



THE OHIO STATE UNIVERSITY

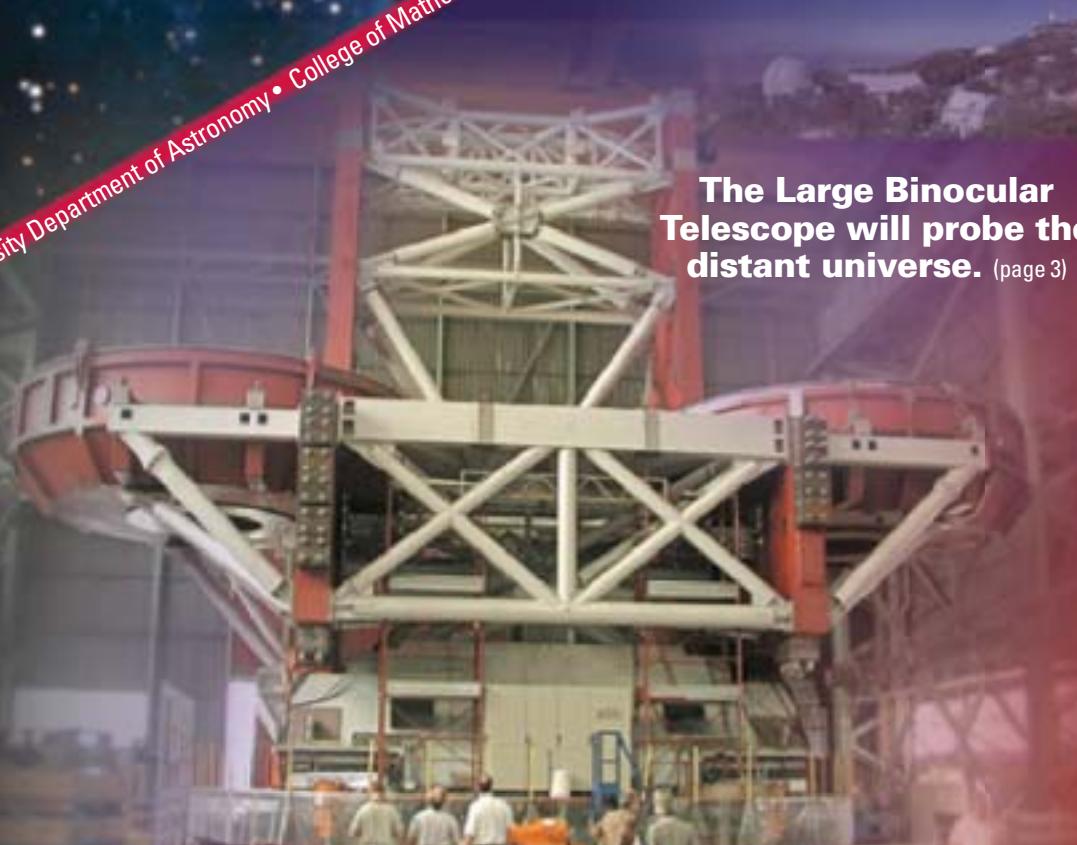
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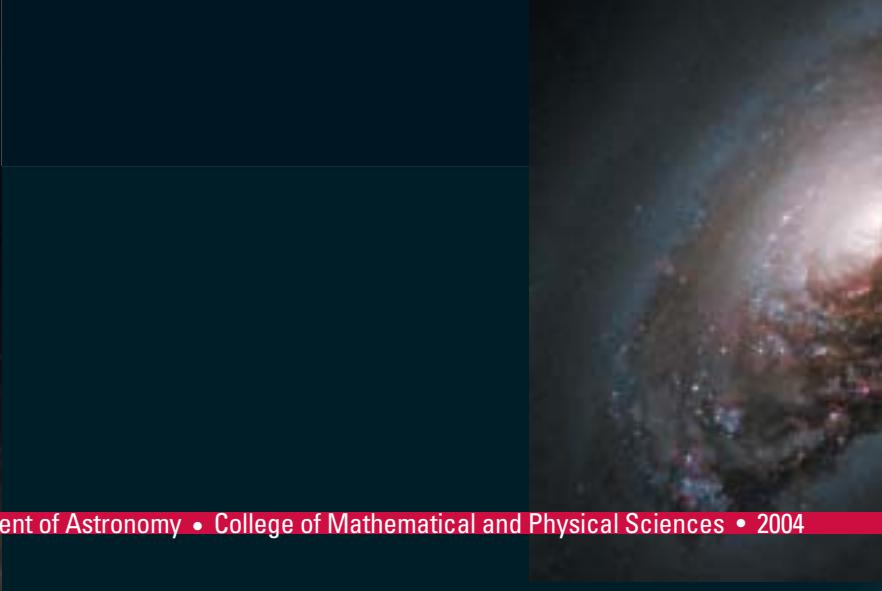
ASTRONOMY

Magazine

The Ohio State University Department of Astronomy • College of Mathematical and Physical Sciences

**The Large Binocular
Telescope will probe the
distant universe.** (page 3)



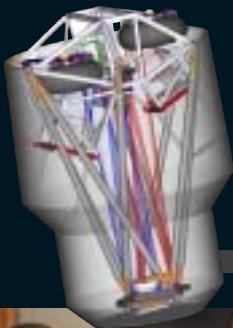


The Ohio State University Department of Astronomy • College of Mathematical and Physical Sciences • 2004



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Large Binocular Telescope (LBT) — a new generation of telescopes



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DEPARTMENT OF

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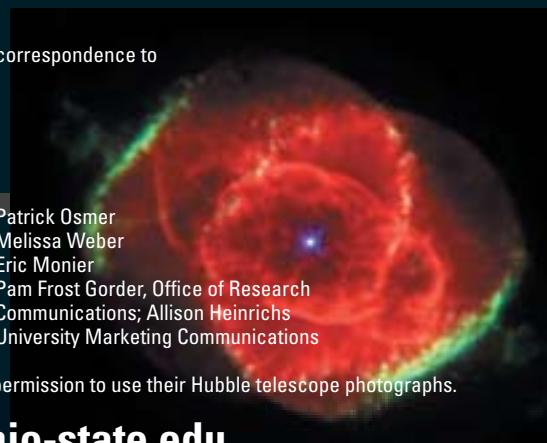
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Department of ASTRONOMY Magazine • 2004

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THE
OHIO STATE
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Letter From the Chair

I am delighted to introduce the inaugural issue of the *Department of Astronomy Magazine*. Last fall, I completed 10 years of service as chair of the Department of Astronomy. As I look back over the last decade, I am struck by the tremendous progress we have made in strengthening our program. I hope you will gain a sense of the excitement of what we are doing from the photos and stories that follow.

I have long said that our people—faculty, researchers, postdocs, staff, and students—are our basic strength, and I am extremely proud of the accomplishments and contributions of everyone in the department. Our faculty members are known worldwide for their research in topics ranging from cosmology to the search for planets around other stars. We have established strong programs in astronomical instrumentation, observational astronomy from space and ground-based observatories, and theoretical astrophysics and cosmology.

Our students have won prestigious graduate school and postdoctoral fellowships and honors. The scientists and engineers in our Imaging Sciences Laboratory (ISL) build astronomical instruments that are in use in observatories around the world. We have developed an atmosphere of intellectual excitement and scientific interaction that is unsurpassed in the world. These great minds meet at our daily Morning Coffee. Please join us and experience it for yourself. (See page 12 for details.)

Forefront astronomical research and teaching are not possible without modern facilities and infrastructure. After outgrowing our quarters in Smith Laboratory, we moved into the completely renovated McPherson Laboratory, where we occupy the entire fourth floor. In addition, we have laboratory space for the ISL in the basement, with high ceilings to accommodate the instrumentation now being built.

The new space has been a tremendous asset to our program. We have obtained a quarter share of the MDM Observatory on Kitt Peak and joined the Large Binocular Telescope project as a one-eighth partner. Thanks to a generous grant from the Research Corporation, we will have one-sixth of the observing time on what will be the world's largest telescope on a single mount.

The first 8.4-meter primary mirror is in place on Mount Graham, and we are expecting first light in autumn 2004. When complete, the LBT will have unique capabilities in terms of light gathering power and resolution; indeed, the 23-meter span from the outer edge of one primary to the other will make it the first of the 20-meter class telescopes.

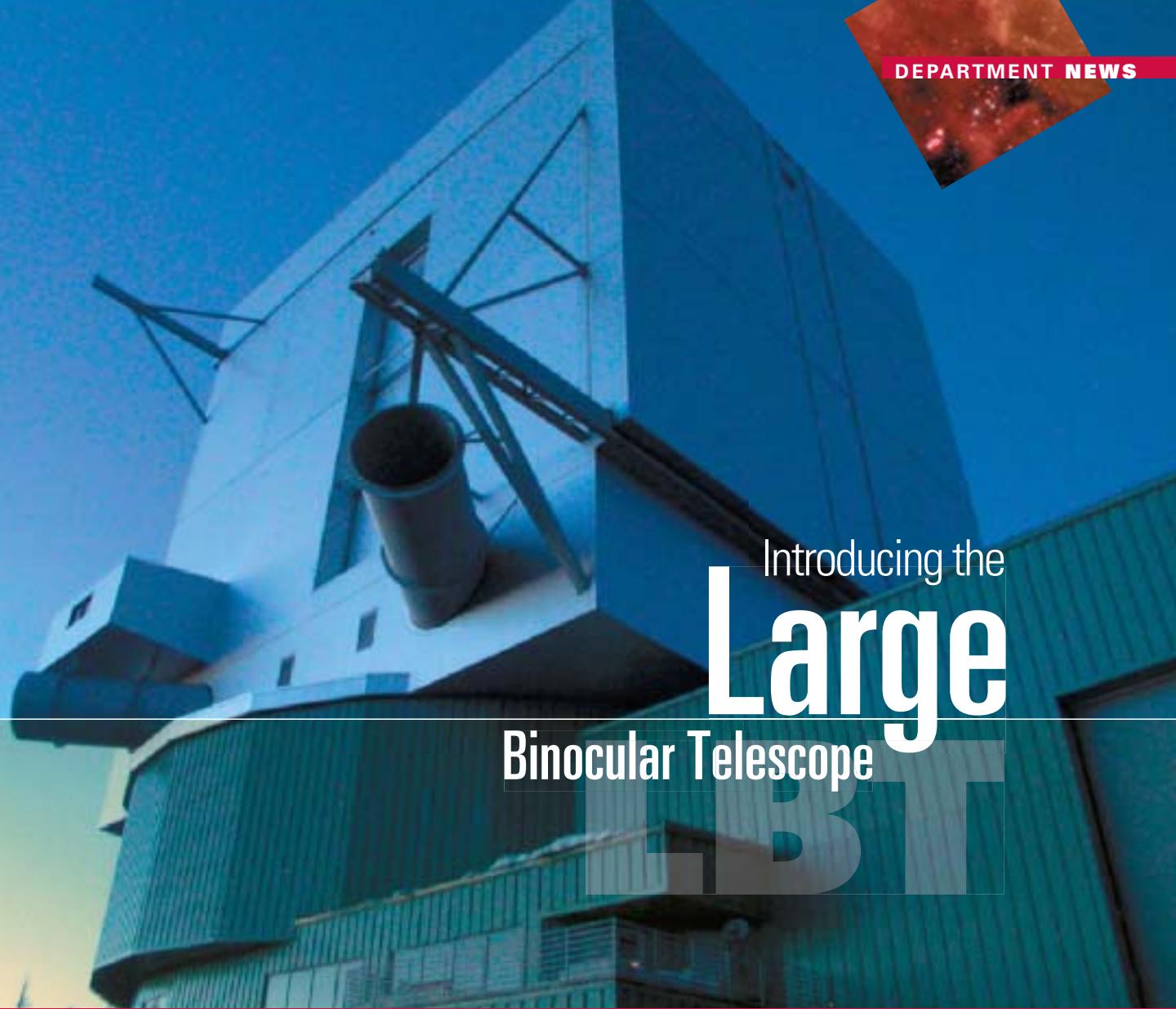
Finally, of course, we have been fortunate to have the support of alumni and friends of the department, and their contributions have made a crucial difference in our drive to become a top-10 department. We believe we are there. Now we are ready to build on our efforts to maintain our quality programs and strive to be the best. We hope you will want to be part of our continued drive to excellence. Please see page 24 for a list of departmental priorities and naming opportunities.

I am honored to be a member of this department, and I look forward to our continued progress as we move ahead in the 21st century.

Sincerely yours,

Patrick S. Osmer,
Chair and Professor





Introducing the
**Large
Binocular Telescope**

THE LBT ON MOUNT GRAHAM, ELEVATION 10,400 FEET

Astronomers can demonstrate the existence of planets in distant solar systems around other stars. With the Large Binocular Telescope, or LBT, on Mount Graham in Arizona, we may soon be able to see these planets.

"You don't have to be a scientist to be excited about the possibilities that exist with this telescope," said Richard R. Freeman, dean and distinguished professor in the College of Mathematical and Physical Sciences.

In the past decade, advances in mirror technology have led to bigger mirrors, the development of adaptive optics has allowed correction for the atmospheric blurring of images, and revolutionary construction designs have resulted in observatories capable of housing and moving 700-ton telescopes. Today, images from telescopes on the ground can be 10 times sharper than those from the Hubble Space Telescope—at a fraction of the cost.

The LBT, currently under construction by a consortium that includes Ohio State, is at the forefront of astronomy in terms of both its light-collecting mirror area and the high degree of sharpness that will be possible in its images. When complete, the LBT will collect more light and produce images with higher resolution than any other existing telescope.

Despite its impressive capabilities, the LBT is the most cost-effective telescope in its class, per square meter of collection area. To achieve its incredible resolution, the LBT will be composed of two 8.4-meter mirrors, making it the world's largest telescope on a single mount.

(continued on page 4)



Computer model of the LBT,
courtesy of Ads Italia



Above, the LBT superstructure, built in Italy and shipped to Arizona, is reassembled on Mount Graham.

Below, the mirror cell with the 8.4-meter mirror installed lifts off.

Bottom, integrating the cell with 8.4-meter primary mirror on the left side of the telescope.



Ignoring atmospheric twinkling, a telescope's resolution depends on the size of its mirror, so it can be improved either by using a bigger mirror or, as in the LBT, by combining the light from two mirrors separated by some distance. Large networks of radio telescopes, such as the Very Large Array (VLA) in New Mexico, are familiar examples of this principle of interferometry. The LBT will be one of the first telescopes using the technique for visible light. With adaptive optics to correct for the atmosphere, the LBT will be able to spy details smaller than a dime seen from a hundred miles away.

