Yale University Astronomy Department Newsletter

Vol. 2 Spring 2010 No. 1

Grand Opening of the Leitner Family Planetarium

Inside the Leitner Family Planetarium

The new planetarium at Yale's Leitner Family Observatory and Planetarium (LFOP) opened in January 2009. It is a beautiful facility which has already had an enormous impact on Yale students, K-12 students, and the general public.

The planetarium is located together in same building with the Leitner Family Observatory and lecture hall, which were completed in 2006. All phases were designed by the architect David Thompson. In its first year of operation, over 7,000 people visited the planetarium.

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INSIDE THIS ISSUE:

New Faculty Hires Strengthen Yale Astronomy

In the last 3 years, Yale has hired 6 new faculty in Astronomy and Astrophysics, in fields of exoplanets, star formation, galactic structure, dwarf galaxies, galaxy formation, galaxy clusters, large scale structure and cosmology. These new hires were made possible by a combination of retirements (actual or anticipated), modest expansion in the Astronomy Department, and growth of Astrophysics in the Physics Department. The addition of so many terrific young faculty in such a short time will greatly strengthen Astronomy and Astrophysics at Yale.

Arce

Fischer

Last year Marla Geha (galactic structure and dwarf galaxies) and Héctor Arce (star formation) started in the Astronomy Department and Daisuke Nagai (galaxy clusters and cosmology) started in the Physics Department with a joint appointment in Astronomy. (We introduced all 3 in last year's newsletter.) If these 3 were our only recent hires, we'd still be in pretty good shape.

Geha

But this year we have hired 3 additional new faculty! Frank van den Bosch and Debra Fischer were hired in the Astronomy Department, and Nikhil Padmanabhan was hired in the Physics Department with a joint appointment in Astronomy. Debra, who is widely known as one the world's top experts in exoplanets, officially joined the Department as a Senior Faculty member in July 2009 but is taking a Radcliffe Fellowship at Harvard during 2009-10, and will start in full force at Yale this summer of 2010. Frank, an authority on galaxy formation and evolution, is staying this year at University of Utah, and will officially join the Department in July 2010. Nikhil, a leading expert on large scale structure, the formation and clustering of galaxies, and gravitational lensing, is already in New Haven. (There is more on Debra and Nikhil in the People section of this newsletter. Since Frank is not official yet, we'll save details on him for next year's newsletter.)

Nagai

Padmanabhan

van den Bosch

SIMULATING CONVECTION IN STARS

- by Pierre Demarque

In the last ten years, simulating atmospheric convection has been the main focus of the research of professor emeritus Pierre Demarque and his collaborators. The treatment of turbulent convection remains a weak link of the theory of stellar structure and evolution. Convection plays a major role in energy transport in the interiors and atmospheres of stars and affects most phases of their evolution.

Cool stars exhibit convection in their envelopes. The structure and depth of these convection zones depend on the detailed properties of turbulent convection and its interaction with radiation in the outer layers. A key unknown is the physics of the thin transition layer (the superadiabatic layer or SAL) that lies between the optically thin atmosphere in which radiative transport dominates and the regions of efficient convection immediately below the photosphere.

Progress in computing power now permits the performance of numerical simulations in three dimensions (3D), including physically realistic hydrodynamics, equation of state and radiative transport. Figures 1 and 2 display vertical and horizontal slices from the simulation of a main sequence star of solar abundance. The simulation describes the effects of overshoot and induced turbulence into the primarily radiative observable layers where spectral lines are formed, as well as the velocity fields in the deep regions. Figure 2 shows the top of the ascending columns of hot gas that characterize the granulation at the surface and the cool downdrafts and plumes that penetrate deep into the star.

One of the exciting aspects of Demarque's work is the advent of new observing tools, thanks to helio- and asteroseismology, that probe the interior structure of the sun and stars, respectively. This is done by studying the propagation properties of sound waves (p-modes) and gravity waves (g-modes) in stellar interiors. In particular, p-mode frequencies are very sensitive to the detailed physical conditions near the surface and below the photospheric layers. Seismology thus probes directly the simulated regions that are unobservable by conventional optical means. Solar seismic observatories and ground-based telescope networks and dedicated asteroseismic space missions, such as MOST, Convection Rotation and Planetary Transits (CoRoT) and Kepler now provide high quality observational data to challenge the theoretical predictions derived from computer simulations.

The Yale 3D simulations have already successfully contributed in several ways, such as improving agreement with observed solar p-mode frequencies, analyzing asteroseismic observations, and calculating the orbital decay of a massive exoplanet near a star with a deep convection zone.

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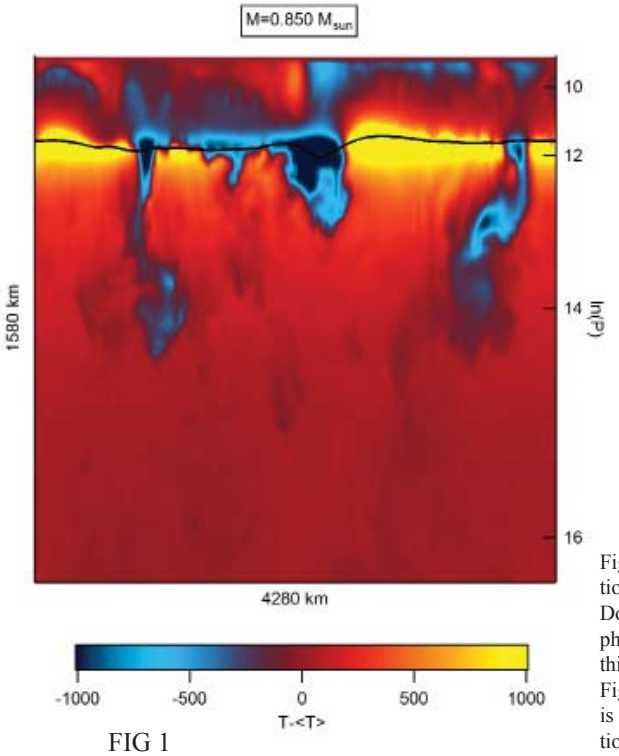


FIG 1

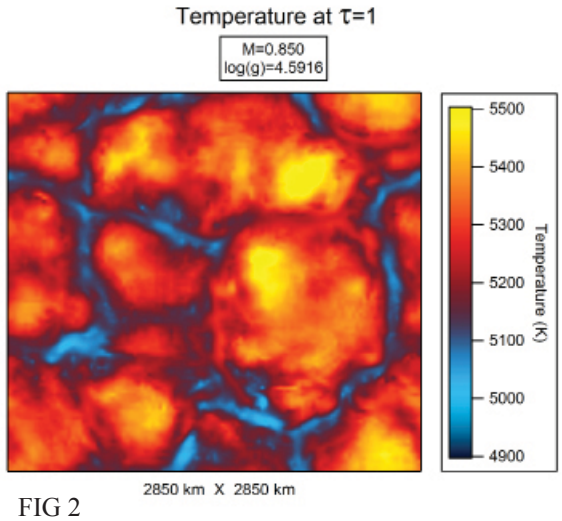


FIG 2

Figure 1. The vertical slice shows temperature fluctuations through the top part of a 3D simulation for a star of solar composition. The black line traces the optical surface (tau=1) of the slice. Downdrafts (or plumes) can be seen extending more than four pressure scale heights below the photosphere. Above the black line, note that turbulent motions penetrate far into the optically thin layers (overshoot).

