a knack for speaking ‘computerese,’ ” he says. He stays proficient with telescopes by running public nights at the university’s campus observatory.

Upon finishing his thesis during the next two years, Martin expects to move through a series of postdoc studies while searching for a more permanent position in academia. — M.B.





Pauline Barmby | The Dual-Career Dilemma

Canadian Pauline Barmby thought she would go into either physics or engineering. "My father thought I should be more practical," she says. So she took a summer job at a civil engineering firm and learned about sewers and dams. But her interests switched to astronomy when she began to consider becoming an astronaut.

Now in her fifth year at Harvard, Barmby, 27, hopes to obtain her doctoral degree by the end of 2000. She has been using the 48-inch telescope on Mount Hopkins in Arizona, as well as the 3-meter telescope at the Lick Observatory in California, to study globular clusters in other galaxies. She is particularly interested in the clusters surrounding the Andromeda Galaxy.



Barmby observes those objects with a variety of techniques, including optical photometry, spectroscopy, and in the near infrared. Some of these globular clusters are rich in such elements as carbon, oxygen, and nitrogen, what are known as "metals." Other globular clusters are metal poor. She hopes to determine why this discrepancy occurs, which may shed some light on how a galaxy forms.

Upon finishing her dissertation, Barmby faces competition for a post-doctoral position. She also has the infamous dual-career problem: Her husband is a medical physicist. She has narrowed her job search to cities where both careers can thrive, perhaps Boston, San Francisco, Washington, D.C., or Seattle. — M.B.

Charles McKenzie

decided by the talks students give as they enter the professional world," says Ransom. "I would never have guessed that when I was in high school." Astronomy is not for the people who need their hands held, adds Ransom's classmate Jha. "You learn from talking with other people, such as fellow graduate students and postdocs. It's up to you to pick up the skills you need," he says.

Tinkerers have an edge. "People who can build instruments can have their pick of jobs," says Goodman. At the University of Arizona, for example, graduate student Joanna Hinz is helping build a near-infrared camera specifically to increase her experience in hardware. She will be using it to search for brown dwarfs.

And, more and more, it's becoming necessary to be a computer jock. Astronomers long ago moved away from the era of bulky photographic plates and chilly nights perched at the prime focus. Almost all data are now gathered and analyzed with computers. "I knew I wouldn't be observing every night, but I didn't realize all the monotonous time I'd spend in front a computer analyzing data," notes Pauline Barmby, a Ph.D. candidate at Harvard. "You have to be patient in this field. There is no instant gratification. The 'Eureka!' moments are rare."

A new trend at many university departments is to hire a new Ph.D. in astronomy to administer the department's

computers and then allow for part-time observational opportunities as well. For instance, astronomical surveys, such as the Sloan Digital Sky Survey, which is now gathering immense stores of data by imaging the sky beyond the Milky Way, present additional points of entry for beginning astronomers. An upcoming specialty may well be the astronomer/computer scientist, who must

devise the means to maneuver through extensive data bases in order to answer certain questions about the universe.

The upside to this trend is that it allows astronomers to easily shift careers in times of tight job markets. And astronomers with advanced computer experience can apply their skills in a number of arenas. Indeed, many are already leaving graduate school, lured by the potential riches of the Internet. But those who stay are carried by their zeal.

"If I can only do it for six years, I'll still consider it a blessing," says Gottbrath. "I will have lived my dream." **A**

Author and science writer Marcia Bartusiak is a member of Astronomy's editorial advisory board. Her article "Catch a Gravity Wave," appeared in the October 2000 *Astronomy*. Marcia's latest book is Einstein's Unfinished Symphony. Find it in bookstores or order it directly through <http://www.jhpress.org>.