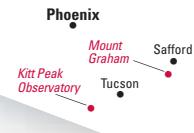
"When completed, the LBT will have the combined interferometric resolving power of a 23-meter telescope," said Patrick Osmer, chair and professor of astronomy. "It is really the first instrument in the greater than 20-meter class, the first in the next generation of telescopes."

The twin 8.4-meter mirrors, the largest single mirrors ever made, were cast at the Steward Observatory Mirror Laboratory, housed under the football stadium at the University of Arizona. Using a revolutionary new technique in mirror technology, 20 tons of glass were heated to a temperature of 2,100 degrees Fahrenheit and rotated in a circular furnace like a giant carousel in order to obtain the mirrors' parabolic curve.

"This telescope will provide us with extraordinary scientific and technical breadth and capabilities," Osmer said.

With an anticipated first-light in the autumn of 2004, the LBT will play a major

ARIZONA



Transporting the 18-ton mirrors to the 10,480-foot-high Emerald Peak required five months of preparation that needed to consider the sharp turns in the mountain roads.



THE MIRROR CASTING TEAM AT THE UNIVERSITY OF ARIZONA

role in clarifying several questions facing astronomers. Among these questions is how the material content of the universe evolved from the original smooth distribution just after the big bang to the current "lumpy" distribution of galaxies, stars, and planets. The LBT also can be used to detect and study faint, low-mass stars and brown dwarfs within young, star-forming regions and may even be able to detect extra-solar planets directly.

Through a cost-effective budget plan involving monetary and in-kind contributions from Ohio State and a grant of observing time from the Research Corporation (a private foundation that invests in scientific research), the Department of Astronomy will have a one-sixth share of the observing time on the LBT. This translates to approximately 60 nights of observing time per year. Ohio State owns a one-eighth share of the telescope.

Other partners in the LBT project include the University of Arizona, with participation from Arizona State University and Northern Arizona University; a group of Italian observatories led by the Arcetri Astrophysical Observatory in Florence; and a group of German institutes and observatories led by the Max Planck Institute for Astronomy in Heidelberg. Each partner holds a one-fourth share of the project. In addition to the share that it has granted to Ohio State, the Research Corporation has also reached agreements with the University of Notre Dame, the University of Minnesota, and the University of Virginia for the use of its observing time.

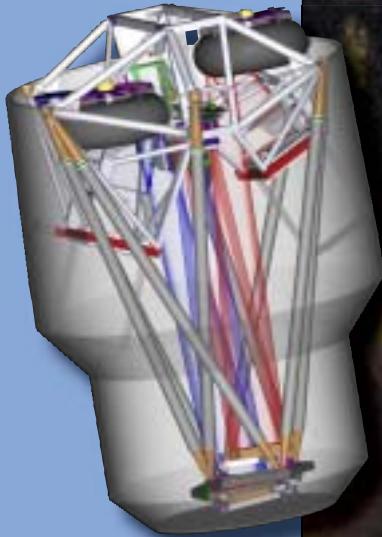


By December 2002, the telescope support was in place.

To control the mirror's temperature and avoid mirror distortion, no glass on the LBT is thicker than 1 inch. While the mirror will still expand and contract with changes in temperature, it will do so uniformly.

THE LBT WILL BE THE MOST POWERFUL OPTICAL TELESCOPE IN THE WORLD.





MODS

MULTI-OBJECT DOUBLE SPECTROGRAPH

May Decipher Cosmic History



Upper structural frame of the MODS spectrograph under construction at Indian Creek Fabricators, near Dayton, Ohio

How did the first stars form? What drives galaxy evolution? What is the structure of the universe, and why did it form this way?

These are just a few of the questions astronomers at The Ohio State University hope to answer using the Multi-Object Double Spectrograph (MODS), currently being built by the Imaging Sciences Laboratory (ISL) team. MODS is one of Ohio State's largest contributions to the Large Binocular Telescope (LBT) project and the most complex instrument ever built by the Ohio State team.

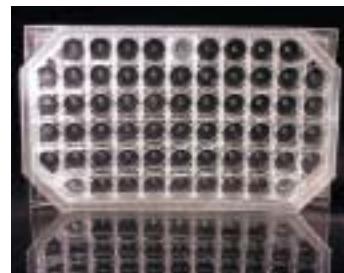
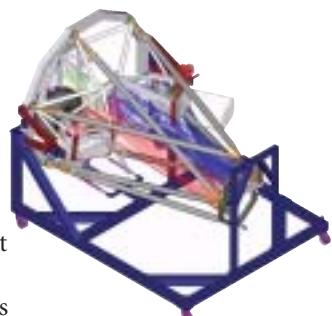
"We had to build this instrument; you must have this capability on a large telescope," said Darren DePoy, professor of astronomy and MODS project manager. "It is a crucial and vitally important instrument to the science research programs that we will conduct using the LBT."

Thanks to a \$1 million, 3-year grant from the National Science Foundation, the ISL team will have the necessary resources to build the instrument, which is expected to be fully operational by early 2006.

Optical spectrographs, such as MODS, break light into its component wavelengths, in the same way a prism splits white light into a rainbow of colors. By analyzing light received at different wavelengths, including ultraviolet and infrared light invisible to the human eye, astronomers can determine the distance, physical conditions, and chemical makeup of distant objects, including stars, galaxies, and quasars.

"MODS is going to be the Ferrari of optical spectrographs," said Richard Pogge, professor of astronomy and instrumentation scientist. "The challenge is going to be how to make it easy for the typical astronomer to use. It has 33 separate mechanisms to put it into its various configurations, including imaging, long-slit spectra, multi-slit spectra, calibration modes, etc."

With MODS and the light-collecting area of the LBT, Ohio State astronomers hope to read cosmic history in the properties of the faintest, most distant galaxies yet observed.



Above, a computer model of MODS on its handling cart

Left, one of four 632 by 372 mm lightweight camera primary mirror blanks manufactured for MODS by Hextek Corporation of Tucson, Arizona



MIRRORS' BELL JAR AND DUMMY MIRROR CELL ON THE TRACK



Above, clockwise from lower left, David Brewer, Dan Pappalardo, Bruce Atwood, David Steinbrecher, Jerry Mason, and Mark Derwent

MIRRORS' Reflective Aluminum

Essential for Large Binocular Telescope

Excerpted from an article by Pam Frost Gorder

On November 26, 2002, in an airport hangar in Columbus, Ohio, some 80 tons of steel, electronics, and cryogenic equipment came together in preparation to deposit 1 ounce of aluminum as a near-perfect, whisper-thin coating on a giant telescope mirror.

In a 9.1-meter diameter steel cell, an 8.4-meter sample, or dummy, mirror simulates one of the Large Binocular Telescope's mirrors. The cell was successfully sealed against a similarly sized lid, called a bell jar, to create a clean, high vacuum environment for coating. Ohio State research scientist Bruce Atwood explained that the coating would be an essential part of the LBT.

"The telescope's concrete foundation, the support structure, the glass mirrors—the entire LBT building—is being made just to support this thin coating of reflective aluminum," said Atwood. "Without it, the telescope can't see."

To meet the challenge of scaling up the technology for the huge mirrors, Atwood and his colleagues have had to devise new ways to create the vacuum and assure a completely uniform film. Once the bell jar and dummy mirror cell are sealed, mechanical vacuum pumps siphon away most of the air inside; all but a tiny fraction of 1 percent remains. Then a special cryogenic system is employed: extremely cold charcoal absorbs almost all of the remaining air molecules.

After the vacuum is established, the scientists will super-heat an array of 28 crucibles, each containing a quarter of an ounce of aluminum. The aluminum will melt, then boil inside the chamber. Just as steam escapes from a boiling pot and condenses as water on the lid, some of the evaporated aluminum will float through the chamber and condense on the surface of the mirror, forming a smooth, uniform coating.

Once testing is complete in 2004, the bell jar will be dismantled and shipped to Mount Graham in Arizona, where it will be reassembled to coat the mirrors on the telescope.



ANDICAM ON THE CERRO TOLOLO 1.3-METER TELESCOPE

Imaging Sciences Laboratory

Focuses on Maximum Scientific Return

The traditional icon of astronomy is Galileo, spending his time squinting through the eyepiece of his telescope and jotting down sketches of what he saw. Today, in contrast, astronomers use sensitive instruments attached to telescopes, analyze the light from the objects being observed, and output the data to a computer. Now it is even possible for an astronomer to be observing at a telescope from halfway around the world.

According to Darren DePoy, professor of astronomy at Ohio State, the laboratories in which those instruments are built are not usually located near the astronomers who use them. Ohio State is unique in that the engineers and optical specialists on the Imaging Sciences Laboratory (ISL) team actually work in the same building with the astronomers who use the instruments in their research.

"This location allows the ISL scientists and the department faculty to interact closely throughout the process of building an instrument," said Bruce Atwood, a research scientist in astronomy at Ohio State. "This close interaction has produced a focused effort on achieving the maximum scientific return, yielding efficient and cost-effective instruments."

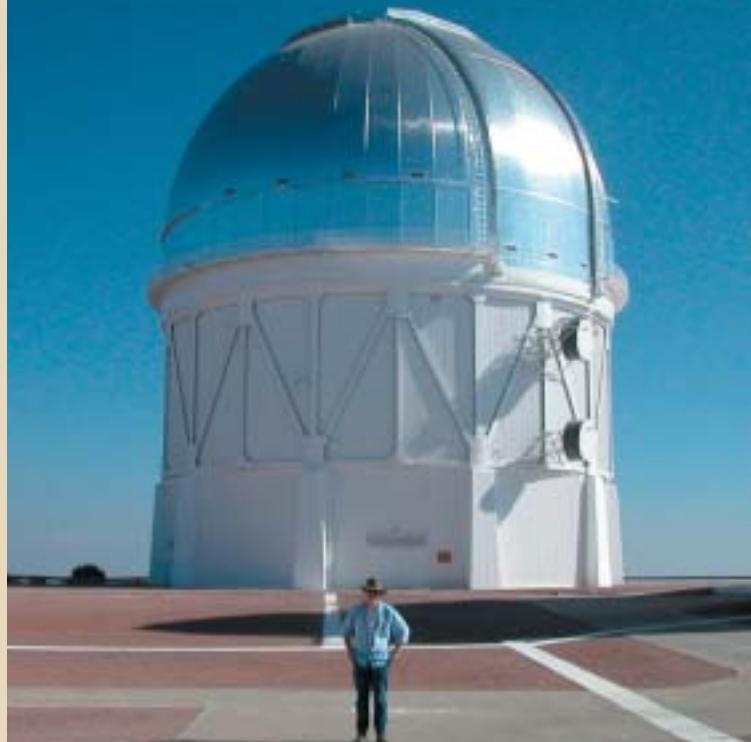
Having the ISL housed in the same building as the Department of Astronomy also allows graduate students to participate in instrumentation projects. Joshua Pepper, a third-year graduate student, is currently working on an innovative way to find transiting planets. Jennifer



DANDICAM, above, has been deployed at the 1-meter Elizabeth Telescope at the South African Astrophysical Observatory.



RICK POGGE IN FRONT OF THE 4-METER BLANCO TELESCOPE BUILDING

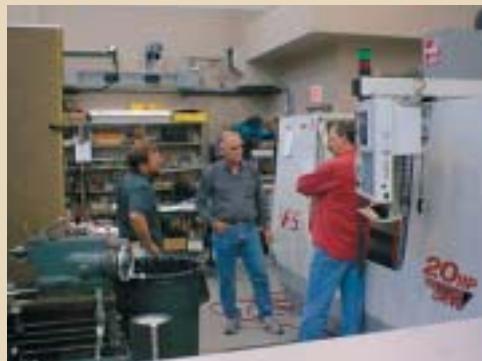


Marshall and Christopher Morgan, fourth- and second-year graduate students respectively, are designing and building various subsystems for the Multi-Object Double Spectrograph (MODS).

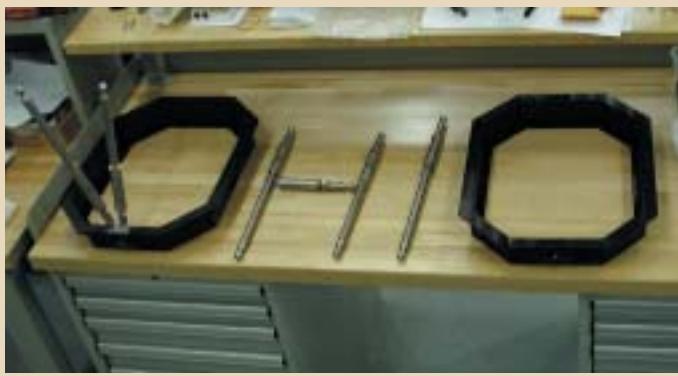
"The option to work on an instrument for such a large telescope is pretty unusual for graduate students," said DePoy. "There aren't many places where that can happen."

The ISL has excellent capabilities in detectors, electronics, and optical design, as well as mechanical engineering, design, and fabrication. The high-bay laboratory space in the basement of McPherson contains machining and testing equipment, including a computer-controlled mill and lathe, plus the space needed to assemble instruments.

Over the past several years, the ISL team has built everything from spectrometers and infrared imagers to various CCD camera systems. Ohio State instruments are used at observatories throughout the world, including telescopes at the Cerro Tololo Inter-American Observatory in Chile, the Crimean Astrophysical Observatory in Ukraine, the Perth Observatory in Western Australia, and the Wise Observatory in Israel.