Figure 2. The horizontal slice shows temperature for the same simulation as in Figure 1. The slice is extracted along the optical surface traced by the black line in the vertical slice image (simulations by Joel Tanner).

- Simulating Convection Continued from page 2

Perhaps the most surprising result was provided by a seismic study of the bright star Procyon by an international team led by D.B. Guenther ('83 PhD), which cleared up a puzzling discrepancy in the interpretation of ground-based data and space observations with the Canadian space mission MOST. The ground-based radial velocity observations of Procyon showed evidence for global p-mode frequencies. By contrast, the highly sensitive MOST photometry from space did not reveal any clear pulsation signal in the star. The Yale 3D simulation of the Procyon atmosphere helped to resolve the discrepancy. The simulation shows that the Procyon atmosphere is highly turbulent, with short-lived p-modes and granulation (i.e. convention currents) extending far into the optically thin shallow layers. In addition, it revealed that the expected broad peak in the granulation noise (in the vicinity of 1 Hz), coincides with the power peak of the Procyon p-modes, thus masking the p-mode signal when measured in intensity.

Collaborators in the early phases of this research have included postdoctoral researchers F.J. Robinson, L.H. Li and C.W. Straka, as well as D.B. Guenther ('83 PhD) and Y.-C. Kim ('93 PhD). The work has built on earlier pioneering efforts by K.L. Chan and Yale Professor Sabatino Sofia ('63 BS, '65 MS, '66 PhD) and by Y.-C. Kim ('93 PhD). Recently, the Yale convection project received new impetus under the direction of Yale Professor Sarbani Basu. The simulation code has now been parallelized by graduate student Joel Tanner ('12GRD) to take full advantage of the powerful capabilities of the Bulldog clusters of Yale's high performance computing (HPC) facilities. Tanner is currently producing a grid of simulations as part of his PhD thesis research and it is his work that is shown in Figures 1 & 2. A primary scientific objective is the implementation of turbulent convection in parametric form in stellar models.

We can now at last look forward to fulfilling the long awaited dream of supplanting the mixing length theory in stellar evolution calculations, of constructing reliable interior models for the lowest mass stars and of deriving precise and reliable abundances for cool stars, based on a physically consistent description of turbulent motions in their atmospheres.

CoRoT Satellite Image from
http://smsc.cnes.fr/COROT/

Greetings from the Chair

Dr. Jeffrey Kenney
Chair of Astronomy

The past year has been an exciting one for Yale Astronomy, with new Yale facilities, many new people, and special events.

The year 2009 produced two major beginnings for Yale astronomy: the first Yale observations on the Keck telescopes and the opening of the Leitner Planetarium. One will greatly benefit the research programs of Yale observers, and the other is a terrific facility for inspiring Yale students and public schoolchildren about science.

At least as momentous is the hiring of exciting new faculty. With Debra Fischer, we have a new and significant presence in exoplanets. We foresee increasing ties with the Geology & Geophysics Department, since some of their faculty are also interested in planets! With Nikhil Padmanabhan, we have an expert in large-scale structure and cosmology, as well as data handling for large surveys. Nikhil has used the Sloan Digital Sky Survey for much of his research, and largely because of his expertise and interests, Yale will be joining the SDSS-III consortium. With Frank van den Bosch, we have a world leader in galaxy formation and evolution. Among the plentiful evidence for this claim is that Frank (along with Houjun Mo and Simon White) has just published a major textbook on this subject!

We have also hired many new postdocs and hosted several visitors. This year we welcomed 6 new graduate students, and we have more undergraduate astronomy majors than ever before. (Can we handle them all? We'll find out!) With so many new people, it has become a challenge to find space for them all.

As many of you know, the year 2009 was named as the International Year of Astronomy, a special worldwide celebration of astronomy. For IYA2009 the Astronomy Department sponsored numerous talks and other events and distributed Galileoscopes to people in the community. The combination of IYA2009 and the opening of the Leitner Planetarium has enabled us to reach many more people in the general public and the broader Yale community than ever before.

It is true that we are dealing with cuts to the University and department budgets due to the Great Recession, so we can't be as ambitious over the next year or so without additional funding. But we remain in good shape for the long term, since President Levin has made it clear that further strengthening of the sciences remains a high priority for Yale.

It remains a Golden Age for astronomy, and an exciting time for Astronomy at Yale!

ASTRONOMERS DISCOVER MOST DARK-MATTER-DOMINATED GALAXY IN UNIVERSE

Professor Marla Geha of the Yale Astronomy department has discovered the least luminous, most dark matter-filled galaxy known to exist.

The galaxy, called Segue 1, is one of about two dozen small satellite galaxies orbiting our own Milky Way galaxy. The ultra-faint galaxy is a billion times less bright than the Milky Way. Despite its small number of visible stars, Segue 1 is nearly a thousand times more massive than it appears, meaning most of its mass must come from dark matter. "I'm excited about this object," said Geha, "Segue 1 is the most extreme example of a galaxy that contains only a few hundred stars, yet has a relatively large mass."

Geha, along with her colleague Josh Simon at the California Institute of Technology, has observed about half of the dwarf satellite galaxies that orbit the Milky Way. These objects are so faint and contain so few stars that at first they were thought to be globular clusters – tightly bound star clusters that also orbit our host galaxy. But by analyzing the light coming from the objects using the Keck telescope in Hawaii, Geha and Simon showed that these objects are actually galaxies themselves, albeit very dim ones.

