The changing face of astronomy education

From the outside, Swain Hall West looks pretty much the same, but for our majors, the education that goes on inside has undergone a revolution in the past decade or two. The forces behind that change include new technology, federal support for undergraduate research, and the changing expectations of graduate programs.

Technology has played a key role in shaping today's undergraduate experience in astronomy. As astronomy itself has moved toward larger facilities, more space telescopes, and major observational surveys, today's undergraduates will operate in a different world than most of us encountered in our early careers. Their training needs to prepare them for astronomy in the 21st century. Our field is now a multi-wavelength science, and research that doesn't integrate what can be learned from other wavelengths will fall short. The National Virtual Observatory is not so virtual anymore, as the NVO begins to connect databases everywhere to help us pull together observations at different wavelengths and using different techniques. Even the astronomy journals no longer reside in the Swain West Library, since we uniformly access the literature on the Web, and the dusty atlases that students once found so indispensable have been moved out. Observing skills are different, too. Automation has taken over many of the tasks of yesterday's astronomers, and remote observing gives us access to telescopes around the world right from campus, or from our own homes. The work of today's astronomers requires more teamwork, often with collaborators themselves distributed around the world, and a greater ability to access and merge observations from many sources in new ways.

Federal support has also played a role in changing undergraduate education. NSF-funded Research Experience for Undergraduates programs give students from colleges and universities everywhere a chance to try astronomy research in summer programs as some of the top institutions in the country. Research experience is now an essential part of the undergraduate experience and of preparation for graduate school. Undergraduates present their research at AAS meetings and often arrive at graduate school with refereed publications on their resumes. It is now common for 10% of the papers at AAS meetings to be given by undergrads. Our own REU program hosts students from around the country for a 10-week research experience that includes observing with the WIYN 0.9-m telescope at Kitt Peak.

For astronomy undergraduates at IU, our curriculum integrates classroom learning with research experience. Problem sets and exams are still part of the mix, but our teaching now incorporates research projects and real data at all levels in our undergraduate courses. Even non-science majors in our introductory courses find novae in the Andromeda Galaxy using images from the WIYN 0.9-m telescope. For our majors, classroom projects incorporate data not only from the 0.9-m, but from the 3.5-m WIYN telescope and from even larger telescopes. Real data and computation play a role not only in our observing course, but also as part of learning about stars and galaxies. Many, if not most of our majors undertake research projects with faculty, and most have an opportunity to observe with faculty at our telescopes at Kitt Peak. If you have a chance, stop by the department to see our undergraduate research lab - a busy place these days!
More Sky at the WIYN 0.9-m Telescope

The WIYN 0.9-m Consortium received some good news in 2006 from the National Science Foundation, in the form of funding for a proposed new "Half Degree Imager" (HDI) camera for the telescope. Since 2001, IU Astronomy has participated in the WIYN 0.9-m Consortium to operate the former Kitt Peak National Observatory 0.9m telescope, along with nine other partners including state and private universities and colleges from around the nation.

The new HDI camera will feature a new, low-noise, fast read-out, 4K x 4K CCD that will cover a field of view of 29' x 29' of sky, virtually the full disk of the Moon. The camera will replace the 15-year-old S2KB detector that has served as the observatory's workhorse imager. The new camera will double the field of view observed, and the camera's smaller pixels will also take advantage of the good seeing the telescope now provides to give us sharper images.

The proposal team was led by the Consortium's chief executive officer, Professor Constantine Deliyannis from IU. The proposal is funded through the NSF's Program for Research and Education on Small Telescopes. The work to build the imager is beginning soon, and the new imager should be ready for early use in 2008.

HDI will assure a robust future for research at the WIYN 0.9-m telescope.