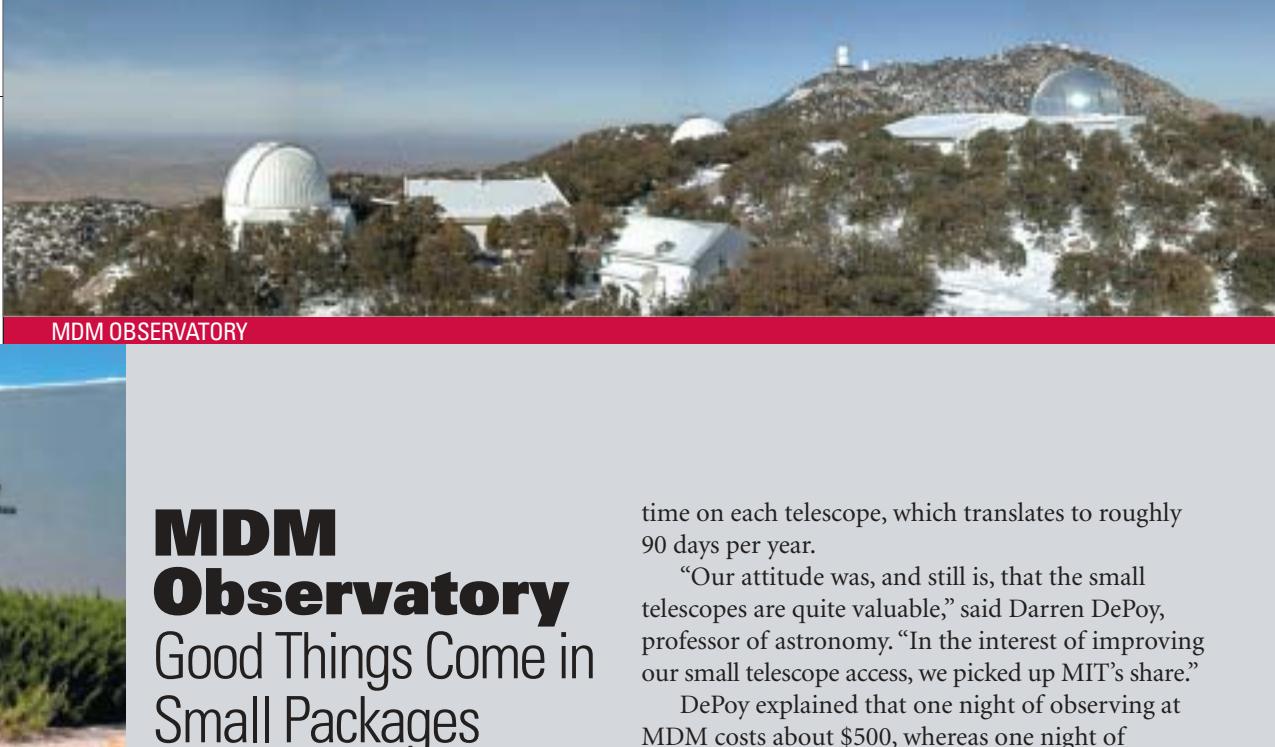
Inside the Imaging Sciences Laboratory at Ohio State



CERRO TOLOLO 1.3-METER TELESCOPE



Another view of the ANDICAM



MDM OBSERVATORY



Above, graduate students Stephan Frank and Misty Bentz at the MDM Observatory.

Below left, 12.5-inch Emerson McMillin telescope in the dome of McMillin Observatory on campus. It was used from 1896 until 1962 for instruction and research. McMillin Observatory was demolished in 1976, and, since 1984, the telescope has been located at the Sandusky Valley Astronomical Society's Ballreich Observatory near Tiffin, Ohio.

Below middle, Perkins Observatory near Delaware, Ohio, was the site of the 69-inch Perkins Telescope used by Ohio State and Ohio Wesleyan astronomers for their research from 1931 to 1961.

Below right, 72-inch Perkins Telescope on Abderson Mesa, near Flagstaff, Arizona. This was Ohio State's primary research telescope from 1961 until 1998.

MDM Observatory

Good Things Come in Small Packages

Ohio State University astronomers have enjoyed guaranteed telescope observing time since 1896, when a 12.5-inch telescope saw first light at the McMillin Observatory near Mirror Lake on campus. Ohio State and Ohio Wesleyan University jointly operated a 69-inch telescope for 30 years at the Perkins Observatory north of Columbus until 1961, when the telescope was moved to darker skies outside Flagstaff, Arizona, and the Lowell Observatory joined the partnership.

In 1998, when that partnership ended, Ohio State astronomers focused their efforts on the Large Binocular Telescope (LBT) on Mount Graham in Arizona and the two telescopes at the MDM Observatory on the south ridge of Kitt Peak, near Tucson. At first glance, the two 8.4-meter mirrors of the LBT dwarf the 1.3- and 2.4-meter telescopes at MDM. However, as Ohio State astronomers have discovered, good things often come in small packages.

MDM was founded by the University of Michigan, Dartmouth College, and Massachusetts Institute of Technology. Ohio State and Columbia University joined the consortium when MIT withdrew to pursue larger telescope projects. Ohio State now enjoys a 25 percent share of the observing

time on each telescope, which translates to roughly 90 days per year.

"Our attitude was, and still is, that the small telescopes are quite valuable," said Darren DePoy, professor of astronomy. "In the interest of improving our small telescope access, we picked up MIT's share."

DePoy explained that one night of observing at MDM costs about \$500, whereas one night of observing on the LBT will cost approximately \$15,000. In other words, a student can observe for a month at MDM before reaching the cost of observing for one night at LBT.

"MDM provides key, hands-on learning and experience for students in the actual operation of telescopes and modern instrumentation," said Patrick Osmer, chair and professor of astronomy. "This is an opportunity for an experience that is becoming increasingly scarce in our field."

"Both telescopes are quite serviceable and have good instruments that take a lot of useful data," said DePoy. "Our involvement with MDM will probably continue for quite some time. I think the small telescopes still have a role to play in terms of calibration and training purposes, as well as in some survey programs."

Ohio State currently maintains two instruments used on the MDM telescopes, a Boller & Chivens visible-wavelength grating CCD Spectrometer (CCDS) and TIFKAM, a near-infrared imager/spectrometer.

"Looking ahead, MDM will be a useful facility to develop instrumentation and research programs for LBT," Osmer said. "This will provide capabilities for survey and preparation for observations using LBT."





2.4-METER HILTNER TELESCOPE AT MDM



1.3-METER McGRAW-HILL TELESCOPE AT MDM



THE INNER WORKINGS OF TIFKAM, AN INFRARED IMAGER/SPECTROMETER AT MDM

Renowned Astronomers Receive Honorary Doctorates from Ohio State



JOHN N. BAHCALL, LEFT, AND FORMER OHIO STATE PRESIDENT WILLIAM E. "BRIT" KIRWAN

In the past decade, The Ohio State University has honored internationally renowned astronomers John N. Bahcall and Vera Cooper Rubin with honorary doctorates.

One of the most influential astrophysicists in the world, Bahcall is the Richard Black Professor of Natural Sciences at the Institute for Advanced Study at Princeton, New Jersey.

He has held a position as a visiting lecturer with the rank of professor at Princeton University for 30 years.

Bahcall played a major role in the development and success of the Hubble Space Telescope, receiving the NASA Distinguished Public Service Medal in 1992 for his scientific work and leadership. He held several leadership roles with the National Academy of Sciences during the 1990s, serving as chair of its Survey Committee for Astronomy and Astrophysics from 1989 to 1991. During his tenure, the committee successfully set priorities for astrophysical research projects. He also served as president of the American Astronomical Society from 1990 to 1992.

Rubin has been a member of the Department of Terrestrial Magnetism at the Carnegie Institution of Washington since 1965. Her observational work on spiral galaxies demonstrated for the first time that gravitational mass, now known as dark matter, extends to the visible edges of galaxies.

From 1982 to 1985, Rubin served as president of the Commission 28 (Galaxies) International Astronomical Union. She actively promoted the role of women in science through her service with the American Physical Society's Panel on Faculty Positions for Women Physicists and Astronomers, the American Astronomical Society's Committee on Women, and the American Women in Science Council. In 1996, she became the second woman to win the Gold Medal of the Royal Astronomical Society in London. Rubin received an appointment to the President's Committee on the National Medal of Science in 1995 and served as committee chair from 1997 to 1998.

Bahcall received a doctor of science degree during the 2001 autumn commencement, and Rubin received her doctor of science degree during the 1998 summer commencement ceremonies.



VERA RUBIN, LEFT, WITH FORMER PRESIDENT KIRWAN

Morning Coffee



MORNING COFFEE TALK

Astronomy Gathering Encourages Research, Student Growth

By Pam Frost Gorder, Research Communications

Morning Coffee, a daily half-hour meeting of faculty, staff, and students in the Department of Astronomy, started nine years ago and quickly took on a life of its own, said Pat Osmer, professor and chair of the department.

In this accelerated age of electronic media, Osmer and his colleagues have found that the best way to keep pace with research is to put their computer e-mail aside once a day for an old-fashioned face-to-face coffee klatch.

Over the course of the meeting, busy people come and go. Many have time only to catch one or two points in the ongoing conversation, offer a single comment, and leave. They discuss everything from the largest galactic clusters to the tiniest specks of interstellar dust. Black holes, quasars—you name it, they talk about it.

They comment on their own journal articles and others from around the world that have been posted on the Web's "e-print arXiv" (arxiv.org). This electronic archive of physics, astronomy, and computer science research is maintained at Cornell University.

New articles appear on the archive overnight. Professor David Weinberg and Professor Andrew Gould share the task of assembling a few key abstracts into an informal agenda for the next day's meeting.

Throughout the meeting, the faculty critique each other's research, and students interrupt these exchanges with impunity. In the end, everyone walks away with a better understanding of the discipline and a finely honed ability to describe and defend their ideas.

"It's a free-form gathering," Osmer said. "If it were more organized, it wouldn't be as effective. We try to maintain a sense of whimsy in our group."

In departments that prize hierarchy, distance from the conference table is a direct indication of one's lot in life. Lesser personnel on the academic food chain generally occupy chairs against the wall.

Osmer feels his department's more democratic approach makes graduate students better prepared for life in academia. "They're immediately thrown into the thick of things with





everybody else," he said, "so they can develop the skills they will need to interact with other astronomers once they leave here. That's why we truly believe we have one of the best graduate programs in the world."

Though most benefits of Morning Coffee are intangible, a few concrete examples exist. NASA recently accepted a project proposal from Associate Professor Smita Mathur, whose innovative methods for studying quasars grew out of Morning Coffee discussions.

The department has Weinberg to thank for starting the Morning Coffee tradition. He came to Ohio State after getting his doctorate at Princeton University, where the custom was afternoon tea, and doing postdoctoral work at Cambridge University, where the Institute of Astronomy had its own morning coffee group.

"It's actually quite a lot to ask of people, that they spend 30 minutes a day on something other than their work. I was amazed at how quickly it caught on," Weinberg said. "Now the discussion is considerably more lively and wide-ranging than I have seen anywhere else."

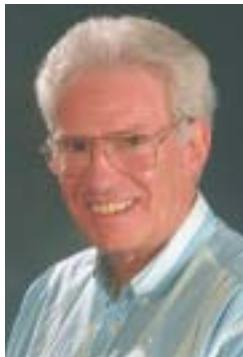
Faculty and students from other academic departments, such as physics, regularly attend the meeting; Osmer stressed that everyone is welcome.

Bring your own mug, and feel free to sit at the big table.





Eric Herbst



Gary Steigman



David Weinberg

Faculty Named APS Fellows

In the past decade, five faculty members in the Department of Astronomy have been named to the rank of fellow by the American Physical Society for their contributions to research and education in astronomy and physics.

David Weinberg became an APS Fellow in 2000; **Eric Herbst** was named in 1999; **Anil Pradhan** received the honor in 1996; and **Richard Boyd** (see next page) was recognized in 1994. Another faculty member, **Gary Steigman** (see page 19), is also a fellow, but claims that it was so long ago that he can no longer recall when he was elected.

The American Physical Society elects as fellows "only such members who have contributed to the advancement of physics by independent, original research or who have rendered some other special service to the cause of the sciences." Each new fellow is elected after careful and competitive review and recommendation by a fellowship committee on the unit level and additional review by the APS. Only one half of 1 percent of the total APS membership is selected for fellowship in the society each year.

"Only such members who have contributed to the advancement of physics by independent, original research or who have rendered some other special service to the cause of the sciences."

— American Physical Society

Pradhan Studies Light Energy Near Central Black Holes

Like most astronomers, Anil Pradhan believes black holes are at the heart of the engines powering active galaxies and quasars. "But so far all the evidence is indirect. We have no absolute proof," he said.

He believes direct proof lies in the light emitted by hot gas close to the central black hole, where it is subject to enormous gravitational forces and consequently heated to millions of degrees. Modern X-ray telescopes, such as NASA's Chandra X-ray Observatory, can take spectra of this gas, but interpreting the spectra depends on our understanding of the underlying atomic physics. Pradhan and his research group are calculating atomic parameters for elements such as iron and oxygen under those extreme conditions and comparing them to the X-ray results.

His efforts are paying off. On December 25, 2001, Pradhan received an e-mail from Claude Canizares, the Bruno Rossi Professor of Experimental Physics at the Massachusetts Institute of Technology and the principal investigator on NASA's Chandra X-ray Observatory. A Chandra observation of an active galaxy, Canizares reported, showed an oxygen feature at exactly the wavelength Pradhan had predicted.

Pradhan and his research group, led by research scientist Sultana Nahar (See page 19.), are members of the Iron Project, an international collaboration devoted to calculating the atomic parameters of iron-peak elements. Their detailed calculations predicting atomic spectra at X-ray, ultraviolet, visible, and infrared wavelengths have made them one of the largest users of the Ohio Supercomputing Center's resources. While Pradhan is primarily interested in applying these results to astrophysical environments, including stars, supernovae, and quasars, the theoretical data describing X-ray emission from iron are also important for modern fusion experiments.



Anil Pradhan

Weinberg Uses SDSS to Study Dark Matter

David Weinberg is interested in how the galaxies we see relate to the underlying distribution of dark matter, which is invisible to us. Since theory predicts that galaxies form in the gravity wells provided by dark matter, Weinberg wants to trace out the dark matter by looking at how the galaxies are distributed. He is comparing theoretical predictions of how galaxies cluster with the locations of galaxies observed in the Sloan Digital Sky Survey. SDSS is an ambitious effort to map out a large area of the sky and measure the distances to 1 million nearby galaxies and 100,000 distant quasars. The 10-year program is now half finished. "It's a fantastic data set—100 times better than anything that came before," Weinberg said. "We're trying to get everything out of it."

The distribution of dark matter was determined by small fluctuations that existed in the smooth initial distribution of gas in the early universe and led to the galaxies we see today. While astronomers know the basic physics involved in the formation of galaxies, the details remain elusive. In addition to his research on galaxy clustering, Weinberg also models the evolution of the universe using supercomputer simulations. "The computer does with math what the universe did with physics," he said. He is comparing the simulation results to the SDSS data to understand the process of galaxy formation, testing conventional theories to see if they account for the properties or even the existence of galaxies. "We want to understand the relation between galaxies today and when the universe was young," Weinberg said.