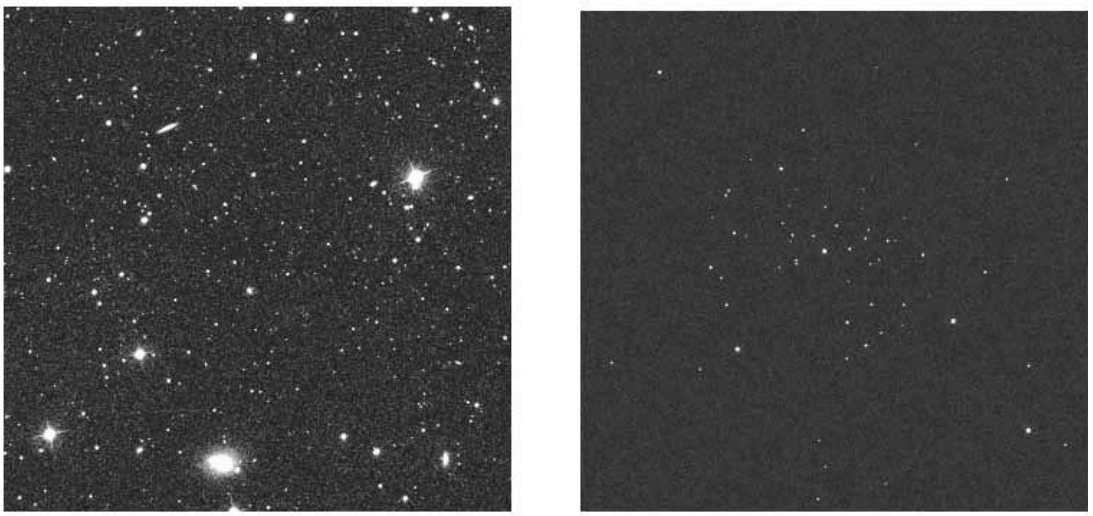
Looking only at the light emitted by these ultra-faint galaxies, Geha and her colleagues expected them to have correspondingly low masses. Instead, they discovered that they are between 100 and 1000 times more massive than they appear. Invisible dark matter, she said, must account for the difference.

Although dark matter doesn't emit or absorb light, scientists can measure its gravitational effect on ordinary matter and believe it makes up about 85 percent of the total mass in the universe. Finding ultra-faint galaxies like Segue 1, which is so rife with dark matter, provides clues as to how galaxies form and evolve, especially at the smallest scales.

"These dwarf galaxies tell us a great deal about galaxy formation," Geha said. "For example, different theories about how galaxies form predict different numbers of dwarf galaxies versus large galaxies. So just comparing numbers is significant."

It's only recently that astronomers have discovered just how prevalent these dwarf satellite galaxies are, thanks to projects like the Sloan Digital Sky Survey, which imaged large areas of the nighttime sky in greater detail than ever before. In the past two years alone, the number of known dwarf galaxies orbiting the Milky Way has doubled from the dozen or so brightest that were discovered during the first half of the twentieth century. Geha predicts astronomers will find even more as they continue to sift through new data. "There are possibly hundreds of small galaxies orbiting around our Milky Way, yet we've so far found only 25. It's a very exciting time to be working in this field."

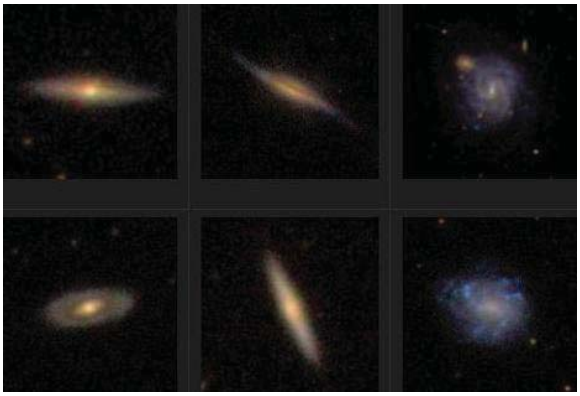
Geha has also been recently featured in the November 2009 issue of Popular Science Magazine as one of this year's top-ten brilliant young scientists in the U.S.



"The most dark matter-dominated galaxy in the universe, Segue 1, is shown among background and foreground stars in a Sloan Digital Sky Survey image (left). The galaxy's 24 known stars have been singled out in the image at right (Left image: SDSS; right image: M Geha)."

YALE ASTRONOMY IN THE NEWS

Galaxy Zoo and the Dawn of Citizen Science



SDSS images of galxies classified in Galaxy Zoo 2.

Galaxy Zoo is an online astronomy project which invites members of the public to assist in classifying over a million galaxies. It is an example of citizen science, as it enlists the help of members of the public to help in scientific research.

The original Galaxy Zoo was launched in July 2007 by Yale astrophysicist Kevin Schawinski (the YCAA Prize postdoctoral fellow) and colleagues from the UK and the US, with a data set made up of a million galaxies imaged with the robotic telescope of the Sloan Digital Sky Survey (SDSS). With so many galaxies, the team thought that it might take at least two years for visitors to the site to work through them all. Within 24 hours of launch, the site was receiving 70,000 classifications an hour, and more than 70 million classifications were received by the project during its first year, from almost 150,000 people. By crowdsourcing the visual classification of astronomical images to the web, Galaxy Zoo has been able to tap into the amazing powers of pattern recognition that are innate in the human brain, but that computers still struggle with. Taking part in Galaxy Zoo is very easy and anyone can join: after a brief introduction to galaxy shapes, users go and classify and contribute to cutting-edge research.

Having multiple classifications of the same object is important, as it allows us to assess how reliable each one is. For some projects, we may need only a very broad division into spirals and ellipticals, while other projects need very clean samples of galaxies where the vast majority of classifiers agree.

The success of the original Galaxy Zoo, together with the users' request for more detailed classification options has led to the development of Galaxy Zoo 2 (http://www.galaxyzoo.org/), which allows for much more detailed analysis: how many spiral arms can you see? Is there a bar? And is it more or less prominent than the bar in a similar galaxy? The launch of Galaxy Zoo 2 was a HUGE success, increasing the number of users to almost a quarter of a million. As part of the IYA 100 hours of astronomy, the team aimed at 1 million classifications in 100 hours - the users joined with enthusiasm and did 2,617,570!

Discoveries are sometimes made by the citizen scientists. One of the users, a Dutch school teacher called Hanny van Arkel, spotted a strange green blob next to the galaxy she was asked to classify. The object, now named “Hanny's Voorwerp” (Voorwerp is Dutch for object), has made headlines and is intriguing astronomers. The mystery is not fully solved yet, but it is now thought to be a portion of a gas cloud heated by the jet from a black hole. (This discovery was featured as NASA's Astronomy Picture of the Day on June 25, 2008.)

The citizen scientists have made Galaxy Zoo a scientific success. There have been eleven scientific papers published and at least five more in the works. These are the the first astronomy papers with a quarter of a million collaborators!

Yale Joins Connecticut Space Grant College Consortium

Yale University has recently joined the NASA-funded Connecticut Space Grant College Consortium, and Héctor Arce, Assistant Professor of Astronomy, has been named Yale's first Director of this program. The CT Space Grant College Consortium is a member of the NASA-funded national Space Grant College and Fellowship Program, and serves to promote and support NASA aeronautic and space-related research in Connecticut. It has existed for many years, but for various reasons Yale did not join until now.

Undergraduate and graduate students can apply for research grants, and faculty can apply for collaborative research grants or curriculum development grants. In the first year, a large fraction of Yale proposals were successful, and Yale students and faculty were awarded a total of $60K. The program is available to anyone at Yale University, and the first year awardees include people in the Astronomy and Physics Departments, as well as the School of Forestry and Environmental Science.