Honoring Kent Honeycutt

A special dinner and symposium was held in Bloomington in early April to honor Emeritus Professor Kent Honeycutt, who retired in 2005. The event, organized by Arne Henden, was attended by many of Kent's colleagues and former students, including Arne, Charles Gow, Stella Kafka, Eric Schlegel, Jeff Pier, Wayne Warren, and Todd Hillwig. Presentations at the symposium ranged from reminiscences of graduate school days to observations of objects in low Earth orbit to studies of cataclysmic variables. The symposium was capped with a visit to the Department's new 1.25-m robotic telescope in the Morgan-Monroe State Forest. Despite his official retirement, Kent remains busy completing the commissioning of the new observatory and beginning science operations. For those of you unable to share the event with us, this Newsletter includes a montage of photos of this wonderful celebration.
Gift Funds

The Astronomy Department is fortunate to receive financial support from many friends and former students. Your support makes it possible for us to bring in speakers for our colloquium series; to reward students for outstanding success in research, teaching, and outreach; to recruit top new graduate students and faculty; and to host special events for students, the campus, and the community. All of these activities strengthen our program and contribute to the broad mission of the Department and the University. We strive to create an environment that enables our students, both graduate and undergraduate, to realize their own goals and to achieve success. With your help, we can make that happen.

The chart at right summarizes how your gifts are spent by the Department. We offer heartfelt thanks to each of you for your financial support.

Summer Astronomy Workshops for Teachers

During the summers of 2005 and 2006, the Astronomy Department has offered workshops for middle school and high school teachers. During the summer of 2006, we joined with the IU School of Education, the Department of Geological Sciences, and the University of Tennessee to present a 3-day workshop on astrobiology, funded through grants from NASA’s Indiana-Princeton-Tennessee Astrobiology Initiative, the Indiana Space Grant Consortium, and the Spitzer Science Center.

The workshop, held in late June at the IU School of Education, was attended by twenty teachers from middle and high schools in Indiana and Tennessee. The workshop included science content on habitable environments in the Solar System, the biology of life, and the search for planets around other stars, as well as inquiry-based, classroom activities. The goals of the workshop were to provide teachers with a better understanding of astrobiology, to offer new opportunities for science in Midwestern middle and high schools, and to encourage the teaching of astrobiology integrated into other science disciplines (e.g. biology, physics, chemistry, Earth science).

Richard Durisen, Caty Pilachowski, and graduate student Scott Michael from Astronomy presented material during the workshop. The 2006 workshop was organized by Glenn Simonelli, a graduate student at the School of Education. Activities and presentations from the workshop have been made available on the departmental website at www.astro.indiana.edu/astrobio.shtml.

Research Highlight

Open Cluster with WIYN

The IU Astronomy department is well-known for its research on star clusters, and the work of Professor Con Deliyannis and his many students takes full advantage of our WIYN telescopes to uncover what star clusters have to tell us about stars and the Milky Way. Since stars in clusters have a similar age and composition, star clusters have traditionally provided the observational foundation of stellar astrophysics. They play a central role in studies of stellar structure and evolution, and of the formation and evolution of our Galaxy. Clusters may hold the key to Galactic lithium evolution, with implications for the Big Bang lithium abundance and cosmology. Indeed, few fields in astrophysics do not somehow rely on results obtained from studies of star clusters.

The WIYN telescopes are ideally suited for studying the properties of open clusters in a systematic and comprehensive way. The WIYN 3-5 meter with its Hydra multi-object, fiber spectrograph allows spectroscopy of dozens of cluster stars simultaneously, while the WIYN 0.9-m telescope provides excellent, wide-field images of clusters for photometry and astrometry. Con and current or former graduate students Aaron Steinhauser, Steve Margheim, Kevin Croxall, Jeff Cummings, Ryan Maderak, and Angela Sarrazine, as well as many undergraduate students have spent many nights at these two telescopes peering at star clusters.