While using the SDSS database, Weinberg keeps his eyes open for hints of "surprising things about the universe" that may be fully detectable with bigger telescopes like the Large Binocular Telescope. "With LBT, we'll be able to see far back to the early universe, when galaxies first started to form."

Richard Boyd Named to Rank of AAAS Fellow

Richard Boyd, professor of astronomy and physics, was among the 288 members of the American Association for the Advancement of Science (AAAS) awarded the rank of fellow in 2001.

Boyd earned this honor through his "distinguished contributions to the fields of nuclear physics and nuclear astrophysics, especially to experimental applications of radioactive nuclear beams to issues in nuclear astrophysics."

Richard Boyd came to Ohio State in 1978 as a nuclear physicist. "That's what all my research was in at the time," he explained. "That's what I was being funded to do." But then he attended a conference that changed his research direction.

Boyd was talking with a friend who asked about nuclear data that he had wanted for a particular nuclear reaction; however, the target only lived for a few minutes, so experimental study of the reactions was impossible. From there, Boyd began his work on a method to capture the same data through a slightly different process.

"My greatest compliment came when Willie Fowler (renowned Nobel Laureate and Ohio State graduate) became supportive of the process," said Boyd. "He was so well-known and well-respected that he easily sold the idea to the research community despite that fact that I was really an outsider."

Understanding the production of unstable nuclei through radioactive beams led to studying similar reactions that take place in stars. "Nature gives us conditions that can't be produced in a lab," said Boyd. "When a star explodes, the conditions that can exist may be so extreme that the nuclear reactions that take place

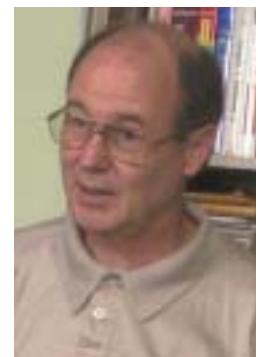
can involve extremely unstable nuclei. Since these often can't be produced in the laboratory, we have to guess what processes actually occurred, and then infer what stable nuclei they would ultimately have produced. "It's really a matter of looking for smoking guns. We find nuclei that are unique, that can't be produced any other way."

Boyd and his colleagues also search for the neutrino, perhaps the most abundant particle in the universe. Despite huge numbers, neutrinos are difficult to detect: they are so weakly interacting that they tend to pass through objects without interacting. One of the great difficulties in observing the neutrino is the interference from the cosmic radiation that surrounds the Earth. So when searching for neutrinos, detectors are built deep underground.

"We're working on a new detector right now in Carlsbad, New Mexico, that we hope to have completed just before the next supernova explodes," Boyd said with a smile. "We estimate that a massive star explodes in our galaxy about once every 20 years, so we hope we're ready for it." Such an explosion should bombard the Earth with neutrinos that astronomers will be able to "see" with the new detector. "I always like to say the best way to find a needle in a haystack is to get rid of the haystack."

AAAS members are elevated to the rank of fellow because of their efforts toward advancing science or fostering applications that are deemed scientifically or socially distinguished. AAAS represents the world's largest federation of scientists and works to advance science for human well-being through its projects, programs, and publications. It conducts programs in the areas of science policy, science education, and international scientific cooperation.

Boyd's name was published in the journal *Science*, and he was honored in Boston in February 2002 during the AAAS Annual Meeting.



Richard Boyd

Eric Herbst Named Distinguished University Professor

Eric Herbst, professor in the Departments of Astronomy, Physics, and Chemistry, was named Distinguished University Professor in 2003.

Professor Herbst is internationally regarded as a pioneer and one of the leading researchers in the world in the field of molecular astrophysics. In 1973, he and William Klemperer wrote "The Formation and Depletion of Molecules in Dense Interstellar Clouds," a seminal paper about which Herbst's nominators wrote, "This paper literally started the field of molecular astronomy." To date, he has more than 250 papers published in peer-reviewed journals.

"Simply put, we use the tools of physics to understand how molecules actually form in space," he said.

Interstellar clouds are vast regions of gas and tiny dust particles found in galaxies, including our own Milky Way. More than 30 years of observational studies show a rich variety of gas-phase molecules associated with these interstellar clouds. Molecules are not limited to our solar system; instead, they appear to exist throughout the universe.

Herbst's research has spanned astronomy, physics, and chemistry, and he has taught basic and advanced courses in all three departments during the course of his career. He has been recognized with the Alfred Sloan Foundation Award, the Max Planck Research Prize, Ohio State's Distinguished Scholar Award, and twice with awards for graduate teaching, among others. In addition, he currently serves as a science editor for the prestigious *Astrophysical Journal*. He also has served on numerous departmental committees, the promotion and tenure committee of the College of Mathematical and Physical Sciences, and the university's selection committee for the Distinguished Scholar Award. Herbst's research has been consistently well-funded by the National Science Foundation and NASA.

Dr. Herbst received his AB in chemistry from the University of Rochester and his master's and doctorate degrees from Harvard University. He joined Ohio State's faculty in 1991.

The Distinguished University Professor title is awarded permanently to no more than three exceptional faculty per year at The Ohio State University. The title recognizes accomplishments in research, scholarly or creative work, teaching, and service that are both distinguished and distinctive. The Office of Academic Affairs awards honored faculty an annual budget of \$10,000 for a period of three years to support their academic work.



From left, Pat Osmer, Ohio State President Karen A. Holbrook, Eric Herbst, William Saam, chair of the department of physics, and Zuheir Sofia, former chair, board of trustees.

Welcome

New Faculty

Jordi Miralda-Escudé



"I became interested in astronomy very early in life," said Jordi Miralda-Escudé, associate professor of astronomy at Ohio State. "When I was young, I would look at the night sky through a telescope that a friend helped me build."

Miralda-Escudé earned his Ph.D. in astrophysics from Princeton University in 1991 and then participated in a SERC Postdoctoral Fellowship in Cambridge, UK. From there, he had a long-term membership in the Institute for Advanced Study at Princeton and was an assistant professor at the University of Pennsylvania before settling down at Ohio State in 2000.

"This is the place with the best research interaction between the faculty and students," he said. "There is a great deal of communication and collaboration among the faculty."

Miralda-Escudé's current research focuses on how black holes at the centers of quasars are "fed."

Astronomers believe the energy a quasar releases comes from a hot disk of gas and dust surrounding its black hole. "Quasars are produced when black holes are eating," he said. Eventually, however, the gas will fall into the black hole, so additional "food" is regularly required to keep the quasar shining for several million years.

Miralda-Escudé and graduate student Juna Kollmeier recently suggested a mechanism to supply the gas. In this model, the black hole's gravity perturbs the orbits of stars in the galaxy's central regions, forcing the stars to pass through the disk. As the stars crash into the disk, they slow down and eventually merge with it.

Miralda-Escudé is also interested in the early history of galaxy formation and the period when the first stars and quasars were formed. "I try to be broad in my research," he said. "I like following different areas. But figuring out which ideas are good takes time." His other research interests include gravitational lensing, the nature of dark matter, and the formation of structure in the universe.

Miralda-Escudé's honors include an Alfred P. Sloan Research Fellowship, the Princeton University Harold W. Dodds Fellowship, and the Princeton University Prize Fellowship.

Ohio Eminent Scholar Christopher Kochanek

Professor Christopher Kochanek transferred to Ohio State from a job at the Smithsonian, and he is happy with the results.

"This was an excellent opportunity," said Kochanek, Ohio Eminent Scholar of Cosmology and professor in the Department of Astronomy. And instead of the "two-body problem" often encountered when faculty couples move, Ohio State realized an opportunity as well: a two-body solution in which Kochanek's spouse, Barbara Wyslouzil, is now an associate professor in the Department of Chemical Engineering in the College of Engineering.

A real advantage of Columbus living over their old home in Lexington, Massachusetts, is the reduction in the number of cannon attacks. Really. Each year, the beginnings of the Revolutionary War are reenacted near his old neighborhood. Part of the event includes firing a British cannon toward the house next door to the former Kochanek-Wyslouzil residence.

"One year, there was nearly a cannon-induced



injury," Kochanek said. "A friend was watching the reenactment at an open window, which came crashing down, startling all of us."

Now that he has moved away from the "danger," Kochanek will be able to spend more time pursuing his research. What exactly does he study?

"All kinds of stuff," he said, laughing. Some of his interests include extragalactic astronomy; the distribution of matter, especially dark matter, in galaxies; and the evolution of galaxies.

For part of his research, Kochanek takes advantage of a relatively new field in observational astronomy: gravitational lensing. These studies enable observational astronomers to use quasars in distant galaxies to study the structure of foreground galaxies. Further, observations also can be made of distant quasars and even black holes. In gravitational lensing, light bends around both sides of a massive object, and multiple images are produced. Gravitational lensing typically results in two or four images, but Kochanek says that there are observations of three, five, and even six images of the same object being studied.

"God is a lousy optician," he said.

In order to study these images in a more systematic way, he is planning to propose a different way to share time on telescopes. Rather than requesting an entire evening, the standard in observational astronomy, he proposes to request the same 15-minute period every day, over a longer period of time, even weeks or months.

"We know how much of everything should be in the universe, yet there is so much that we really don't understand about the nature and distribution of dark matter and dark energy in particular," he said. "Over the next 10 years, we'll be learning so much about the history and details of the universe. We look around now and realize the universe is not smooth. There are lumps. We're trying to understand how the galaxies and stars are assembled."

Despite his involvement with telescope observations, Kochanek started his research career as a theorist.

"You can have many amusing discussions trying to classify people as theorist or observer," Kochanek said. Many astronomers do both, avoiding easy classification into either category. "I guess you can just say I'm a theorist who has gone bad."

Smita Mathur

Smita Mathur, associate professor of astronomy, is more than happy with her decision to come to Ohio State. "I love it here – no question about it," Mathur said. "Everyone here is very good at what they do and at the same time very friendly. That makes it an enjoyable place."

Mathur received her Ph.D. from The Tata Institute of Fundamental Research in 1991 and then went on to conduct research at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. She joined Ohio State's Department of Astronomy in 1999.

Mathur's research involves studying active galactic nuclei, from low-redshift Seyfert galaxies to high-redshift quasars, with multiwavelength observations that span the spectrum, covering everything from radio waves to X-rays.

"Lately I've been interested in low-redshift intergalactic gas, mainly because we can now study it in X-rays," said Mathur. "It's very hot and it was not possible to observe before we had the Chandra X-ray Observatory and FUSE [Far Ultraviolet Spectroscopic Explorer]."

Using these observations, Mathur and her colleagues have detected what they believe to be evidence of baryonic gas surrounding our local group of galaxies.

"We believe baryons are drawn to the gravity of the dark matter, so they trace the location of dark matter through space," Mathur said. "One provides a map to the other."

Mathur is quick to point out that although Chandra has made many breakthroughs in helping us understand the evolution and makeup of the universe, there is still a long way to go. "Computer simulations have been telling us for several years that most of the 'missing' gas in the local universe should be in hot filaments. Most of those filaments are too faint to see, but it looks like we are finally finding their shadows."

"Most of the matter in the universe is expected to be in the intergalactic medium," she said. "Now, with Chandra, we are able to find it."



As the field of astronomy has grown, so has The Ohio State University Department of Astronomy's need for space.

In August of 1999, the department moved to its present quarters on the fourth floor of McPherson Lab, with the Imaging Sciences Laboratory in the basement.

"We wanted to keep the department together," said Gerald Newsom, professor and vice chair in the Department of Astronomy. "So when the instrumentation group moved, the department had to be moved with it."

Originally part of the Engineering Department in the late 19th century, astronomy was housed in McMillin Hall. As astronomy transformed into astrophysics in the 20th century, The Ohio State University Board of Trustees transferred the astronomy program to the Department of Physics. In 1961, the Department of Astronomy was formally separated and, in 1968, the department was moved out of the aging McMillin Hall and up to the fifth floor of Smith Laboratory.

In the early 1980s, Ohio State joined the Columbus Project, now known as the Large Binocular Telescope (LBT). With ambitious plans for an expanded department and partnership in a large telescope project, the Department of Astronomy clearly needed more space, including a laboratory in which science instruments for the telescope could be built. In the mid-1990s, the university awarded the department space in the soon-to-be remodeled McPherson Laboratory.

For the first time in years, the faculty, staff, and graduate students all work on the same floor, enhancing the personal interactions that are already a hallmark of the department's program. The new space offers an expanded library, modern offices, and a large conference room used for daily "Morning Coffee" research discussions. (Read more about coffee and the department atmosphere on page 12.)

A New Space for a New Century:

Department of Astronomy
Moves to McPherson Lab



MOVING DAY: FROM LEFT, DON TERNDRUP AND BARBARA RYDEN BEGIN TO UNPACK.



Kris Sellgren demonstrates the "joy" of moving. (She'll be sticking with her new office.)

Massive stars produce iron during the last stage of the fusion process that makes them shine. Once fusion ends in the star's core, the now-cooler interior can no longer support the weight of the outer layers. The ensuing collapse and supernova explosion spews iron into the universe, enriching the surrounding region and becoming subsumed into gas clouds that provide the material for future star formation.



Meet the Iron Lady

Sultana Nahar, research associate in the Department of Astronomy, attended a conference last summer and discovered she had an unusual nickname: the Iron Lady.

"After my talk, someone I did not know spoke with me and called me the Iron Lady," she said. "I was very surprised."

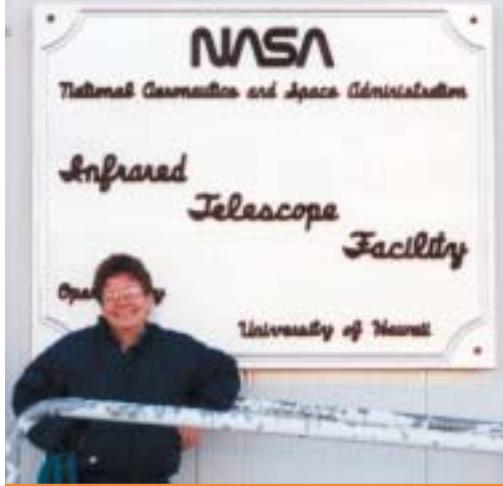
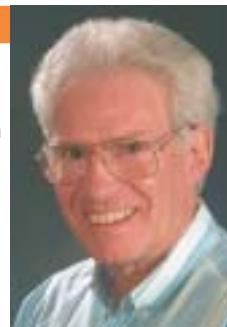
Physicists and astronomers around the world depend on her computationally intensive mathematical models of the iron atom when interpreting complicated spectra produced by high-energy astrophysical processes, such as those that occur near black holes at the centers of active galaxies. Iron is relatively abundant in the universe; it has a complicated spectrum, with 26 electrons

potentially contributing to thousands of spectral lines, depending on the ionization state of the gas.