Yale undergraduates were awarded funding for microgravity experiments. The “Yale Drop Team” is an umbrella organization

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International Year of Astronomy 2009

The Yale University Department of Astronomy was excited to participate in the International Year of Astronomy 2009, a global effort initiated by the International Astronomical Union (IAU) and UNESCO to help the citizens of the world rediscover their place in the Universe.

The International Year of Astronomy marked the four-hundredth anniversary of the first astronomical observation through a telescope by the Italian astronomer Galileo Galilei.

Universities, science centers and museums around the world commemorated Galileo's discoveries with a range of programs and special events throughout the year.

Yale arranged a series of talks, movies, exhibitions, concerts, and other events so that the Yale and greater New Haven communities may join the world in experiencing and celebrating astronomy. Yale Astronomy sponsored or co-sponsored (along with the Peabody Museum and the Yale Secretary's Office, through the Charles Gallaudet Trumbull Lectureship) a broad range of public talks aimed for various audiences, including young schoolchildren, older schoolchildren and the general public, and the Yale community. These talks were delivered by a diverse set of speakers, including Yale & non-Yale researchers, noted authors and popularizers of science, local dark sky activists, and engineers from the space industry. The 7 talks drew 500 participants in total.

On March 28, 2009, the Department of Astronomy hosted an event on light pollution and what we can do to reduce it. The event coincided with "Earth Hour", when communities throughout the world turned off outside lights for one hour. The keynote speaker at our event was Bob Crelin, noted local author of the book "*There Once was a Sky Full of Stars*". He shared his story of how he and other dark sky activists convinced Connecticut towns and the State to establish lighting ordinances that reduce light pollution. After his talk, the sky brightness in the greater New Haven area was charted, with audience participation, using measurements that were gathered as part of the international "The Globe at Night" campaign to increase the awareness of light pollution.

The Astronomy Department co-sponsored a special exhibit from April through June at the Beinecke Rare Book & Manuscript Library entitled "Starry Messenger: Observing the Heavens in the Age of Galileo". The exhibition drew in part on a recently acquired collection of early modern comet literature, as well as other rare holdings from Beinecke. The display highlighted European observations of the heavens from the sixteenth through the eighteenth century, which revealed the cratered and irregular faces of heavenly bodies for the first time, leading people to realize that the heavens are less "perfect" than once thought. Dava Sobel, the noted author of "*Galileo's Daughter*" and "*Longitude*" gave the talk celebrating the opening of this exhibit, entitled "Galileo and the International Year of Astronomy" at the Yale Law School. Sobel's talk was notable for including "volunteer" poetry readings by three members of the IYA team!

For younger children, we offered talks by noted author and science popularizer Dr. Phil Plait, and again by Bob Crelin. Phil Plait gave a talk entitled "Bad Astronomy!" at the Peabody Museum in April. Dr. Plait's talk demolished a wide array of scientific misconceptions, from standing eggs on end to blowing up asteroids. Using video clips from several blockbuster movies

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Galileoscopes

The Department of Astronomy purchased 200 Galileoscopes to distribute in various ways during the International Year of Astronomy. The Galileoscope is a high-quality, low-cost (~$15) telescope kit developed for IYA 2009 by a team of leading astronomers, optical engineers, and science educators. With this 50-mm (2-inch) diameter, 25- to 50-power achromatic refractor, one can see the celestial wonders that Galileo Galilei first glimpsed 400 years ago. While similar to Galileo's original telescope, the Galileoscope has improved optical design and lens quality, so that images are sharper, brighter, and over a larger field of view than Galileo's original. They require assembly, so that kids and adults alike can learn how telescopes work. Galileoscopes were given to schoolchildren throughout the New Haven area, some during events at Leitner or special IYA events. A few ended up with Yale undergraduates in introductory astronomy classes who answered special questions correctly!

REPLICA OF GALILEO'S TELESCOPE BUILT FOR YALE ASTRONOMY

The International Year of Astronomy represents a unique opportunity to introduce the general public – and astronomers as well – to the history of astronomy. One of the many initiatives fielded by the Yale Astronomy Department has been the purchase of a few hundred low-cost telescopes designed to teach the general public the characteristics of the instruments used by Galileo. However, while they can give a sense of the power and field of view of the first telescopes, they do not provide any hint on the materials, the construction techniques or the kind of expertise that underlay these instruments. For this reason, the Astronomy Department decided to acquire a telescope that closely resembled the ones actually used by Galileo for his discoveries.

Of the tens of insturments made by Galileo and his craftsmen only 2 survive. Both are preserved in the History of Science Museum in Florence, along with a single lens. The one chosen as a model is lavishly decorated and according to some scholars could be the telescope used for the observations published in Galileo's Starry Messenger. Galileo himself sent that instrument as a present to the Grand Duke of Florence in March 1610. However, Galileo described the instrument as an "unadorned and unpolished one, which I made for my personal use", writing to the Grand Duke's secretary that his master would soon have "wonderfully adorned ones". The telescope now preserved in Florence might be one of them. It is possible to purchase outstanding replicas of this instrument, but they are expensive display items and are unfit for classroom teaching and field observations. We decided to make our own replica, still close to the original and better suited to our needs. Our "Galilean" telescope was made in Verona, Italy, by Mauro Pozzato. An amateur astronomer, Mr. Pozzato works as a restorer of antique furniture, and his familiarity with early modern materials and techniques proved invaluable. In the following lines, we will describe the instrument and its main components: the optical system, its case, and the mount.

OPTICS

The "Galilean telescopes" use a plain-convex or biconvex objective lens and a plain-concave or biconcave eyepiece to form a virtual image. The original eyepiece was lost together with its eyepiece holder. However, we know that the telescope had a linear magnification of 20x, and Galileo writes in his "Starry Messenger" that he used a plain-concave eyepiece, with the concave side mounted towards the observer's eye. The eyepiece we used in the replica is a plain-concave lens, with a focal length of 50 mm and a diameter of 28 mm. The objective is faithful to the original: We used a plain-convex lens with a diameter of 37 mm and a focal length of 980 mm. The quality of workmanship in the first telescopes was surprisingly good: a study on the surviving lenses made by Galileo (or by his craftsmen) show that their surfaces were polished within ½ λ. In contrast, in the early 17th century it was almost impossible to purchase disks of glass without bubbles of impurities. Four centuries later, we faced the opposite problem: it proved impossible to find glass as bad as that, so the quality of the images in our replica is probably a bit better. As in the original, in our replica a leather diaphragm limits the available aperture of the objective to just 15 mm. Tests conducted on the original lenses have shown that the resolving power of the instrument is in the range of 15-20 arcsec. Its most limiting feature is the extremely small field of view: with just 20x, barely ¼ of the full Moon is visible in our reproduction.

TUBE

The material of the tube varied greatly in early telescopes: the one presented by Galileo to the Doge of Venice was made of tin, while one of those preserved in Florence is made of paper. The instrument we reproduced is made of 20 wooden staves glued together and wrapped around a sheet of fabric.

