Amanda Morris

HEAVENS ABOVE AND BEYOND:

The Dearborn Observatory and CIERA

Gathering of the American Astronomical Society on the steps of the Observatory in 1914. Edwin Hubble is the third person from the right. Image from the American Institute of Physics Emilio Segre Visual Archives.

In 1609 Galileo first used a telescope to study the sky — an event the United Nations commemorated by the 2009 International Year of Astronomy. In 1889 Northwestern's Dearborn Observatory was dedicated. The observatory housed a telescope with an 18.5-inch lens ground in the 1860s, the largest in the world at the time. Today, in the observatory and in offices in the Technological Institute at Northwestern, faculty, postdocs, and students are using 21st-century instruments to study events that occurred throughout the universe going back billions of years as well as to record what's happening in skies now.

Dave Meyer, physics and astronomy and director of the Dearborn Observatory, has on his wall a photo of a gathering of the American Astronomical Society on the steps of the observatory in 1914. Pointing out Edwin Hubble, then working on his PhD at the University of Chicago, he says, "That meeting may well have been the catalyst to get Hubble to look at galaxies and figure out that the universe was expanding."

Hubble discovered that there are galaxies beyond the Milky Way, and it is for him the Hubble Space Telescope, first launched in 1990, was named. Meyer uses data from the Hubble Space Telescope in his research, studying the interstellar gas between the stars in the Milky Way Galaxy.

Dave Meyer

In addition to taking photos, the telescope also has spectrographs that can take light from a star and break it into its colors. Spectroscopy, Meyer explains, can help determine the composition of interstellar gas clouds. "The past 30 to 50 years have been a golden age in astronomy, with a wide variety of new observing facilities,

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Vicky Kalogera

Fred Rasio

both on the ground and particularly in space," Meyer says. "There are certain wavelengths of light — like X-ray and gamma ray and ultraviolet — that we can't see from the ground because our atmosphere blocks them. So once we put telescopes above the atmosphere, we can observe the universe at these wavelengths plus take clear optical pictures of nebulae and galaxies that don't get fuzzed out by atmospheric turbulence. That's why the Hubble pictures from space are so spectacular."

Astronomy is a popular science, and it is often a gateway to the study of other sciences. "It gets kids interested in the sciences," Meyer says. "It gets them asking questions." Astronomy is one of the few sciences that allows undergraduates at Northwestern to work on research projects, beginning as early as first quarter freshman year.

It was a research project during her own undergraduate education that enticed Meyer's colleague, Vicky Kalogera, physics and astronomy, into the study of astronomy and eventually brought her to Northwestern to do research. She specializes in the more theoretical study of the skies, especially compact objects, neutron stars, and black holes. Concerning undergraduate research, she says: "For freshmen, we try to design research that's challenging but doesn't drown them in what they don't know. We try to design the right projects for the right levels — projects that demonstrate research teamwork, going beyond the classroom. It's a pleasure to see what they can do."

Astrophysics the Interdisciplinary Way

Kalogera, with Meyer and Fred Rasio, physics and astronomy, have created the new Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA), which started in September. "We are interested in creating a vibrant environment that will strengthen existing, unofficial relationships, as well as create new ones, between the astrophysics group and other groups across the University," explains Kalogera. "There are many centers for astrophysics throughout the nation, but none of them really explore the interdisciplinary relationships that astrophysics has with other disciplines." She cites computer science, applied mathematics, earth and planetary sciences, materials science, chemistry, and biology as areas of collaboration.

Developing a program that attracts postdoctoral students — and with them new research directions — is CIERA's first goal. "It will support less-traditional research, act as a catalyst for interdisciplinary connections, and work to crystallize better arguments for funding," says Kalogera. "It became clear to us that having an entity that can promote these interdisciplinary research projects would give postdocs unique opportunities compared to what we were able to offer in the last decade," Kalogera says.

CIERA's inaugural event will take place February 5, with a lecture for students and the public on extrasolar planets

by world-renowned astrophysicist Geoffrey Marcy of the University of California, Berkeley. Marcy's group has discovered more extrasolar planets than anyone else in the world, and Marcy is considered at the heart of the revolution that started about 15 years ago with the first clear detections of planets outside our solar system.

"The topic of extrasolar planets connects to the subject of astrobiology, the study of the origin, evolution, and distribution of life in the universe," says Kalogera. "Astrobiology is an up-and-coming area that we want to pursue in collaboration with people at Northwestern in planetary science, of course, but also in biology and chemistry."

Answering Life's Big Questions

"Because of our growing understanding of extrasolar planets, we can now compare earth to planets in other systems," says Rasio. "The existence of extrasolar planets will help us answer some of the bigger questions of life in our universe that used to be considered philosophical or hypothetical. Using scientific data we can start to address questions such as, 'Is life on earth a stable commodity?' And 'Are we unique within the universe, and if so, why?'"

Rasio says that because of these discoveries the time is right for astrophysicists to get together with planetary scientists and geophysicists, bring in knowledge from other fields, and confront the big questions of life on this planet and possibly others. He explains: "A group of faculty members interested in astrobiology came together a few years ago when I organized two Domain Dinners [events designed to stimulate faculty interactions across departments and disciplines at Northwestern]. We started having regular astrobiology group meetings, and last year we started to plan real collaborative projects and proposals for external funding. We submitted our first major proposal to NASA last year, and although we didn't get funded, our group is now much bigger and more clearly organized. CIERA is to provide seed funding for this effort."

Kalogera's own research takes her into the theoretical realms of the universe. "Today, we infer the existence of neutron stars and black holes, while for many decades in astronomy we had no evidence that these things existed. The first observational data came in the late 1960s for neutron stars and early 1970s for black holes. The way we observe them is based on how they influence their environment," she says.

Studying these extreme phenomena theoretically often requires the use of large-scale supercomputers and the expertise of software engineers. The goal in this area of astrophysics has been to develop new tools that lead to code and algorithmic development "beyond the traditional education of astrophysicists," according to Kalogera. She and Selim Shahriar, electrical engineering, are both members of the scientific collaboration running the National Science Foundation-sponsored Laser Interferometer Gravitational Wave Observatory (LIGO), which is designed to open a whole new window onto the universe by detecting cosmic gravitational waves and harnessing them for scientific research.

The New Wave Is Gravitational

The study of gravitational waves — ripples in the fabric of space and time — dates back to Albert Einstein, who as part of his theory of general relativity in 1916 predicted that space time itself can be disturbed through gravity. The strongest disturbances are produced by interacting compact objects, such as neutron stars or black holes that collide and merge. The big bang that created the universe is believed also to have unleashed a flood of gravitational waves that are still present today and carry information about the universe as it was immediately after the big bang.

Rasio conducts research into dynamical systems to understand complicated phenomena that change over time, including the interactions of compact objects. He presently is using computer simulations to study gravitational wave sources. Such theoretical work will play a key role in the interpretation of the data to be collected by facilities such as LIGO and for planning more advanced detectors in the future. Rasio recently was awarded a grant from the National Science Foundation under the American Recovery and Reinvestment Act to help fund this research.

Dearborn Observatory with its historic 18.5-inch refracting telescope is open to the public every Friday night from 8 to 10 p.m. Call the observatory at 847-491-7650 for more information or to make reservations.

Visit CIERA at http://ciera.northwestern.edu.

—by Joan Naper