"It's very difficult to represent (iron) mathematically and to get the atomic parameters," Nahar said. Her detailed calculations of iron spectra allow astronomers to describe the physical conditions, such as temperature and pressure, of hot gas accretion disks around black holes. She works with Professor Anil Pradhan (see p. 14) and graduate students in the atomic physics group. "We're among the biggest users of time at the Ohio Supercomputer Center," she said. Their group, in turn, is part of the Iron Project, an international collaboration devoted to determining atomic parameters.

Although astronomy receives more press coverage for its stunning photos of celestial wonders, Nahar's research gets to the heart of how stars, planetary nebulae, and quasars produce high-energy X-rays. Her work was recently featured in *Thikana*, a Bengali newspaper published in the United States, which led to her second nickname: "the Pride of Bangladesh."

She earned her Ph.D. in theoretical atomic physics at Wayne State University in Detroit in 1987 and completed a postdoctoral appointment at Georgia State University before coming to Ohio State as a postdoctoral researcher in 1990.



Astronomy Professor Sellgren Studies Stardust

(The real thing, not the dreamy kind)

Kristen Sellgren, professor of astronomy, has a variety of research interests including interstellar dust, interstellar molecules, the Galactic Center, and star formation

She is currently involved in three major research projects. The first examines dust around stars of different temperatures and aims to answer the question of how light is absorbed by molecules in a galaxy and then re-radiated. Aromatic hydrocarbons, which are important in the process of creating life from inanimate matter, are at the focus of this investigation.

Dr. Sellgren also is studying the correlation between carbon levels and the strength of the 16.4-micron emissions of planetary nebulae to determine whether or not they are carbon-dominated. Data collected by the Infrared Space Observatory (ISO) suggests this may be the case. (It was previously thought that oxygen was the dominant element.) A correlation between carbon abundance and the 16.4-micron feature strength would support suggestions from laboratory astrochemistry identifying the 16.4-micron feature with aromatic hydrocarbons.

A third research project, dependent on the availability of viewing time and necessary funds, aims to study the dust emissions from red giants to determine how stars lose their mass as they leave the main sequence and become planetary nebulae. Targets for this project include the Large and Small Magellanic Clouds and possibly the Milky Way.

Sellgren is also collaborating with the Spitzer Space Telescope team on observations made with the infrared observatory. She recently returned from research leave at the Jet Propulsion Laboratory in Pasadena, California, where she completed the first of a series of papers on brand-new Spitzer results on infrared spectra of reflection nebulae.

Universe Is Professor's Laboratory

Gary Steigman, professor in the Departments of Astronomy and Physics, came to Ohio State to build a group in theoretical astrophysics and cosmology.

"The Ohio State cosmology group is now viewed as one of the strongest in the U.S.," Steigman said. The large, vibrant group is the result of a joint effort between physics and astronomy. Members of the group use the universe to probe and test ideas about physics at the very highest energies and smallest scales.

Last year, Steigman spent time at the Institute for Theoretical Physics in Santa Barbara, California. "My work there was an extension of what I've always done," he said. And what he's done has been on the cutting edge of cosmology: using the early universe as a means of testing fundamental physics.

According to Steigman, theorists work in areas directly related to observational data, which in turn stimulate new observations. Steigman's theoretical research interests range from the detection of neutrinos to the study of dark matter in the universe.

"Dark matter problems are a hot topic now," Steigman said. "Although gravity keeps us together, an inventory of the estimated total mass in the universe demonstrates a problem: There is not enough mass to hold galaxies together, yet they stay together. There is also evidence of accelerated expansion of the universe, but theory predicts that gravity should slow down the expansion."

"We use the universe as a laboratory," he said. "Particle physics, astronomy, and cosmology are all connected. We are trying to fully understand the beginning of the universe, from the formation of elements in the first few minutes and from the radiation left over from the big bang. Using the universe and its evolution, we can probe aspects of physics inaccessible to the terrestrial. Large accelerators are limited in particles that can be produced and detected."

Professors Collaborate to Describe How Galaxies Form

Although Don Terndrup and Marc Pinsonneault, associate professors of astronomy, have worked together at Ohio State for about 10 years, they have been collaborating for just six.

"We had some old projects we had to finish up first," Pinsonneault explained. Now, they are working together to develop a good numerical model that describes the formation and evolution of stars.

"There are giant telescopes generating vast amounts of cool data," Pinsonneault said. "We're trying to examine stellar evolution."

In addition to the data gathered from the telescopes, the researchers are trying to construct a precise theoretical calculation to answer fundamental questions about where things come from.

"We know a lot about nearby stars because astronomers and physicists have been studying the sun for years and we have a good understanding of the surface of the sun and other nearby stars," Terndrup said. "But there are many different types of stars—young stars, horizontal



Marc Pinsonneault



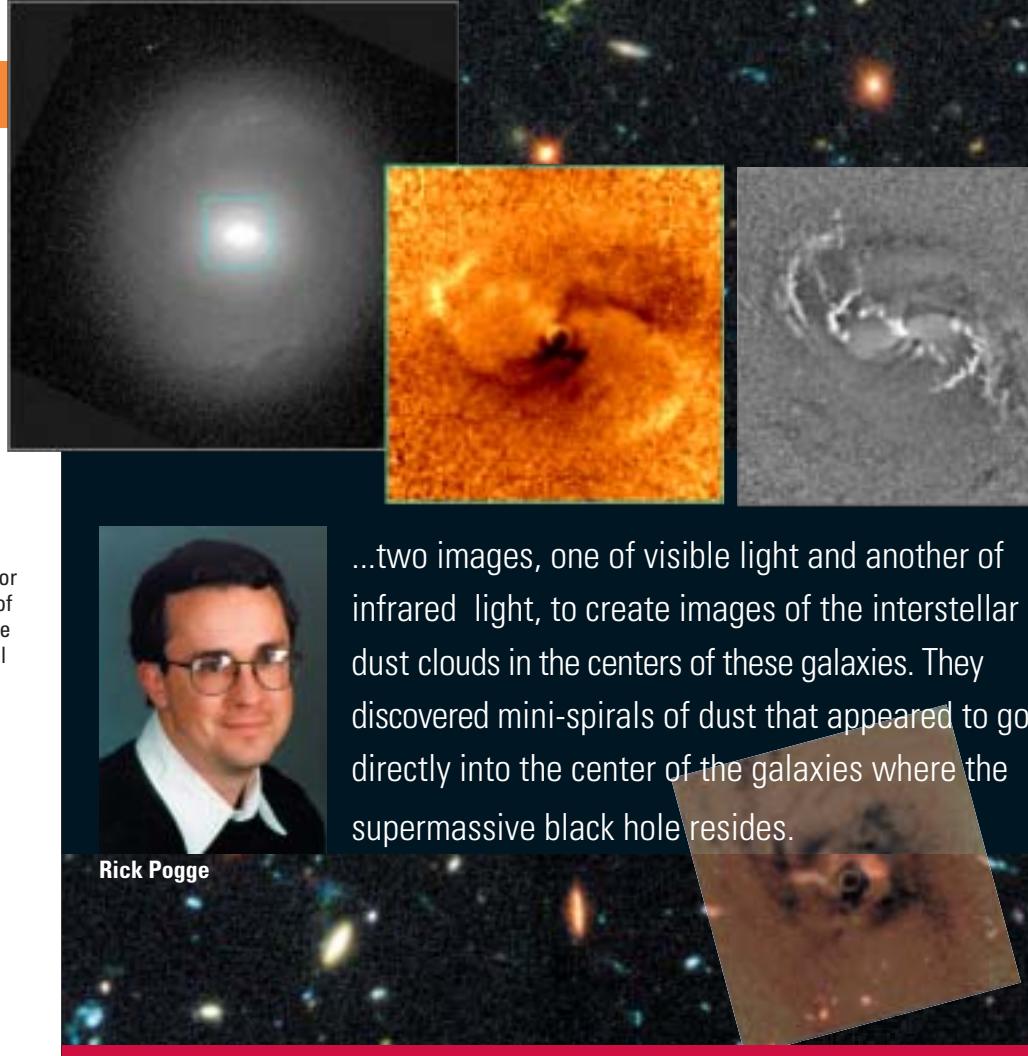
Don Terndrup

branch stars, old red giants—and we still have much to learn about them."

"As we start to understand the processes occurring inside stars, we'll be better able to predict formation of stars in galaxies," Pinsonneault said. "Right now, we don't know which effects are most important in the life of a star. We're building models based on what we know about reactions on the surface, where stars shine."

They're trying to piece together predictions of reactions inside stars based on our observations of the outside. The calculations of stellar evolution require a lot of work, as massive amounts of data are analyzed.

"I like to think of it as galactic archaeology," Pinsonneault said. "We are prospecting through the galaxies."



...two images, one of visible light and another of infrared light, to create images of the interstellar dust clouds in the centers of these galaxies. They discovered mini-spirals of dust that appeared to go directly into the center of the galaxies where the supermassive black hole resides.



Rick Pogge

Ryden's Research Covers Galaxy Shapes and Empty Space

It's difficult to classify Barbara Ryden, associate professor of astronomy, into a single area of research, because her interests are so diverse.

"I guess I have a short attention span," she said. Short, maybe, but long enough to write a textbook, *Introduction to Cosmology*, that was recently translated into Japanese.

Currently, she is studying the shapes of galaxies using the Sloan Digital Sky Survey. Ryden and physics undergraduate student Tony Vincent have downloaded data for tens of thousands of galaxies.

"We're looking at the distribution of sizes and making good guesses about their 3-D shapes," she said. They've also found that the shapes of the brighter, inner parts of galaxies are unrelated to the shapes of their fainter, outer regions. "The outer regions don't care about the inner regions," she said. Ryden suspects the shapes of galaxies are influenced by their environment, since galaxies experience greater tidal forces in crowded clusters than they do in sparser groups.

Ryden is also looking at the properties of voids, literally studying the empty space that comprises much of the universe, using data from the SDSS. Galaxy distribution isn't uniform, she explained. Galaxies are arrayed along strings and filaments, but most of the universe is filled with the empty space between them. Pick a random point, and the odds of being in a galaxy are actually smaller than being outside one.

"I guess I find it more interesting to study the hole instead of the doughnut," she said, and she's using the holes to study how galaxies form. The regions where the dark matter density is highest collect more diffuse gas, which first forms lumpy areas and then condenses to form stars. "I think of it as curdling like cottage cheese," she said.

A small change in mass in the distribution of galaxies can produce huge differences in the size of the voids. "It's the same old story: the rich get richer and poor get poorer," she said. Computer simulations show dark matter extends into the voids, but it's not dense enough for galaxies to form there. Ryden intends to compare simulation predictions with the observed voids in the SDSS to examine assumptions about how galaxies form.



Rick Pogge: A Tinkerer on the Telescope

In addition to his many areas of research, from the spectra of Seyfert galaxies to the X-ray analysis of black holes, Rick Pogge is also an instrumentation scientist. "I've always enjoyed tinkering with stuff," he said. "When I was a kid, I loved to take apart the old vacuum tube televisions. I worked on cars. I was a real gear head."

Now a professor of astronomy at Ohio State, he spends most of his research time with the Large Binocular Telescope (LBT), especially the Multi-Object Double Spectrograph, or MODS. (See page 6 for more information). Pogge serves as the project scientist for the Ohio State team with ultimate responsibility for getting the spectrograph working at the telescope. He said he considers himself fortunate to be part of the generation of astronomers who have found an identity as instrumentation scientists.

"CCD [charge-coupled devices] detectors first began wide use around 1983," Pogge said. "Before that, only about 1 percent of available light from space could be detected. Now it's closer to 90 percent."

As a graduate student at the University of California, Santa Cruz, Pogge worked on some of the first projects taking digital data with CCDs at Lick Observatory. The new techniques resulted in vast amounts of data on tape. He and some of his graduate student colleagues found themselves learning how to write computer code, including drivers for laser printers, to handle the data.

"We had to find new ways of dealing with the data," he said. "We realized that if we could make ourselves computer experts, we would save massive amounts of time in the long run." His ability to diagnose problems from the magnetic data tapes earned him the nickname, "The Tapemeister."

"We no longer play with hardware much," he said. "Now we get data usable by astronomers. It can seem strange, though. Working with the Hubble Space Telescope is odd, because you submit a request, and one day the data just appear on your computer."

Pogge considers the LBT, located in Mount Graham, Arizona, the "biggest, coolest toy" he's ever had the opportunity to work on. "We'll be going to the mountain and actually wrestling photons right out of the telescope," he said. "It will be exciting to really know how something works and be the first one to use it."

Pogge has had great success digging information out of difficult data. He and graduate student Paul Martini, now a Clay Fellow at the Harvard-Smithsonian Center for Astrophysics, studied the inner regions of nearby galaxies with active supermassive black holes. They combined two images, one of visible light and another of infrared light, to create images of the interstellar dust clouds in the centers of these galaxies. They discovered mini-spirals of dust that appeared to go directly into the center of the galaxies where the supermassive black hole resides. For more information about Dr. Pogge's research, go to www.astronomy.ohio-state.edu/~pogge/.

Professor Peterson: AGN Study 'One of the Most Exciting Areas of Astronomy'



Brad Peterson wrote the book on active galactic nuclei. Literally. His *Introduction to Active Galactic Nuclei* is presented at online retailer Amazon.com as "a clear introduction to the one of the most dynamic areas of contemporary astronomy, involving one fifth of all research astronomers."

Since the book was published, the Ohio State astronomy professor has continued to publish papers about AGN in various journals. He also teaches AGN concepts in his two undergraduate courses: Basic Astrophysics and Planetary Astronomy and Introduction to Solar System Astronomy.

"It's been 40 years since AGN were discovered, and it's still one of the most exciting areas of astronomy," he said. "Astronomers are using the light from some of the brightest AGN, quasars, to probe the farthest reaches of the universe."

AGN refers to galaxies with an extraordinary amount of energy at their centers, possibly powered by supermassive black holes. The study of black holes has been enhanced through a technique called astrometry, a method of determining the distribution and motions of gas near supermassive black holes, which in turn reveals fundamental properties of the black holes, such as their masses.

"Black holes are messy eaters," Peterson explained. "They accrete mass at their equators, but seem to spit out mass at their poles."