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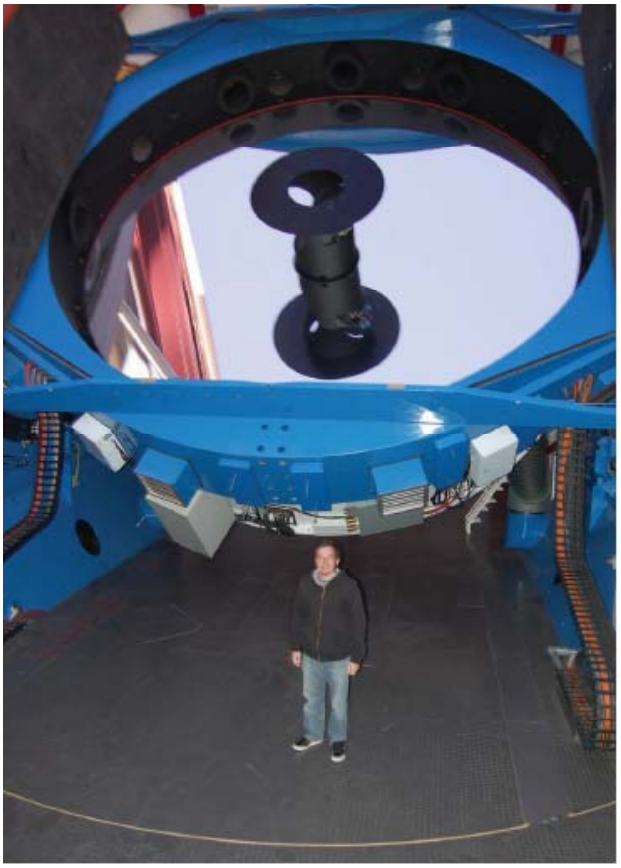
Galileo telescope replica purchased by Yale Astronomy

Chile & Yale

Yale Graduate Student Awarded Fulbright Grant to Study in Chile

Graduate student Gabe Brammer ('10 GRD) received a 2008 Fulbright grant from the US Department of State, which gave him the opportunity to conduct research with Professor Paulina Lira at the Universidad de Chile for a full year. The Fulbright Program is designed to increase mutual understanding between the people of the United States and the people of other countries. It promotes leadership development through learning and international cooperation. Gabe plans to publish the results of his research as part of his thesis. He spent three nights at the Gemini Observatory and four nights at the Las Campanas Observatory conducting spectroscopic research and gathering new data. Gabe is hopeful that a few publications will come out of his research as well. Gabe had the chance to meet the US Ambassador and participate in activities and events that exposed him to the true Chilean culture. He even met his wife in Chile! They were married on April 26, 2009 at the Leitner Family Observatory and Planetarium at Yale.



Gabe Brammer at the Magellan II (Clay) 6.5 m telescope at Las Campanas, November 2008

Joint Research in Star Formation

The newest Yale U de Chile Joint Research Project is Observational Studies of Star Formation in the Milky Way. This is headed by Héctor Arce (Yale University) and Diego Mardones (Universidad de Chile, Santiago). They are currently using a number of millimeter and submillmeter telescopes to investigate the physical and chemical properties of the molecular gas associated with the star formation process. Among these telescopes is the Atacama Pathfinder Experiment (APEX), a single dish antenna on the high altitude site of Llano Chajnantor, in the Atacama Desert of northern Chile. They also plan to use the Atacama Submillimeter Telescope Experiment (ASTE) and NANTEN2 telescopes, two sub-millimeter observatories that are also in the Atacama high desert. Both Arce and Mardones are anxiously awaiting the completion of the Atacama Large Millimeter/submillimeter Array (ALMA) in 2010 or 2011. ALMA is an international astronomy project that consists of an interferometer formed from an array of radio telescopes, located at Llano de Chajnantor Observatory in the Atacama desert in northern Chile. ALMA will be the best radio telescope ever built, providing unprecedented sensitivity and resolution at (sub)-millimeter wavelengths. It will produce spectacular images of the early stages of star formation with a resolution similar to that of the Hubble Space Telescope, but at wavelengths that penetrate the dust that hides protostars from optical telescopes. Once completed 10% of the observing time will be allocated to the host country, Chile. Mardones and Arce hope to use part of this Chilean time to conduct their research.

Sabbaticals at Yale by U de Chile Faculty

As part of the Yale-Chile Joint Astronomy Program, Yale provides support for U de Chile faculty who take sabbaticals at Yale. **Professor Diego Mardones**, a faculty member of the Astronomy Department of the Universidad de Chile, spent last summer at Yale as part of his sabbatical. Diego's main contact at Yale was Professor Héctor Arce, with whom he has an active collaboration on observational studies of star forming regions. Diego spent most of his time at Yale putting the final touches on radiative transfer code that will help analyze the spectral data of star-forming molecular clouds that he and Héctor will gather in the coming year. Last summer, Diego and Héctor also hosted collaborators from the Smithsonian Astrophysical Observatory and the Jet Propulsion Lab, with whom they recently started working on observations of southern star forming regions. In addition, Diego and Héctor put together two successful proposals to use sub-millimeter telescopes in order to study the evolution of the dense gas involved in the star-formation process. **Professor Luis Campusano** will take a six month sabbatical at Yale from March, through August, 2010. During that time, he is planning to work on collaborative projects on numerical simulations of structure evolution, gravitational lensing by clusters of galaxies, high-redshift galaxies, and astrobiology with Professors P. Coppi, P. Natarajan, P. van Dokkum, S. Sofia, and H. Arce. Luis is visiting with his wife Sofia. **Professor Paulina Lira** plans a sabbatical at Yale from August, 2010 through January, 2011.

Yale University Research Observatories

The Yale Astronomy Department currently has proprietary access to three world-class research observatories: Keck, WIYN, and SMARTS. Faculty, postdocs, and students are using the observatories to study everything from the outer solar system to the distant, early universe. Below is a sampling of the projects currently being undertaken by Yale astronomers at the Yale research observatories:

