

Star attraction

With a new Ph.D. program and unique research projects, RIT scientists are building their own place in the universe of astronomy



The surface of Mars can hold dangers for exploration vehicles such as the Phoenix Mars Lander, which landed on the red planet May 25, 2008, as shown in this artist's conception. Among many research projects related to astronomy, RIT scientists are developing a new type of detector that will provide 3-D location information, significantly aiding possible future planetary explorations. (NASA/JPL)



RIT researchers are building an international reputation in the field of astrophysics. Their success will help launch RIT's doctoral program in astrophysical sciences and technology (AST) this fall.

"Astrophysics has universal appeal and what we have going here at RIT right now – and building strongly for the future – is really important to the growing image of RIT as the innovation university," says Stefi Baum, director of the Chester F. Carlson Center for Imaging Science and acting co-director of the AST program with physics head David Axon. "Recently we found that in terms of successful investigators on the Hubble Space Telescope, in the latest round, RIT ranked with the likes of MIT and Johns Hopkins, and outdistanced much larger and well-established departments such as those at Yale, Harvard, and Maryland."

Faculty from the Center for Imaging Science, the Department of Physics and the School for Mathematical Sciences in the College of Science work in two areas related to astronomy. Overlap between scientists who make astronomical observations and those who work with the technology side gives RIT's program a depth and richness uncommon in many astrophysics programs.

"We're very focused in a couple of research areas, and in those areas we're top-notch," Baum says. "Astronomy is a field that excites the public, including non-scientists. It's an area where RIT has made a mark very quickly."

Bright young stars

In July 2004, Joel Kastner and Michael Richmond were the first RIT professors to publish in the prestigious scientific journal *Nature*. Their international team used observations obtained from NASA's Chandra X-ray Observatory to follow the dramatic eruptions of a young star illuminating the newly discovered McNeil's Nebula. They made a connection between the gas falling onto the star from an orbiting disk, causing the visual-light eruption, and a powerful burst of X-rays resulting from the same, sudden episode.

"Young star outbursts are regularly seen (once every couple years) in visible light and in the infrared, but had never been followed in X-rays before our work on McNeil's Star," says Kastner. "Visible-light images had been made of this region several months before Jay McNeil made his discovery, so it could be determined approximately when and by how much the star flared up to produce McNeil's Nebula."

In addition to collaborating on projects

involving space-based observatories, Richmond, an associate professor of physics and the director of the RIT Observatory (located on John Street just south of campus), uses the RIT's 12-inch telescope to study a group of stars called cataclysmic variables. These are binary systems in which an ordinary star orbits a tiny but massive companion known as a white dwarf. The white dwarf steals some of the gas from the ordinary star, which glows brightly as it spirals to its doom on the white dwarf's surface. Kyoto University in Japan and Columbia University's Center for Backyard Astrophysicists collect data recorded by professional and amateur astronomers around the world.

Richmond also contributes to the Sloan Digital Sky Survey, a ground-based project to digitally map the sky. He analyzes astronomical images looking for supernovae – stars that explode. He is also a member of the calibration team working on the Supernova Acceleration Probe (SNAP), a future

What's does it mean?

Here's a glossary of some astronomical terminology:

Accretion disks: rapidly spinning disks of hot gas surrounding and falling into supermassive black holes.

Dark energy: mysterious energy linked to the accelerating expansion of the universe.

Dark matter: unseen material thought to make up about 22 percent of the universe; detected from its gravitational effects on objects.

Magnetar: highly magnetized neutron star formed by the collapse of a massive star.

Nebula: a cloud of interstellar gas and dust.

Quasars: "Quasi-stellar objects" – a type of active galactic nuclei (energetic cores) surrounding super massive black holes in young galaxies; luminous, distant objects too small to be directly imaged.

Spectroscopy: splitting light into its component colors (energies) to reveal physical properties of light emitted or reflected by an object.

Supernovae: massive stars that explode at the end of their lives.

White dwarf: tiny compact core of a star once about the size of the Sun that runs out of fuel and collapses to about the size of the Earth.

space mission to understand the dark energy linked to the universe's acceleration.

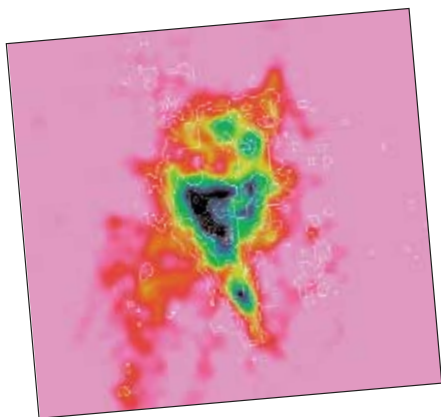
Massive discoveries

Donald Figer, a professor in the Center for Imaging Science, is also a member of SNAP, and a related project, the Large Synoptic Survey Telescope, which will seek dark matter in the universe. Figer's research involves massive stars, star formation at the centers of galaxies and sensor development. He co-authored a paper published in the May 29, 2008, issue of *Nature* – his third in the journal – announcing the detection of an infrared ring around a rare and exotic star known as a magnetar.