The gas and dust orbiting a black hole form a region known as an accretion disk, which is heated to tens or hundreds of thousands of degrees by frictional forces in the intense gravitational field. The variable light from the accretion disk can be used to measure the speed of and distance to the clouds of gases orbiting beyond the inner accretion disk. This astrometric method is known as "reverberation mapping," which is similar to the Doppler radar imaging that is used to study motions of storms in the Earth's atmosphere.

"These measurements give us the mass of the central object," said Peterson. "A black hole the mass of the Earth is the size of your fingernail. A black hole as massive as the sun is about the size of the Ohio State campus."

This process is still being explored. "We know a lot about objects as they orbit black holes," Peterson said. "The weirdness comes when things get too close. The orbital speed decreases as you get farther away."

Observatories all over the world are collaborating to understand quasars more thoroughly.

"We are trying to get to the inner structure of quasars," Peterson said. "From our observations at the MDM Observatories to Hubble projects, they're all tied to understanding quasars."

Professor Andrew Gould Receives Distinguished Scholar Award

Andrew Gould, professor of astronomy, was one of only six Ohio State University faculty members to receive the 2002 Distinguished Scholar Award, funded by the Ohio State Alumni Association.

"I was really shocked by it," Gould said. Former Ohio State President William "Brit" Kirwan interrupted one of Gould's classes to make the announcement.

The Distinguished Scholar Award recognizes exceptional scholarly accomplishments by professors who have compiled a substantial body of research, as well as the work of younger faculty members who have demonstrated great scholarly potential. Recipients, who are nominated by their departments, receive a \$3,000 honorarium and a \$20,000 research grant to be used during the next three years.

Gould's research is so creative and original that, as one nominator wrote, even if he stopped publishing today, "his impact on astronomy would continue to grow as the rest of the field caught up with him."

Lauded as one of the best astrophysicists of his generation, Gould is a world leader in gravitational microlensing, a technique for finding dark matter in the universe. He also uses this technique as a probe to discover extrasolar planets.

"He's an incredibly intense person," said Gerald Newsom, professor of astronomy and vice chair of the department. Newsom said Gould has a great imagination and a "very fertile mind."

Darren DePoy, professor of astronomy, agrees, stating Gould is a "ridiculously smart" person. "He drives himself extremely hard," DePoy said.

Gould graduated cum laude in mathematics from Stanford University in 1971 and returned there after a job in industry to obtain his doctorate in physics in 1988. He conducted research at the Institute for Advanced Study in Princeton before joining the Ohio State faculty in 1993. He received an Alfred P. Sloan fellowship in 1994 and has since mentored doctoral students who have achieved several distinctions of their own: Four earned Presidential Fellowships, and one earned the prestigious Hubble Fellowship and was named a "Top 20 Scientist to Watch" by *Discover Magazine*.



Andrew Gould

Gifts Create **Keenan-Slettebak Reading Room and Bollinger-Kissell Endowment Funds**

Allison Heinrichs and Allen Schade study in the reading room.



Glance into the Keenan-Slettebak Reading Room and you'll see shelf upon shelf of astronomy-related journals, books, and almanacs, racks of scientific magazines, and the occasional student engrossed in his or her studies.

This reading room, created in June 2001 and located at the south end of the fourth floor of McPherson Laboratory, was made possible through an endowment from the estate of Phillip C. Keenan and contributions by Dr. Kenneth E. Kissell, a three-time graduate of Ohio State. The endowment was made to honor the lives of Philip C. Keenan and Arne Slettebak, emeritus professors of the Ohio State

Department of Astronomy.

Keenan is known for his work with Dr. W. Morgan in developing the Morgan-Keenan system that classifies stars according to their spectra. Keenan was a professor at Ohio State from 1946 until his retirement in 1976. He continued research for 24 years after his retirement. (For more information, see "In Memoriam," page 31.)

Slettebak's work set high standards for data description and measurements, particularly in the study of B-type emission-line (Be) stars. Slettebak came to Ohio State in 1949 and served as the first chair of the Department of Astronomy from 1962 until 1978. He remained a member of the faculty until his retirement in 1994.

In addition to the Keenan-Sletteback Reading Room endowment fund, Dr. Kissell also established the Bollinger-Kissell endowment fund in honor of his friend, Loren E. Bollinger, a science columnist with *The Columbus Dispatch* and an instructor in aerospace engineering. This endowment provides funding for the Bollinger-Kissell Award for Science Writing, a scholarship designed specifically to encourage students in the Department of Astronomy, the School of Communications (formerly called the School of Journalism), and the College of Engineering who want to become science writers.

"Ken Kissell has been a wonderful patron to us," said Patrick Osmer, chair and professor of the Department of Astronomy. "He has been enormously helpful."

Cox's Gift to Name Professorship

Henry L. Cox received his master's degree in physics in 1951 and his Ph.D. in 1955 from The Ohio State University. "I nearly went to Minnesota," he said, "but Ohio State's acceptance letter came first, and when Minnesota's letter came, I was on my way to Columbus!"

He then spent 35 years working in research and development at Westinghouse and living in Baltimore.

"I spent quite a bit of time working on applications of gas plasma," he said. One problem his group struggled with was eventually solved by a different company hired by the U.S. Navy, using his group's work. "The next best thing to completing a project is seeing it work for something else."

In addition to his interest in physics, Dr. Cox had a love for the stars and for boating. He spent 23 years teaching celestial navigation to a civilian organization in the Baltimore area. "The most important part was to teach safe boating," Dr. Cox said. His boat was a 13-foot-long Boston Whaler. "It was the smallest boat on the Bay in which I could still feel safe."

Dr. Cox now resides in Florida, and his love of physics and astronomy has led him to make a generous gift to the College of Mathematical and Physical Sciences to benefit both departments. His planned gift will be used to support the exceptional and cutting-edge research of a faculty member in the Department of Astronomy for a five-year term and then the Department of Physics, also for a five-year term. Recipients will be recognized as the Henry L. Cox Professor.

Endowment Brings Stars to Columbus Regardless of Weather

Clear, starry nights are rare in Columbus, Ohio. You can consider yourself lucky if you see the stars more than once a week in a city that had only 75 clear nights last year. Fortunately, people who live in Columbus have access to a starry sky, regardless of weather or light conditions.

The Ohio State University Department of Astronomy offers programs for the general public at least once a month from its planetarium, located on the fifth floor of Smith Laboratory, 174 W. 18th Ave.

The shows, which are free of charge, are made possible through volunteer efforts by the Department of Astronomy faculty and graduate students, along with funding from the Walter E. Mitchell Jr. Endowment. This fund was made possible through contributions from the estate of Dr. Mitchell, a former professor of astronomy at Ohio State.

"Dr. Mitchell really liked the planetarium and left money to the College of Mathematical and Physical Sciences for its upkeep," said Gerald Newsom, vice chair and professor of astronomy. "It allows us to keep the planetarium in good working order."

Topics covered in the planetarium shows include a general description of the night sky, how it changes over time, how it changes

depending on your position on Earth, and why the Earth has seasons. The shows are given by graduate students in the Department of Astronomy and are presented at a level appropriate for students taking introductory-level astronomy courses.

Once the 45-minute planetarium show is finished, participants can go up to the roof of Smith Laboratory and look through the department's new 12-inch telescope to get a view of the actual night sky.

For more information about the planetarium and the schedule of shows, head to www.astronomy.ohio-state.edu/~headta/roof/.

Professor Gerald Newsom conducts a planetarium show.



GIFTS TO THE DEPARTMENT

Adam Steed, right, and a visitor at the roof telescope in Smith Lab



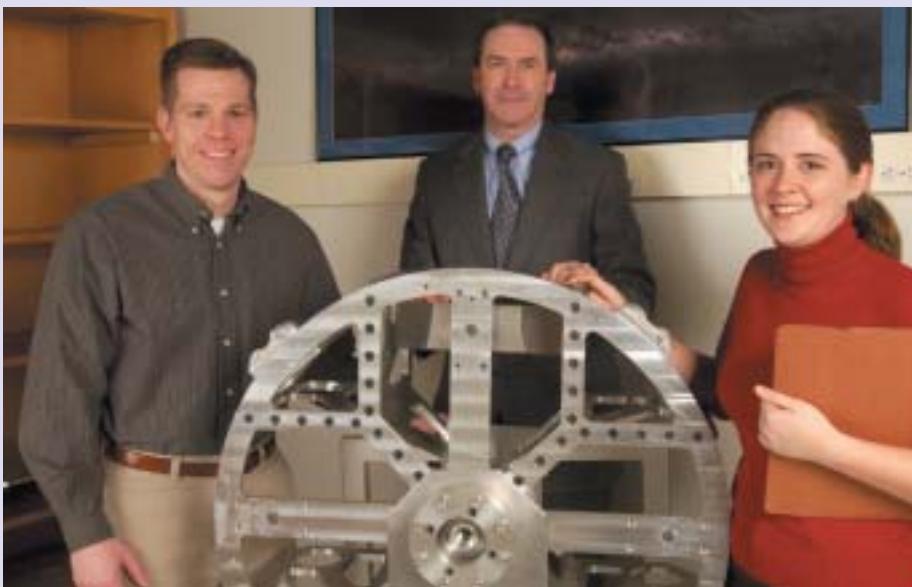
David G. Price (center) with fellow recipients Christopher Morgan and Jennifer Marshall.

David G. Price Fellowship Allows Graduate Students to Focus on Instrumentation

Dr. David G. Price's interest in astronomy has not waned since his graduation from The Ohio State University in the 1970s. Price has donated his time and expertise by serving the College of Mathematical and Physical Sciences as the college representative to the Alumni Advisory Board of The Ohio State University Alumni Association and on the Large Binocular Telescope (LBT) advisory board. To further assist the Department of Astronomy in the LBT project, Price has established an endowment: the David G. Price Fellowship in Instrumentation.

"This fellowship provides funding to support a graduate student or postdoctoral researcher's work on instrumentation projects," said Gerald Newsom, vice chair and professor of astronomy. "The student can then dedicate their time to work on instrumentation, instead of as a research or teaching assistant."

(continued on page 24)



Price Fellowship (continued from page 23)

The fellowship was first awarded in 2001. For the first two years, the award went to support graduate student Jennifer Marshall for her work on the Multi-Object Double Spectrograph, or MODS. MODS is 3.5 meters long and weighs about 1.5 tons, so it will flex slightly as the telescope moves.

"I'm working on an Image Motion Compensation System [IMCS] that will compensate for the bending of MODS with gravity," Marshall said. "It will allow motors attached to the collimator mirror to change the mirror's position to account for the

movement of the structure. Basically, it will keep the light from the star in the same place on the detector at all times."

Chris Morgan is working on an instrument that will measure the time-variability of gravitationally lensed quasar systems that will be installed on the Hiltner 2.4-meter telescope at the MDM Observatory.

Price's generosity has been a great help in assisting The Ohio State University in its participation in the LBT project, according to Newsom.

"He's one that we really treasure."

Slusher Scholarship Encourages Exceptional Undergrads

To show his appreciation for the kind assistance he received from Gerald Newsom and his wife Ann, L. Earl Slusher has established an endowment fund in the Department of Astronomy. This fund has since been used to create the L. Earl Slusher Scholarship in Astronomy, an annual scholarship for astronomy undergraduates.

"This scholarship is given to an outstanding astronomy major who has shown promise for graduate work in astronomy," said Newsom, who handles the details of the scholarship.

"The award serves as a pat on the back to let our students know that they are not only meeting but also exceeding our expectations," said Brad Peterson, professor of astronomy and undergraduate advisor. "That's something that needs to be rewarded."

The award is usually given to a junior or senior who is ultimately selected by the department chair, though the nomination of students is a joint decision made by faculty members who have taught or worked closely with them.

"I've definitely received support and encouragement from the staff and faculty here," said Mark Pitts, who had a dual major in astronomy and physics and was the 2002 scholarship recipient. "I've been able to do research toward my senior thesis and make a little extra money."

The amount of the award varies from year to year and is usually between \$2,000 and \$2,500. Although it can be an annual award, the scholarship is only given when faculty members deem a student truly exceptional. Students are not previously informed they have been nominated for the award, so it comes as a surprise to most.

See page 30 for a list of scholarship recipients.

The Ohio State University Department of Astronomy

Naming Opportunities

You can support excellence in
The Ohio State University
Department of Astronomy.
For more information, please contact
James Azzaro, development officer,
College of Mathematical and
Physical Sciences, at (614) 292-6980
or azzaro.1@osu.edu.

| | | |
|---|-------|---------------|
| Large Binocular Telescope | | \$25 million |
| Imaging Sciences Laboratory at McPherson | | \$2 million |
| Multi Object Double Spectrograph | | \$2 million |
| Endowed Chairs | | \$1.5 million |
| Endowed Professorships | | \$750,000 |
| Postdoctoral Fellowships | | \$75,000 |
| Graduate Fellowships | | \$35,000 |
| Undergraduate Scholarships | | \$10,000 |



STUDENTS ENJOY A PLANETARIUM SHOW



Andrew Heckler, left, assistant dean of the College of Mathematical and Physical Sciences, and Brad Peterson, professor in the Department of Astronomy

Ohio State Space Week Features Astronomy Activities

In October 1998, the nation watched as John Glenn, Ohio State adjunct professor and former U.S. senator, returned to space on the shuttle Discovery.

At Ohio State, interest in the world-famous astronaut's mission started months in advance and culminated in a widely successful tribute to Ohio State's participation in space research, featuring the Department of Astronomy at numerous events.