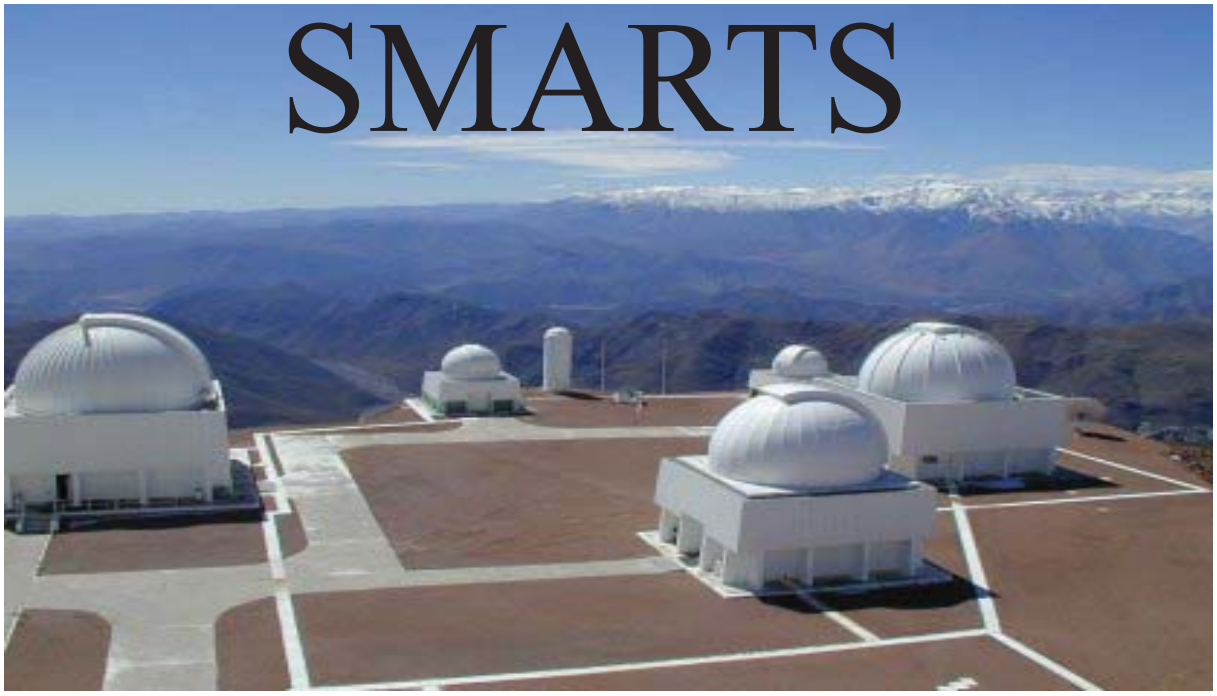
Kinematics of Massive High Redshift Galaxies (Pieter van Dokkum, PI; with Rachel Bezanson, Gabriel Brammer, Katherine Whitaker, Danilo Marchesin, Mariska Kriek (Princeton), Ivo Labbe (Carnegie)) The van Dokkum team is measuring the speeds of stars in galaxies in the young Universe (These galaxies were recently discovered to be remarkably compact for their mass, see article from 2008 on van Dokkum's contribution to this research). They are using the Low Resolution Imaging Spectograph (LRIS) on Keck I to observe targets selected from the NOAO/Yale NEWFIRM Medium Band Survey. Rachel Bezanson, Gabriel Brammer and Kate Whitaker are all using the data for their graduate theses. The goal of the project is to "weigh" the galaxies to determine if they are as massive as has been previously inferred from other data.

Ultra-Faint Galaxies in the SDSS and Beyond (Marla Geha, PI; with Ricardo Munoz) Geha and Munoz are using Keck II with the DEIMOS spectrograph to study the faintest known galaxies in the universe. They are observing candidate Milky Way dwarf galaxies with the hope of adding to the growing number of faint satellite galaxies around our Galaxy. With Keck, Geha has already discovered several new Milky Way satellites, which are the least luminous and most dark-matter-filled galaxies known. They are also observing a known Milky Way satellite galaxy, Ursa Major II, to test whether its kinematics are affected by tidal interactions. For both datasets, graduate student Nhung Ho will perform a detailed modeling analysis to estimate accurate galactic masses.

Near-IR Spectroscopy of Extremely Red X-ray Sources (C. Megan Urry, PI; with Shanil Virani, Ezequiel Triester, Keven Schawinski, Anton Koekemoer (STScI), Martin Elvis (CfA) and Francesca Civano (CFA)) Urry et al. are using NIRSPEC on Keck II in order to determine whether Extremely Red X-ray Objects are supermassive black holes that formed very quickly after the Big Bang or if they are supermassive black holes that were hosted in very dusty objects when the Universe was roughly half of its current age.

Stellar Populations of Stripped Spirals and S0s in the Virgo Cluster
(Jeff Kenney, PI; with Hugh Crowl (PhD '07, UMass)) Keck spectroscopy of stellar populations will help us determine the recent star formation history of the outer disks of cluster spirals in which star formation has been quenched. The optical spectra will be used with GALEX UV photometry to learn when star formation stopped, whether starbursts were triggered at the stripping time, how rapidly disks are stripped, and whether they experience multiple stripping episodes. By comparing the truncated spirals with S0s, we can learn whether any cluster S0s are gas-stripped spirals.

SMARTS



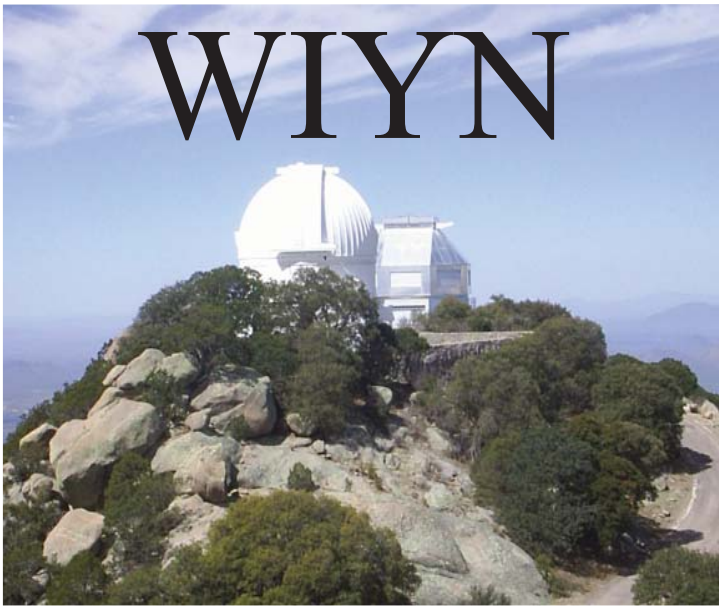
SMARTS Observations of X-Ray Binaries (Charles Bailyn, ’81 BS, PI) This project provided the original motivation for the creation of SMARTS. The goal was to observe binary systems containing a black hole. In quiescence, when the black hole is not accreting mass from its companion, classical techniques of binary star astronomy are used to determine the parameters of the binary system, most notably the mass of the black hole itself. Professor Bailyn and his collaborators were recently awarded the Rossi Prize from the High Energy Division of the American Astronomical Society for this work. During outbursts, when the optical/IR light from these systems is dominated by the accreting gas, the SMARTS data is combined with data at other wavelengths to build up a complete picture of the accretion process onto black holes. This program has generated four Yale PhD theses (Jerome Orosz ‘96, Raj Jain ‘01, Dipankar Maitra ‘06, Andy Cantrell ‘09) and over a dozen smaller graduate student and undergraduate projects.