"Out of the 400 billion stars in our galaxy, there are about a dozen magnetars that we know of," says Figer. "Discovering the ring is groundbreaking because it discovers some other phenomena associated with and physically near a magnetar."

Figer pioneered the subfield of massive young star clusters. His research group is responsible for identifying five of the 10 known massive young clusters in the Milky Way Galaxy. Many of these discoveries were made through observations with an infrared spectrograph – the optics for which Figer designed – mounted on the world's largest telescope, the W. M. Keck Observatory in Hawaii.

In 1997, news that Figer had identified one of the most massive stars in the universe, the Pistol Star, landed Figer on the front page of *The New York Times* and interviews with international media.



In this overlay of two images from the Hubble Space Telescope, the colors show the Lyman alpha emission line, which is a tracer of warm gas where stars are forming. The white contours show the far ultraviolet emission from hot, recently formed stars. In these Hubble ultraviolet images, "We see only the stars on the near side of the cloud," explains physics professor Chris O'Dea, "because the ones inside the cloud are hidden (their light is absorbed by small grains in the clouds)."



Donald Figer

Stefi Baum

Chris O'Dea

The same 16 orbits on the Hubble that gave Figer the Pistol Star also provided evidence of the upper mass limit of stars and startling data and images of young stars in the Arches and Quintuplet clusters, revealing for the first time that young massive stellar clusters exist in the Milky Way.

Figer joined RIT through a faculty development grant awarded by the New York State Foundation for Science, Technology and Innovation to direct the Rochester Imaging Detector Laboratory in the Center for Imaging Science. The two-year-old laboratory has several active projects to develop detectors that promise fantastic discoveries. Figer and his team, working in collaboration with Massachusetts Institute of Technology's Lincoln Laboratory, are developing a new type of detector that uses LIDAR (Light Detection and Ranging), a technique similar to radar that uses light instead of radio waves to measure distances. The project will significantly extend NASA capabilities for planetary exploration by providing 3-D location information for planetary surfaces and a wider range of coverage than previously possible. Figer's team includes Baum and Zoran Ninkov, a professor in the Center for Imaging Science.

From Hubble to RIT

Figer, Baum and Axon all have roots in the Space Telescope Science Institute in Baltimore. Figer developed and tested detectors there for the James Webb Space Telescope, which will replace the Hubble Space Telescope. Baum and Axon worked on technology that made the Hubble Space Telescope possible.

Baum is currently collaborating with Chris O'Dea, RIT physics professor, on the study of giant galaxies using the Spitzer Space Telescope. Baum and O'Dea belong to an international team preparing to use the new Herschel Space Observatory's far infrared telescope to extract more information about the process of forming stars. The European Space Agency will launch the

satellite in the fall. O'Dea won NASA funding to manage the research conducted by the U.S.-based team of scientists.

"Astronomy is about interpreting the light we see," O'Dea says. "Herschel opens up a new window in the electromagnetic spectrum. It gives us access to a range of wavelengths we haven't really seen before because we need to go into space to observe these wavelengths to look at objects that are very faint."

The Spitzer study looking at the cooling intracluster gas and star formation also involves David Axon and Andrew Robinson in the physics department. Their complementary projects use different methods to explore the dynamics of active galaxies, especially those known as quasars.

Robinson and Axon are among the few astrophysicists proficient in a technique called spectropolarimetry, which can penetrate the galactic dust shrouding active galactic nuclei.

In November 2007, *Nature* published a paper by Axon, Robinson and Stuart Young, a post-doctoral fellow and the lead author, confirming that supermassive black holes can produce powerful winds that shape a galaxy and dictate their own growth.

"We really have to understand the most powerful energy sources in the universe, which is accretion on to supermassive black holes," says Axon. "How do black holes grow, how do they release energy, and how is their growth related to the growth of galaxies?"

Robinson says there appears to be a strong link between the mass of a supermassive black hole and the mass of a galaxy. "Understanding the physical mechanisms that govern those processes in nearby objects will help to understand how black holes in galaxies form and evolve over time."

Susan Gawlowicz '95

W Web extra: To learn more about astrophysics at RIT, see the Spring 2008 issue of *The University Magazine* online at www.rit.edu/magazine.