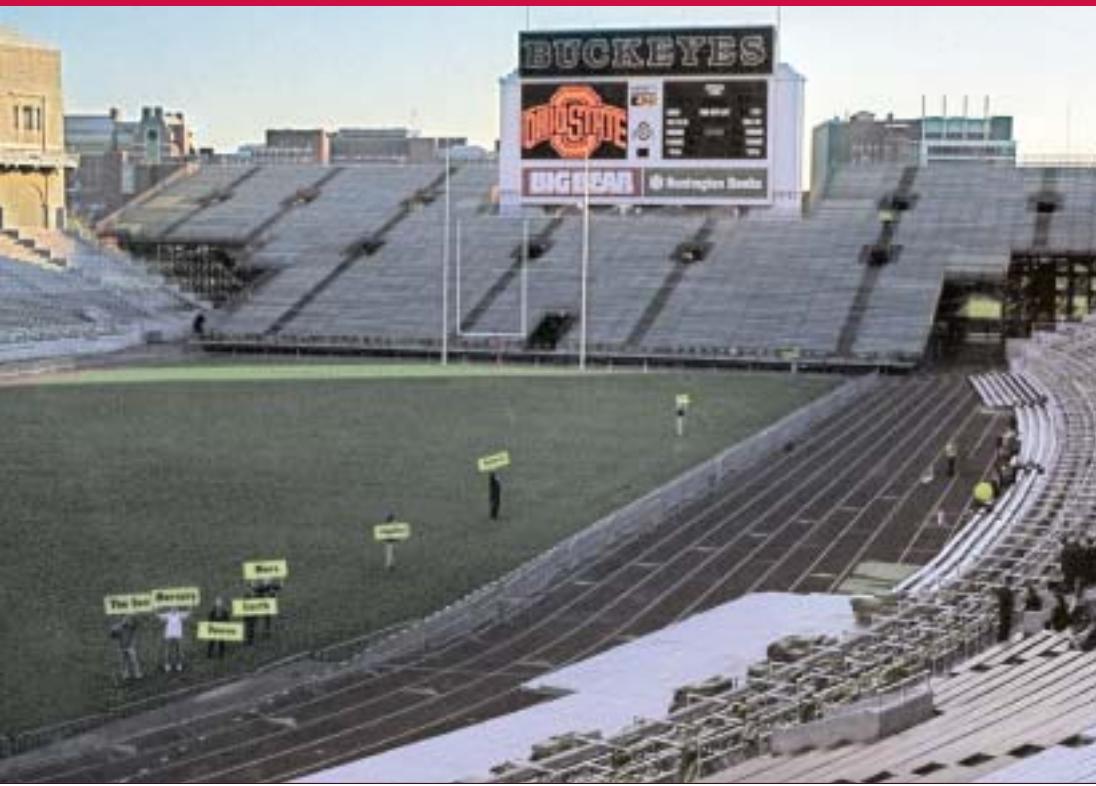
A special display from the department was the backdrop for then-President William Kirwan's news conference in which he highlighted the variety of space research programs in progress at Ohio State. The display was a highlight of the space research exposition held in Bricker Hall.



Former Ohio State President William E. Kirwan welcomes media and faculty to Space Week.

"The Big Bang: Seeing Back to the Beginning."

Pat Osmer, professor and chair in the Department of Astronomy, and Terrence Walker, associate professor in the Departments of Physics and Astronomy, offered a well-attended public talk, "The Big Bang: Seeing Back to the Beginning." They took listeners on a guided tour of the history of the universe from its fiery beginnings to the stars and galaxies we see today. Their discussion included Ohio State's contributions to our understanding of the universe as well as the latest results from modern space observatories such as the Hubble Space Telescope.



How Big Is the Solar System?

Graduate students from the Department of Astronomy assisted Professor Osmer during the John Glenn Aerospace Invitational, a program sponsored in part by Ohio State University Extension. They gave children in grades three through 12 a look at a scale model of the solar system using the world's largest classroom—Ohio Stadium.

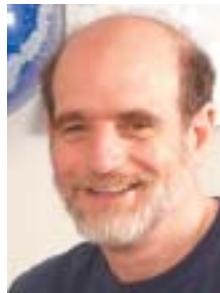
The demonstration featured a 25-foot balloon and an apple approximately 3 inches in diameter. Professor Osmer explained to the 400 students in attendance that the comparative sizes of the sun and the Earth are similar to the difference between the huge balloon and the small apple. Students were asked to imagine that sun was the size of a Ping Pong ball. Professor Osmer placed the ball in the end zone of the football field, and graduate students bearing signs naming each planet positioned themselves at the approximate comparative distance from the "sun."

Graduate Program Prepares Students for Bright Futures



Professor Darren DePoy

"Most students do several independent research projects with different advisors during their first two years," Gould said, "so they learn several different research styles and are in a better position to develop a thesis topic themselves, rather than being handed one."



Professor Andrew Gould

Over the past decade, The Ohio State University Department of Astronomy has placed a tremendous emphasis on strengthening its graduate program—and has been rewarded with exceptional results.

"Thanks to the efforts of Professors Andy Gould, David Weinberg, and others, we've had great success," said Patrick Osmer, chair and professor of astronomy. "Our graduate students have excellent academic records and come from highly ranked undergraduate institutions. We involve our students intensively in research with the result that they have publication records surpassing that of any other program we know of by the time they graduate. That, and an emphasis on writing and communication skills, has enabled them to obtain the best postdoctoral positions in the world."

According to Professor Andrew Gould, the 10 students who have graduated in the past few years have gone on to postdoctoral positions at Caltech, the Institute of Astronomy (Cambridge, UK), Carnegie Observatories, the University of Chicago, the Institute for Advanced Study (Princeton, New Jersey), Observatorio de Brera (Italy), the University of Pittsburgh, and the University of California at Los Angeles.

This remarkable success is the result of an innovative approach to graduate education, including the early involvement of students in research, an order-of-magnitude class where students learn how to break down unfamiliar problems and derive basic results, the involvement of students in daily coffee discussions, participation by students in the weekly Journal Club talks, and trips to various conferences. This approach helps students develop communication and presentation skills, as well as an ability to discover interesting research opportunities in fields in which they may have had no formal preparation.

"Most students do several independent research projects with different advisors during their first two years," Gould said, "so they learn several different research styles and are in a better position to develop a thesis topic themselves, rather than being handed one."

To find out more about graduate study in astronomy at Ohio State, visit www.astronomy.ohio-state.edu/grad/. To download an application, please go to gradapply.osu.edu.

Patrick Osmer leads a graduate student discussion.



Prestigious Awards Recognize Outstanding Graduate Students

Students Receive Hubble Fellowships

Graduate students and postdocs from The Ohio State University Department of Astronomy have been recognized with the prestigious Hubble Fellowship.

Scott Gaudi, Robert Blum, and James Bullock received the fellowship, which provides funding for three years of study to recent Ph.D. recipients in astronomy, physics, and related disciplines. Paul Martini, another graduate student in the program, declined to accept the Hubble, in order to take advantage of his receipt of a Clay Fellowship (see below). Initiated in 1990, the Hubble Postdoctoral Fellowship Program allows fellows to take up their appointments at participating host institutions throughout the United States for research that is broadly related to the mission of the Hubble Space Telescope.

Clay Fellowship Awarded to Paul Martini

Paul Martini, a 2000 Ph.D. graduate of The Ohio State University Department of Astronomy, was awarded a Clay Fellowship at the Harvard-Smithsonian Center for Astrophysics.

This four-year postdoctoral research fellowship gives recent Ph.D. recipients a stipend and research budget to pursue study in instrumentation, observation, and theory in atomic and molecular physics, geophysics, the solar system, stars, galaxies, and cosmology at the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts.

At CfA, Martini will be investigating the origins of quasars and the growth of the black holes that power them. He will also begin work on a new infrared instrument to search for galaxies around distant quasars. This project extends the research he began as a graduate student at Ohio State and continued as a Carnegie Fellow at the Observatories of the Carnegie Institution of Washington in Pasadena, California.



Paul Martini

Recent Ph.D. Recipients

Vijay Krishna Narayanan, Ph.D. 1999

Dissertation: *Reconstruction Analysis of Galaxy Redshift Surveys*
Advisor: David Weinberg
Current Position: Postdoctoral Fellow, Princeton University Observatory

Solange V. Ramírez S., Ph.D. 2000

Dissertation: *Stellar Abundances in the Inner Bulge and Galactic Center*
Advisor: Kristen Sellgren
Current Position: Postdoctoral Fellow, SIRTF

B. Scott Gaudi, Ph.D. 2000

cfa-www.harvard.edu/~sgaudi/
Dissertation: *Microlensing and the Search for Extrasolar Planets*
Advisor: Andy Gould
First Postdoctoral Position: Hubble Fellow, Institute for Advanced Study
Current Position: Postdoctoral Fellow, Harvard University

Paul Martini, Ph.D. 2000

cfa-www.harvard.edu/~pmartini
Dissertation: *The Structure and Evolution of Galaxies*
Advisor: Darren DePoy
First Postdoctoral Position: Carnegie Fellow, Carnegie Observatories
Current Position: Clay Fellow, Harvard University

Alberto Conti, Ph.D. 2000

www-int.stsci.edu/~acconti/
Dissertation: *Interpreting the Properties of Galaxies*
Advisors: Barbara Ryden and Pat Ossmer
Current Position: Computer Scientist, CSC/STScI

Andrew Stephens, Ph.D. 2001

www.astro.princeton.edu/~stephens/
Dissertation: *The Stellar Populations of Nearby Galaxies*
Advisor: Jay Frogel
Current Position: Princeton/Catolica Postdoctoral Fellow,
Princeton University and the Universidad Catolica, Santiago, Chile

Andreas Berlind, Ph.D. 2001

cosmo.nyu.edu/aberlind/
Dissertation: *Biased Galaxy Formation and Large Scale Structure*
Advisor: David Weinberg
Current Position: Postdoctoral Research Associate,
Department of Astronomy, University of Chicago

Jin-Hyeok An, Ph.D. 2002

www.astronomy.ohio-state.edu/Dept/phd_alumni.html
Dissertation: *Astrophysics from Binary-lens Microlensing*
Advisor: Andy Gould
Current Position: Postdoctoral Research Associate, Institute
of Astronomy, University of Cambridge, UK

Patrizia Romano, Ph.D. 2002

www.merate.mi.astro.it/%7Eromano/
Dissertation: *Multi-Wavelength Study of Narrow-Line Seyfert
1 Galaxies*
Advisor: Brad Peterson
Current Position: Postdoctoral Fellow, Osservatorio
Astronomico di Brera, Merate, Italy

Samir Salim, Ph.D. 2002

Dissertation: *Applications of High-Resolution Astrometry to
Galactic Studies*
Advisor: Andy Gould
Current Position: Postdoctoral Researcher, Division of Astronomy
and Astrophysics, University of California at Los Angeles



Jordi Miralda-Escudé captures the students' attention in the classroom.

heat from the surface to the air
troposphere.

What Are Two of the Most Popular Undergraduate Courses?

According to an article in Ohio State's student newspaper, *The Lantern*, astronomy is among the most popular subjects for undergraduates trying to satisfy their general education curriculum (GEC) science requirements. The introductory astronomy sequence, Astronomy 161 and 162, offers students the opportunity to learn about the one topic that seems to interest everyone: the night sky.

Astronomy 161 covers the sky visible by the naked eye, the history of astronomy, the physics of light and matter, and a comparison of the planets in the solar system. In Astronomy 162, students learn about the life cycles of stars, the nature of galaxies, and the origin of the universe.

The courses have earned an appealing reputation for all undergraduate students, regardless of major. Many students in the introductory courses have a general knowledge of the solar system and the universe, and they are enthusiastic about learning more. Department chair Pat Osmer said that students are interested in the nature of astronomy as an ever-changing field, with exciting research and new discoveries occurring every day. He explained that the goal of his department is not to simply fulfill a requirement but to help students understand how the universe works. "We're concerned about delivering the best possible course," he said.

Students especially enjoy the enthusiasm of Associate Professor Barbara Ryden. She employs many demonstrations to help students better understand phenomena such as eclipses and star formation. One of Ryden's most popular visual aids is a stuffed warthog, which she frequently uses to illustrate astronomical concepts.

Astronomy is a visual science, she told *The Lantern*. "It has a great appeal to the public at large."

Darren DePoy teaches his astronomy courses with enthusiasm.

Astronomy 161 and 162



Professor Ryden shows off her favorite teaching tool, a stuffed warthog.



Students have responded well to the changes in the structure of astronomy courses.

Department of Astronomy Revitalizes Undergraduate Program

Over the past 10 years, the Department of Astronomy has honed its course offerings to better fit the needs of the science community and produce well-educated graduates. For instance, the introductory class for astronomy majors is now a 200-level course that requires students to complete a year of physics and calculus first. "We hope this will reduce the huge gap between the freshman astronomy courses and the senior courses," said Bradley Peterson, a professor in the department.

Upper-level courses were also revamped. In addition to the traditional 600-level astrophysics and star studies, students are also studying stellar interiors and cosmology. These subjects allow professors to increase the amount of math and physics needed to prepare students for graduate work.

"It was a modernization," said Gerald Newsom, professor and vice chair in the department.

Students are also strongly encouraged to participate in undergraduate research projects with members of the Ohio State faculty and at research facilities abroad. Research experience gives good students the edge they need to get into the best graduate programs.

"We're always looking at the ways we can do things better, ways that we can improve the educational experience of our undergraduates," Peterson said.

Stutz Helps Rethink Standard Universe Measurements

When Amy Stutz agreed to help Department of Astronomy Professor Andrew Gould with a research project, she had no idea she would—as an undergraduate—publish a paper in a prestigious astronomy journal, peer at galaxies through a telescope in Chile, or go to Tasmania to search for dark matter.

**Amy Stutz**

The Ohio State graduate, who received her bachelor's degree in astronomy and physics in 2002, worked as a research assistant in the department during her undergraduate career. She has already made an impact on the field. The research she published in the *Astrophysical Journal* with Professor Gould revealed that a type of star astronomers use as a standard ruler to measure the size and age of the universe might not be standard after all. If, as Gould and Stutz found, the stars vary in brightness and color, all measurements based on those stars may be off-kilter.

This research earned Stutz a first-place, \$500 prize in The Ohio State University's annual Denman Undergraduate Research Forum. The Ohio State University Board of Trustees also recognized her in the fall of 2001 with their Student Recognition Award.

Stutz spent the summer of 1999 surveying galaxies at Cerro Tololo Inter-American Observatory atop the Andes in Chile. During the summer of 2000, she traveled to Canopus Observatory in Tasmania, Australia, where she searched for planets around other stars.

Stutz started graduate school at the University of Arizona in the fall of 2003.

astronomy journal, peer at galaxies through a telescope in Chile, or go to Tasmania to search for dark matter.

**Amy Stutz**

L. Earl Slusher Scholarship in Astronomy Past Award Recipients

1993**Sean M. Smith:**

received master's in education at Ohio State and went into teaching

1994**Gordon A. Baugh:**

received master's in education at Ohio State and went into teaching

1997**Choong C. Ngeow:**

went on to graduate school in astronomy at University of Massachusetts

**Choong C. Ngeow****1998****Jill S. Jacobs:**

received master's in education at Ohio State and went into teaching

2000**Karoline M. Gilbert:**

currently in graduate school in astronomy at University of California Santa Cruz, recipient of a graduate fellowship from the National Science Foundation.