SMARTS Observations of Fermi/LAT Monitored Blazars (Charles Bailyn, PI, with C. Megan Urry; Michelle Buxton; Erin Bonning; Richard Scalzo; and Jedidah Isler, ’13 GRD) This program, begun in 2008 in order to better understand the jet emission in blazars, was detailed in the Fall 2008 Astronomy Department newsletter (see p. 10). It continues successfully and data from the program is made public on a daily basis on the website http://www.astro.yale.edu/smarts/fermi.

Synoptic Light Curves for Small Icy Bodies in the Outer Solar System (David Rabinowitz, ’83 BS, PI; with Suzanne Tourtellote; Brad Schaefer (LSU); and Martha Schaefer (LSU)) Dr. Rabinowitz and his team have been measuring surface properties of Kuiper Belt Objects (KBOs) and other distant solar system objects, including dwarf planets such as Eris, discovered with Yale’s QUEST camera, and the orbit of one of the moons of Haumea, detected by SMARTS observations. These are relics from the time of planet formation and studying their physical nature can reveal the astrophysical processes leading to the formation and evolution of our solar system. This work has already led to 15 papers addressing the nature, origin and evolution of KBOs. Current research is focused on discovering orbital history; solving the mystery of the Haumea collision family, which has ancient fragments with seemingly young surfaces; and detecting more dwarf planets.

Spectroscopy of RR Lyrae Variables and Properties of the Galactic Halo (Robert Zinn, ’74 PhD, PI; with Kathy Vivas, ’02 PhD (CIDA))In this project, begun in 2008, relatively bright RR Lyrae variables within 5 kpc of the Sun are observed spectroscopically in order to measure their radial velocities and metallicities. The proper motions of these stars are known from the Southern Proper Motion program; hence their space velocities can be obtained once their radial velocities have been measured. This sample will be examined for correlations between kinematics and metallicity and compared with more distant samples of this kind of variable to see how the velocity dispersion varies with galactocentric distance. The sample will also be examined for halo substructure, which if detected would provide additional support for the hierarchical paradigm of galaxy formation.

WIYN Observations of Pulsating Blue Subdwarfs in Clusters (PhD project of Lisa Esch, '12 GRD; Charles Bailyn and Sarbani Basu, advisors) Lisa Esch is using WIYN with OPTIC, a visiting imager, for her graduate thesis to search for pulsations in blue subdwarfs in star clusters. Using asteroseismology and stellar modeling, she is measuring the Helium (He) abundance and overall stellar structure of these stars in clusters with a range of ages and metallicities. By determining the He abundance of globular clusters, which contain the oldest stars in the Universe, one can extrapolate the primordial He abundance, which affects stellar evolution and populations, as well as cosmology.



Orbits of Dwarf Spheroidals and Globular Clusters (Dana Casetti, PI, with Terry Girard and William van Altena) Casetti, Girard and van Altena are using OPTIC, and will eventually use ODI once it comes online, to determine the proper motions of globular clusters, of stars in remnants of disrupted satellites of the Milky Way (MW), and of dwarf galaxies that currently orbit the MW. These measurements, which are possible only in our Galaxy, will provide a detailed picture of the formation of the MW in a cosmological context.

Measuring the Size Evolution of the Most Massive Galaxies from z=2 (Danilo Marchesini, PI; with Pieter van Dokkum; Gabriel Brammer, '10 PhD; Kate Whitaker, '12 GRD; Adam Muzzin; Rik Williams (Leiden University) and Garth Illingworth (UC/Lick)) Marchesini and his team are studying very massive galaxies that have been selected from the NOAO/Yale NEWFIRM Medium-Band Survey. They are using WHIRC on WIYN to measure the sizes of 48 galaxies with redshift $z<2$ and high stellar masses. The main goals of the project are to derive the evolution of the sizes of the most massive galaxies in the universe and to determine the relationship between mass and size in massive galaxies.

Speckle Imaging with DSSI: Toward the Thin and Thick Disk Binary Samples (Elliott Horch, '89 MS (SCSU), PI, with William van Altena) This project continues van Altena and Horch's long-term effort to provide high-precision relative astrometry and differential photometry of binary stars. Their project aims to understand better the mass-luminosity relationship of main-sequence stars, especially for low-mass and metal-poor stars. They also aim to test stellar evolution models in order to better understand stellar evolution as well as galactic structure and evolution and see if binaries can be used as probes of galactic structure. They are using the Differential Speckle Survey Instrument, a highly efficient and uniquely capable diffraction-limited imaging system completed by Horch. The WIYN speckle program has produced about 6% of all speckle data on binary stars by all investigators since the inception of the speckle technique in 1970.

WIYN Update

Instrument development and upgrades are going strong at the WIYN observatory. Of especial note is the completion of the Bench spectrograph upgrade project. The Bench spectrograph upgrade team, led by Dr. Pat Knezek, worked for several years and finally their work has paid off with an instrument that performs significantly better. The Bench received a new collimator, a new CCD imager, reworked fiber toes and new VPH gratings. All of this work has improved throughput by factors of 1.5-3! More information about the upgrade, data and pictures can be found here: http://www.wiyn.org/instrument/bench_upgrade.html.

The biggest project continuing at WIYN is the building of the One Degree Imager (ODI). ODI is now more than coming; a large portion of it is complete and assembled. All of the optics have been made and are being treated with an anti-reflection coating. Once the coating is done, the instrument support package can be fully assembled. The detectors are being fabricated by the Imaging Technology Laboratory (ITL) and are being tested as they are produced. One of the two Silicon Carbide focal base plates is fully assembled and was shipped to ITL for eventual detector installation. The other base plate was populated with detector simulators and is now mounted in the ODI dewar. The dewar is now undergoing testing of the thermal system. So far four filters for ODI have arrived (g', r', i', and z' band), and all have an excellent transmission (>95%). Significant progress has been made on software, and for the first time we are now reading out images from OTA detectors with our software. Parallel to the instrument assembly a plan for an ODI data pipeline is being developed.

The ODI team hopes to begin commissioning in Fall of 2010 and have the instrument ready for shared-risk science observations in Summer of 2011. More information about the progress of ODI can be found here: http://www.wiyn.org/ODI/.

Written by: Victoria Leigh Gardner, Coordinator of Yale Research Observatories & Daniel Harbeck of WIYN

LFOP....

continued from page 1

LFOP is located at 355 Prospect Street, just north of Science Hill, at the edge of Farnham Gardens, and next to Betts House (formerly Davies Mansion). The entire facility has been renamed the Leitner Family Observatory and Planetarium. We are extremely grateful to Jim Leitner, Sandra Shahinian Leitner, and their children for their generous gifts that have made this terrific facility possible."