The classical lithium problem has challenged astronomers for over 40 years. Ever since the first observations of lithium in solar-type stars in the Hyades, astronomers have known that the lithium abundance decreases in stars further
down the main sequence. This general pattern of lithium depletion with temperature remains a fundamental test that stellar evolution theory must pass. Con and his students have been investigating the physical processes that affect the abundance of lithium on the surfaces of stars like the Sun, but that span both ages from 50 million years to over five billion years as well as a range of metallicities. Since lithium is easily destroyed by nuclear reactions in stellar interiors, the surface abundance can be used to probe how the surface layers of a star mix with interior layers and how specific elements sink or float in the hydrogen soup. Research by Con and his students, using clusters of different ages, has confirmed that lithium is lost from the surfaces of main sequence stars, in contrast to the prediction of standard theory. For nearly two decades, the light element tracers, especially Li, have hinted at the limitations in the standard theory of evolution of ordinary stars like the Sun. The standard models are only now beginning to incorporate more realistic physics (e.g. rotation, diffusion, mass loss, magnetic fields) and the behavior of lithium as a function of mass and age provides enticing clues to guide theorists about the importance of these physical mechanisms, which can have significant effects on stellar evolution. For example, diffusion in the outer layers of stars could lower globular cluster ages by as much as 25%, bringing them in closer agreement with Hubble ages, and slow mixing could imply a higher big bang Li abundance than is observed in halo dwarfs.

Concerning metallicity, Con and his students have begun comparing lithium in the Hyades to that in two other clusters of similar age but differing metal abundance. The Li depletions do indeed turn out to be rank-ordered with metallicity, and, although standard theory cannot account for the total Li depletion, it may well explain the metallicity dependence of the Li depletion.

Comparing the Sun's lithium abundance with that of similar stars in the comparably old cluster Messier 67 suggests that our star is relatively normal. This issue is potentially of much broader interest, not only to astronomers and scientists in general, but also to the public. If it is true, as some believe, that Li is depleted by rotationally-induced mixing, which in turn might be related to the initial angular momentum of the star, which in turn may be related to the ability of a star to form planets, one may ask the question, "Did life form in the Solar System because it is normal, or because it is abnormal?" The answer to that question could have implications for the frequency of life in the Universe.

Explanations for the dip's cause include diffusion, mass loss, and various forms of mixing. Con and his students found that the Li dip forms early, within just a few hundred million years of cluster formation, and becomes deeper and wider with age, and a larger fraction of stars in the narrow temperature range that defines the dip become affected. These observations argue in favor of rotational mixing and against mass loss or diffusion as a cause of the dip. And at even higher temperatures, they found the first super-Li-rich dwarfs at temperatures near 7000K, above the temperature of the lithium dip. Lithium rich dwarfs are predicted by the diffusion model in this temperature range, under the right conditions.

Con's work on star clusters is helping to guide the development of stellar evolution theory, pinpointing the observable diagnostics and constraints that help theorists incorporate complex physics like mixing and diffusion into their models. WIYN's contributions to research on star clusters continue to have far-reaching impact.

Summer REU Program 2006
Research Experience for Undergraduates

The Department’s Research Experience for Undergraduates (REU) Program, funded by a grant from the National Science Foundation, completed its fifth summer of activities.

**Jesse Lord** worked with Aaron Boley and Richard Durisen on radiative hydrodynamics simulations of gravitationally unstable protoplanetary disks. In particular, Jesse investigated whether radiative cooling with realistic opacities permit gas giant formation by disk fragmentation. This work involved analyzing gravitational and hydrodynamical stresses in disks and characterizing the density fluctuations caused by gravitational instabilities. His results are included in a paper that is in preparation for publication in The Astrophysical Journal.

**Amandeep Gill**, a physics student at the Brown University, and **Walter Trentadue**, an astronomy and physics student at North Eastern Illinois University, worked with Kevin Croxall and Constantine Deliyannis to determine the Li abundance trend in the old open cluster NGC 188. While some studies have been done on this cluster, this new data set contains many more stars with high signal-to-noise radius. Walter focused his attention on the observed subgiants while Amandeep focused on the dwarfs. During the summer, Walter and Amandeep learned how to reduce HYDRA data

Left to Right: Jennifer Lozier, Stephen Battazzo, Alex Shvonski (front), Jesse Lord (back), Amandeep Gill, Walter Trentadue.
and how to determine abundances via measuring equivalent widths. Their work will be presented at the January AAS meeting.