2001**John H. Harrison:**

(no information available)

2002**Mark A. Pitts:**

currently in graduate school in astronomy at University of Hawaii

Arne Slettebak came to Ohio State in 1949 as an instructor, and was made a full professor in 1959. He was director of the Perkins Observatory from 1959 to 1978, and was the first chair of the Department of Astronomy, a position he held between 1962 and 1978. During that time, he oversaw the conversion of astronomy into an independent department, and he helped move it from the aging McMillin Observatory to Smith Laboratory. Slettebak retired from the faculty in 1994 after 45 years of service at Ohio State. He passed away in 1999.

Dr. Slettebak was born in Freistadt Danzig (now Gdansk, Poland) on August 8, 1925, and immigrated to the United States with his family in 1927, becoming a naturalized U.S. citizen in 1932. He was a graduate of the University of Chicago, receiving a B.S. in Physics in 1945 and a Ph.D. in Astronomy in 1949.

The professor's principal research work was on stellar rotation and spectroscopy, particularly the study of B-type emission-line (Be) stars. His work set high standards for data description,

measurements, and caution in interpretation. Many of his papers on Be stars remain among the standard benchmark references for describing the spectral signatures of those stars.

In the larger astronomical community, Dr. Slettebak served as a councilor of the American Astronomical Society from 1964 to 1967, and was a member of the AAS Education and External Awards Committees. In the International Astronomical Union, he was a member of IAU Commissions 29 (Stellar Spectra) and 45 (Stellar Classification), serving as vice president and then president of Commission 45 from 1976 to 1982, and was active in the Working Group on Active B Stars.

From 1961 until 1978, he was on the board of directors of the Association of Universities for Research in Astronomy (AURA), serving as chair of the Scientific Committee for three of those years. During his career, Dr. Slettebak also held Fulbright fellowships at Hamburg and Vienna, and was a visiting professor at Vienna and Strasbourg.



Arne Slettebak

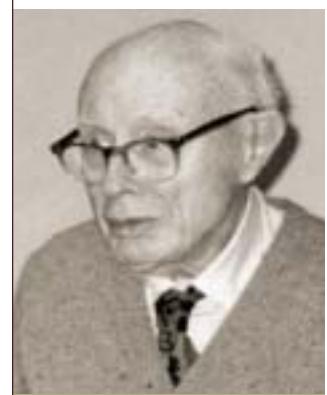
The work in the classification of stars by Philip C. Keenan, emeritus professor of astronomy at The Ohio State University, helped astronomers understand the chemical evolution of galaxies. He wrote the *Atlas of Stellar Spectra* in 1943 with Dr. W. W. Morgan, who died in 1994. Their system of classifying stars by their spectra, or the wavelengths of light they emit, is still in wide use.

In 1997, Dr. Keenan claimed the title of longest publishing astronomer with the publication of a new atlas of stars with atmospheres rich in carbon, aptly named "carbon stars," in the *Journal of the Astronomical Society of the Pacific*.

Dr. Keenan was born in Bellevue, Pennsylvania, on March 31, 1908. As an undergraduate at the

University of Arizona, he published his first paper in 1929, describing the color of the moon during eclipses. He received his B.S. and M.S. degrees from the University of Arizona in 1929 and 1930, respectively, and his Ph.D. from the University of Chicago in 1932; he was an instructor there from 1936 until 1942. Dr. Keenan was a physicist with the Navy Bureau of Ordnance from 1942 until 1946.

In 1946, he became an assistant professor in the department of astronomy at Ohio State and a member of the staff at Perkins Observatory. He retired from Ohio State in 1976, but continued his research here for 24 years, until his death in 2000.



Philip C. Keenan

Professor Walter E. Mitchell earned his B.S. degree from Tufts College, his M.S. from the University of Virginia, and his Ph.D. from the University of Michigan. He joined The Ohio State University in 1957 as an instructor, moving through the professional ranks and becoming a professor in 1969. He retired as professor emeritus in 1991, and passed away in 1996.

Dr. Mitchell's research interests were concentrated in the high-resolution study of the spectrum of the sun, including measurements of the variation of spectral lines with location on the solar disk and with the 11-year sunspot cycle. Dr. Mitchell also worked on the theoretical interpretation of the observations to deduce conditions in the sun's atmosphere. While most of his publications were in solar physics, he also published papers on the spectra and photometry of several peculiar stars.

Before attending college, Professor Mitchell served in the U.S. Army in World War II, reaching the rank of 2nd lieutenant in the infantry. He was an assistant professor at Brown University for one year before coming to Ohio State. He frequently spent time observing at the Mount Wilson Observatory in California and Kitt Peak National Observatory in Arizona.

Dr. Mitchell was a member of the American Astronomical Society (including the Solar Physics and the Historical Astronomy divisions), the Royal Astronomical Society, the International Astronomical Union, and the Great Lakes Planetarium Association. He had a special interest in undergraduate education and public outreach through the use of Perkins Observatory and the planetarium on the Ohio State campus.



Walter E. Mitchell

**Meet the current faculty
in the Department of
Astronomy and learn about
their areas of expertise.**



Richard Boyd,
Professor of Astronomy,
Physics and Chemistry,
Ph.D., Univ. of
Minnesota, 1967

My efforts are in neutrino astrophysics, specifically detection and understanding of supernova neutrinos, and nuclear astrophysics, specifically measurement of cross sections associated with the rp-process, and production and observation of nuclei along the r-process path. Currently I'm serving as a program officer at the National Science Foundation in Particle and Nuclear Physics. (PAGES 14, 15)



Andrew Gould,
Professor of Astronomy,
Ph.D., Stanford Univ.,
1988

My three central interests are microlensing, galactic structure, and planet detection. I am PI of the Space Interferometry Mission (SIM) Microlensing Key Project to measure the mass function of dark objects. I am searching for planets using microlensing and transits. I study halo stars as probes of early galactic history. (PAGES 12, 21, 26, 30)



**Jordi Miralda-
Escudé,**
Assoc. Professor of
Astronomy, Ph.D.
Princeton Univ., 1991

I work on the early history of galaxy formation and the reionization of the intergalactic medium, and the relation between galaxies and the absorption spectra caused by intergalactic gas. I am also interested in the development of substructure in dark matter halos and in the Galactic Center. (PAGES 16, 28)



Darren DePoy,
Professor of Astronomy,
Ph.D., Univ. of Hawaii,
1987

I am currently involved in observational programs studying gravitational microlensing events, variable stars in clusters and the Galactic Center and searching for extra-solar-system planets. I also actively participate in instrumentation projects. (PAGES 8, 10, 21, 26, 28)



Eric Herbst,
Professor of Physics,
Astronomy, and
Chemistry, Ph.D.,
Harvard Univ., 1972

We study the formation of molecules in both interstellar and circumstellar sources. The observation of molecules yields detailed information about physical conditions in various sources if one understands the details of molecular formation. We have developed chemical models for an assortment of sources, with particular attention paid to sites of active star formation. (PAGES 14, 15)



Gerald Newsom,
Vice Chair and Prof. of
Astronomy, Ph.D.,
Harvard Univ., 1968

While I maintain an active interest in discoveries astronomical, my duties as vice chair and in the classroom no longer allow time for research. (PAGES 18, 21, 23, 24, 29)



Jay Frogel,
Professor of Astronomy,
Ph.D., Cal. Tech., 1971

Current interests: stellar and galactic evolution and stellar synthesis models of galaxies. My research is based primarily on infrared observation of stars, clusters, and galaxies from the ground and from space, although I am collaborating with others on making UV observations of the same galaxies that are observed in the infrared. For the past two years, I have been on leave of absence at NASA Headquarters in Washington, D.C. There, I worked as the infrared discipline scientist and program scientist for the recently launched Spitzer Space Telescope and the Herschel Telescope, to be launched in 2007. (PAGE 27)



Chris Kochanek,
Ohio Eminent Scholar
and Professor of
Astronomy
Ph.D., Cal. Tech., 1989

My research consists of theoretical and observational studies in extragalactic astronomy and cosmology. This includes the structure and evolution of galaxies, cosmology, quasars and their hosts, gravitational lenses, and the interstellar medium. (PAGE 16)



Patrick Osmer,
Chair and Professor of
Astronomy, Ph.D., Cal.
Tech., 1970

My main research interest concerns the evolution and nature of quasars, particularly at high-redshift, where we observe the peak activity of optically selected quasars. A long-term goal is to understand better how quasars form and evolve and how they are related to developments in their host galaxies. (PAGES 2, 4, 10, 12, 22, 25, 26, 28)



Bradley Peterson,
Professor of Astronomy,
Ph.D., Univ. of Arizona,
1978

My research is directed toward determination of the physical nature of active galactic nuclei (AGNs) or quasars. The focus of my current research is probing the structure of the broad emission-line region in these sources and determining the masses of their central supermassive black holes. This research involves ground-based telescopes as well as space-based observatories such as Hubble Space Telescope. (PAGES 21, 29)



Smita Mathur,
Associate Professor of
Astronomy, Ph.D. Tata
Inst. of Fundamental
Research, 1991

I work on active galactic nuclei, from the highest redshift quasars to low redshift Seyfert galaxies. I do multiwavelength observations with emphasis on X-rays. I have been studying absorption systems to study the environment around nuclear black holes. Recently, my focus has shifted to observations of the warm-hot intergalactic medium predicted by cosmological theories. (PAGES 13, 17)



Marc Pinsonneault,
Associate Professor of
Astronomy, Ph.D., Yale
Univ., 1988

In the area of stellar structure, I work on extending our understanding of the physics of stars, concentrating on processes traditionally neglected in theoretical calculations. In stellar evolution, I work on topics with broad applications to astrophysics. Recently I've become interested in the properties of protostars as a window into our understanding of star and planet formation. (PAGE 20)



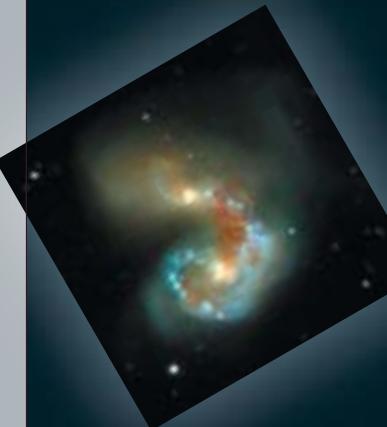
Barbara Ryden,
Associate Professor of
Astronomy, Ph.D.,
Princeton Univ., 1987

I am interested in the internal structure of galaxies and other stellar systems; in particular, I am studying how the morphology and dynamics of a galaxy are affected by the presence of a central black hole. I also have a continuing interest in the evolution of intergalactic voids. (PAGES 18, 20, 28)



Donald Terndrup,
Associate Professor of
Astronomy, Ph.D., U.C.
Santa Cruz, 1986

My research areas are in stellar populations and stellar rotation. I am completing an extensive survey to find hot horizontal-branch stars in the bulge of the galaxy. I am also working on new observations of stellar rotation, to constrain models of the angular momentum evolution in stars and the amount of core/envelope mixing. (PAGES 18, 20)



Richard Pogge,
Professor of Astronomy,
Ph.D., U.C. Santa Cruz,
1988

My research is primarily concerned with the astrophysics of active galactic nuclei, addressing questions of their interaction with their host galaxy environments, their circumnuclear stellar and gaseous environments, and the nature of their central black holes and how they might be fueled. This work uses ground-based telescopes, the Hubble Space Telescope, and the Chandra X-Ray Space Telescope. I also build instruments for imaging and spectroscopy, including the Ohio State Imaging Fabry-Perot Spectrometer (IFPS) and the MODS spectrographs for the LBT. My instrument work also involves the development of new data-acquisition and analysis software. (PAGE 20)



Kristen Sellgren,
Professor of Astronomy,
Ph.D.,
Caltech, 1983

I work on the Galactic Center, where I currently use infrared spectroscopy to measure elemental abundances, ages, and masses for stars in the Galactic Center. I am also using ground-based and space-based infrared imaging and spectroscopy to study molecular hydrogen and large aromatic molecules. (PAGES 18, 19)



Terrence Walker,
Professor of Physics
and Astronomy, Ph.D.,
Indiana Univ., 1987

My research interests lie at the interfaces between particle physics, astrophysics, and cosmology. Dark matter candidates and their detection, ultrahigh energy cosmic and gamma-rays, and neutrino astrophysics and cosmology form the current framework of my group's efforts. (PAGE 25)



Gary Steigman,
Professor of Physics and
Astronomy, Ph.D., NYU,
1968

My current research compares the constraints on the baryon (nucleon) density of the universe and its radiation content at two epochs in its evolution: Big Bang Nucleosynthesis (BBN), which probes the universe at 20 minutes and the Cosmic Background Radiation (CBR), which offers a view some 400,000 years later. The agreement between BBN and the CBR, while excellent, leaves some room for new physics beyond the standard models of particle physics and cosmology. (PAGES 14, 19)



David Weinberg,
Professor of Astronomy,
Ph.D.,
Princeton Univ., 1989

I study the formation and evolution of galaxies, the clustering of galaxies, and the intergalactic medium. Most of my work is "observationally oriented theory," often involving computer simulations. As a member of the Sloan Digital Sky Survey, I am especially interested in using the survey to learn about the early universe, galaxy formation, and quasar evolution. (PAGES 12, 14)



Anil Pradhan,
Professor of Astronomy,
Ph.D., Univ. College
London, 1977

The atomic astrophysics program at Ohio State is aimed at spectroscopic diagnostics of astronomical objects: nebulae, active galactic nuclei, quasars, supernovae, stars, and the interstellar medium, to determine temperatures, densities, abundances, ionization, and kinematics. The theoretical physics program entails quantum mechanical studies of fundamental atomic processes and astrophysical applications. Most of the work entails large-scale computations at the Ohio Supercomputer Center. (PAGE 14)

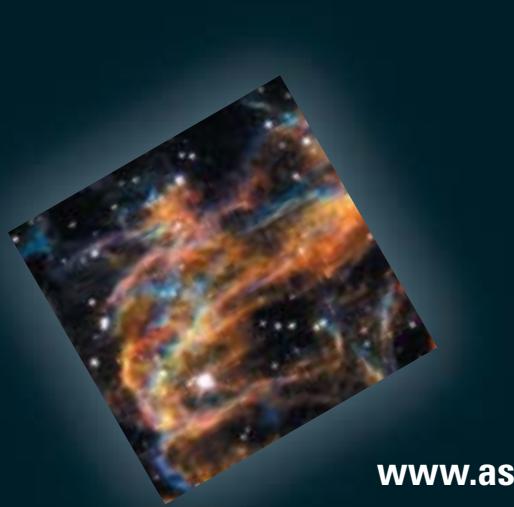


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