Steve Battazzo, an physics student from University of Oregon, worked in Stuart Mufson's SNAP laboratory with Nick Mostek, Chuck Bower, and Brice Adams. He successfully prototyped and tested an integration circuit for the SNAP focal plane that will be integrated into the calibration light system. Steve also researched and developed several of the tools necessary to test the transmission properties of commercial glass fibers. Finally, Steve compiled and did preliminary analysis of LED data collected over the wavelength range 400nm - 1,000 nm.

Alexander Shvonski, an astronomy student from Wheaton College, worked with TalaWanda Monroe and Caty Pilachowski to identify unresolved debris disk candidates in the young open cluster NGC 2362. He used mid-Infrared data from NASA's Spitzer Space Telescope to identify which stellar members show infrared excesses characteristic of debris disks. This is part of an ongoing project to examine late B and early A dwarfs in young open clusters, spanning ages of a few million years up to 100 million years, to determine the frequency of debris disks as a function of stellar age. Alex used published optical and NIR data on the members of the 5 Myr old cluster to supplement the mid-IR data, to try and ascertain the nature of any excess stars; that is, whether the disk candidates are primordial or of a second generation.

Jennifer Lozier, a physics and English major at Mount Union College, worked with Scott Michael and Richard Durisen this summer. She used supercomputing resources at IU to carry out simulations to investigate the origin of binaries with very small separations. The simulations explored the possibility that a rapidly rotating protostar might fission into a binary system. Jennifer determined that an instability described in the work of other researchers was unable to be detected in our simulations, making the possibility of forming a close binary system via fission unlikely.

Kai Cai successfully completed his Ph.D. dissertation entitled "3D Hydrodynamic Simulations of Gravitational Instabilities in Embedded Protoplanetary Disks" in August, 2006. Kai's dissertation research was supervised by Richard H. Durisen. For his dissertation, he explored the role of gravitational instabilities (GIs) in protoplanetary disks during the embedded phase, when the star and disk are still surrounded by an in-falling envelope of interstellar gas. Kai has established that heating of the disk by radiation from this envelope decreases the amplitudes of the instabilities and, if strong enough, can even suppress them. Kai also found that the strength of instabilities varies with metallicity and that disks do not fragment over the range of metallicities from one-quarter to twice solar. Moreover, GIs are stronger for lower, not higher metallicity, which is the opposite of what one might expect from the observed relation between the probability of detecting a planet and the host star's metallicity. Kai won a coveted National Research Council of Canada fellowship to join Ralph Pudritz's group at McMaster University, where he moved this fall, and is continuing his work on star formation and disks.

Heather R. Jacobson presented a successful candidacy seminar in May 2006 and received her Master of Arts degree in Astronomy. She is investigating the chemical composition of the Milky Way at the outer edge of the Galactic disk to understand the origin and evolution of the outer regions of our galaxy.

TalaWanda Monroe presented a successful candidacy seminar in May 2006 and received her Master of Arts degree in Astronomy. She is investigating the role of metallicity in the origin and evolution of debris disks around young stars using both WIYN 3.5-m telescope spectra and Spitzer Space Telescope observations of stars in young star clusters.

Ryan M. Maderak presented a successful candidacy seminar in August 2006 and received his Master of Arts degree in Astronomy. He is working with Constantine Deliyannis to examine oxygen abundances in stellar clusters to look for an age-metallicity relation in the Galaxy and also to see if the age-metallicity relation for iron in star clusters parallels what is seen for field stars.

Kevin V. Croxall presented a successful candidacy seminar in August 2006 and received his Master of Arts degree in Astronomy. He is studying stellar evolution as traced by lithium in Milky Way star clusters older than a billion years, specifically to understand how physical mechanisms such as rotation and mixing affect evolution.

Jeffrey D. Cummings presented a successful candidacy seminar in November 2006 and received his Master of Arts degree in Astronomy. He will study the metallicity dependence of lithium depletion by expanding the sample of Hyades age clusters to a wider range of metallicity and will also look at the undepleted lithium plateaus in young clusters to explore the evolution of the Galactic lithium abundance.
**Undergraduate Degrees**

**David Reagan** received his B.S. in Astronomy & Astrophysics degree in Spring 2006. He is now attending Graduate School at Indiana University.

**Caitlyn Smith** received her B.S. in Astronomy & Astrophysics degree in Spring 2006. She is now attending Graduate School at Brown University.

**Undergraduate Research Experiences**

**Elizabeth Adams** spent the summer in Manoa, HI as an REU student at the Institute for Astronomy. Betsey worked on identification of cluster members in a sample of X-ray selected massive galaxy clusters using a photometric redshift technique in order to explore large scale structure in the universe.

![Elizabeth Adams observing at Keck I.](image)

**Elisabeth Mills** spent the summer in Socorro, NM as an REU student at the National Radio Astronomy Observatory. Betsy worked on submillimeter and radio continuum observations of protostellar sources near the Galactic Center in order to examine the physical properties of these future star forming complexes.

**Miriam Musco** spent the summer in Norman, OK as an REU student at the University of Oklahoma working on several research projects exploring the properties of pre-maximum light supernova.

**Student Awards**

**Aaron Boley** received the 2006 Hollis and Grete Johnson Award for Excellence in student research and he also received Honorable Mention in the National Radio Astronomy Observatory's First Annual Radio Astronomy Image Contest for his image of star formation in NGC 3595. The image, shown below, can be found at [www.nrao.edu/imagegallery/image_contest/image_contest_prizes.shtml](http://www.nrao.edu/imagegallery/image_contest/image_contest_prizes.shtml)

![NGC 3595](image)

**Kevin Croxall, Heather Jacobson, TalaWanda Monroe, and Brian Brondel** received the 2006 Goethe Link Prize for Outreach and Public Education in Astronomy.

**Elisabeth Mills** received the 2006 Astronomy Alumni Award for Overall Academic Excellence and the 2006 Hollis and Grete Johnson Award for Excellence in student research. She also received the Malcolm A. Kochert Scholarship from the College of Arts and Sciences for the academic year 2006-7.

**Elizabeth Adams** received the 2006 Hollis and Grete Johnson Award for Excellence in student research and the 2006 Astronomy Alumni Award for Overall Academic Excellence. She also received a prestigious Goldwater Scholarship in support of her final undergraduate year at IU.

**Faculty News**

**Phyllis Lugger** and **Haldan Cohn**, in collaboration with current graduate student Ted Maxwell and former graduate student Shawn Slavin, prepared a poster for the Jan. 2007 AAS meeting in Seattle on their GRAPE6 simulations. The goal is to understand the evolution of an X-ray binary population in the environment of a collapsed-core globular cluster such as M15, M30, or NGC 6397.

**Constantine Deliyannis** hosted a special viewing night with an eyepiece at the WIYN 3.5-m telescope, and notes spectacular views of planetary nebulae. The blues and greens in the "Blue Snowball" planetary nebula were impressive, as were the reds, yellows, and greens in the Ring Nebula.

**Richard H. Durisen** enjoyed a well-earned sabbatical during the Fall 2006 semester. In addition to research and some scribbling on his novel, Dick delivered a series of lectures at the Workshop on Physical Processes in Circumstellar Disks around Young Stars in Vidago, Portugal. He also traveled to the University of Leeds to work with colleagues there.

**Stuart Mufson**, with Nick Mostek, Chuck Bower, and Brice Adams, continues his R&D efforts on the SuperNova Acceleration Probe for flight calibration hardware and the development of the wide-band interference filters. He's also trying to figure out how to mix and deliver 4.6 million gallons of liquid scintillator for the NOVA experiment at Fermilab.

**Caty Pilachowski** received a National Science Foundation grant in collaboration with Travis Rector of the University of Alaska Anchorage to develop web-based curriculum materials for introductory astronomy. An example is the NOVA search website at [www.astro.indiana.edu/novasearch](http://www.astro.indiana.edu/novasearch).

**Liese van Zee** received a coveted "Outstanding Junior Faculty Award" from IU for the spring, 2006, semester. She was able to devote full time to her research on dwarf galaxies and to mentoring graduate and undergraduate students. Observing on the Keck Telescope with undergraduate student Betsey Adams was one summer highlight.
Steven Dick (B.S., Astrophysics, 1971; M.A. and Ph.D., History and Philosophy of Science, 1977) received the fifth LeRoy E. Doggett Prize for Historical Astronomy from the Historical Astronomy Division of the American Astronomical Society. The prize was awarded for his distinguished career and significant influence on the field of the history of astronomy. The prize was presented at the January, 2006, meeting of the Historical Astronomy Division in Washington, D.C. Dr. Dick's research has focused on the history of ideas about extraterrestrial life, and he has published three books on the subject, as well as an exceptional book on the history of the U.S. Naval Observatory. Dr. Dick served as Historian of Science at the Naval Observatory from 1989 until 2003, when he became Chief Historian at NASA. Congratulations!

Linda (May) French (A.B. Astronomy, 1973) is Associate Professor of Physics at Illinois Wesleyan University in Bloomington, Illinois. She and her husband Ron Emmons have three daughters. Linda recently received a Cottrell Science award from the Research Corporation for her work on photometry of asteroids and comets. Her email address is lfrench@iwu.edu.

Arlo Landolt (Ph.D Astronomy, 1963) was recently honored with the keys to the newly repaired and refurbished Landolt Astronomical Observatory at Louisiana State University. The observatory, which first opened in 1939, houses an 11.5" Clark refractor. What better way to celebrate the many contributions of Emeritus Professor Arlo Landolt to astronomy and to the astronomical community! The drawing of the Landolt Observatory shown at right was made by Mark Slovak some years ago at LSU.

Robert Milkey (Ph.D Astronomy, 1970) retired this year from his position as Executive Officer of the American Astronomical Society and moved to Oro Valley, Arizona. His many years of dedicated service to the astronomical community serve as an inspiration to us all.

John Lynn Smith (A.B. 1942, M.A. in 1948) wrote to share memories of his first days at IU in 1938, when he enrolled in Professor's Cogshall's beginning Astronomy class and Professor Edmondson's evening class observing with the 12" refractor. Back then, the Department was housed at Kirkwood Observatory, and didn't move to Swain Hall - and acquire the department's first telephone, until 1940. Apparently, Dr. Cogshall was concerned that too many people would call with questions about the night sky! (He was right!)

Megan Pickett (Ph.D Astronomy, 1995) accepted a new position as Associate Professor of Physics at Lawrence University in Appleton, Wisconsin, during the summer of 2006. We wish her well in her new position.

Best Wishes for 2007!

Tell us about yourself

Pass along the latest about yourself for our newsletter. Contact the Astronomy Department by regular mail or send an email to astdept@indiana.edu or send your news notes to The Indiana University Alumni Association, P.O. Box 4822 Bloomington, IN 47402-4822.
Name ____________________________________________________ Date _____________________

Spouse Name ________________________________________________

Home Address ______________________________________________________________________

City _____________________________________________  State _________ Zip ____________

When did you graduate from Astronomy and with what degree(s)?
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Email _______________________________________________ Phone _________________________

Where are you? What are you doing?
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Kent Honeycutt Symposium

Kirkwood Society 9