The planetarium includes a 30-foot hemispherical dome, a Spitz digital projector with a resolution of 1920x2000, and a Starry Night based interface. The planetarium has room for 50 people in comfortable seats that can be removed for special events. The lobby area, located between the planetarium and lecture hall, features maple-paneled walls and exhibits of astronomical images created with help from the Peabody museum. Along one wall of the lobby is the "Big Picture", a large 25'x6' mural showing part of the Virgo cluster, from optical images taken by Yale's QUEST Camera. On the opposite side of the lobby are "Astronomical Objects at Different Wavelengths". The Sun, the Orion Nebula, the Crab Nebula, and the spiral galaxy M51, are each shown at 4 different wavelengths, to demonstrate how much we can learn about the universe by using the entire electromagnetic spectrum. A 3D projector is installed at one end of the lobby.

LFOP offers free public nights every Tuesday, which feature a planetarium show and on clear nights, public viewing through several telescopes. Since February of 2009, less than one month after opening to the public, a second planetarium show was added due to popular demand. We are able to reach more of the public with the planetarium, since not only do larger groups typically come to a planetarium show than to the observing nights of recent years, but planetarium shows can be seen in any weather, so we don't have to cancel them.

In addition to public nights each Tuesday, the planetarium offers public lectures on the first Tuesday of each month, as well as a movie night roughly once a month. The lectures are generally given by faculty and graduate students of the Yale Astronomy Department, but on occasion have been given by visitors, such as Bob Crelin, Dark Sky Activist, and noted author of "There Once was a Sky Full of Stars" and "Faces of the Moon". Movie nights, featuring a "space" themed movie followed by a discussion with a Yale astronomer, seem to be a public favorite.

The planetarium has already been visited by hundreds of K-12 school children from New Haven and surrounding areas. A school visit generally includes viewing the telescopes, looking at the Peabody Museums exhibits, and a 30 minute planetarium show. After the show, the Planetarium Instructor, Heidi Herrick fields a variety of questions that have included "Are the men that live on Jupiter real" and "How big are black holes"? Some of the children have returned to the planetarium for a second visit with their parents on public nights.

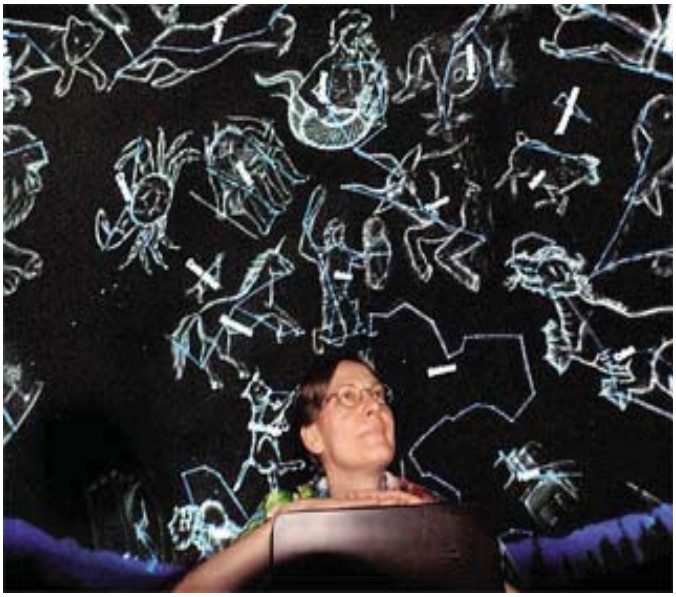
The astronomy department worked with the Peabody Museum over the summer to offer Astro Adventures camp for kids. Children in grades 3-6 participated in an adventurous program and learned all about space. They built models, looked through telescopes, observed the sun with Yale astronomers, learned about the night sky in the planetarium, and visited the Peabody's fantastic collection of meteorites. Another public offering is for Girl and Cub Scouts. Scouts earn their badge or pin by learning how to use the stars to locate North, using a constellation finder, and viewing the moon through a telescope.

There are also classes offered on "How to Build a Telescope", & "How to Use a Telescope" which are taught by Planetarium Director Michael Faison. An Astrophotography course will be offered to the general public in May, and in August an observing course will be offered to high school children.

Students from various introductory astronomy classes have had planetarium and observing sessions. Graduate students are learning to give planetarium shows. Currently, there is an undergraduate student working on a new planetarium show for public nights. Also, the STARRY group is meeting at the observatory twice a month and Grad students are giving three of the public science talks this semester (on the first Tuesdays of each month).

The planetarium has also been a popular venue for several private parties. For a fee, people are able to rent the space for their functions. Some of the parties have even included a private planetarium show and dancing under the stars.

Yale plans to produce entire programs in the domed theater around its own astronomy research, and make the technology available to other departments within the University for presentations.



Planetarium Instructor Heidi Herrick at the new Leitner Family Planetarium, Coutesy of the New Haven Register

- IYA continued from page 6

and television shows including "Armageddon," "Deep Impact," "Enterprise," and "The Simpsons," he talked about Hollywood science (or the lack thereof).

In November, the Department hosted a second talk at LFOP by Bob Crelin who had recently published a children's book called "*The Faces of the Moon".* Bob gave an inspiring talk to a mostly young audience about the Moon and how to enjoy its phases.

Since 2009 was the 40th anniversary of Apollo 11, the first manned mission to land on the Moon, the Department hosted a special event in July on the Apollo missions. Clips from the movie Apollo 13 were shown to a capacity crowd at the LFOP, which were followed by a talk given by Donald Rethke, popularly known as "Dr. Flush". Dr. Rethke, who as an engineer at Hamilton-Standard worked on the Apollo and later space missions, described the many engineering challenges posed by the man-in-space program.

In October, the Department hosted a talk at the Peabody Museum by David Levy, the discoverer of numerous comets, including the famous comet Shoemaker-Levy 9 which impacted Jupiter in 1994. David shared his personal story of how he became fascinated with astronomy as a boy and developed an interest in searching the skies for comets. His discoveries of comets with his small telescopes led to a collaboration with Carolyn and Eugene Shoemaker, their search program with 18-inch Schmidt telescope at Mt. Palomar, and a visit to the White House during the excitement over the impact of Shoemaker-Levy 9.

David Rabinowitz, the Yale scientist who is the co-discover of many of the new dwarf planets in the outer solar system, gave the final Yale IYA talk, "Weird Solar Systems," at the Peabody Museum in November, on all the new discoveries in our own and other solar systems. At this and other fall IYA events, raffles were held for children to receive free "Galileoscopes," which the Department had purchased for increasing the involvement of children in Astronomy.

The Department of Astronomy thanks the members of the Yale IYA team, who planned and organized events thoughout the year: Bob Zinn, Graziella Zinn, Michael Faison, Heidi Herrick, Nicole Whitcher, Ivano Dalprete, and Jeff Kenney.

- Replica Continued from page 7

Jim and Rhoda Morris suggest that Galileo used this technique for mass production purposes; it seems a reasonable assumption considering that in the first year after the invention the astronomer and his assistants produced, on average, 1 telescope every 3 or 4 days. Walnut staves of 900x6x3 mm were used.

The tube of the telescope is covered with red leather, like the original, whose brownish colour is only due to its age. The most apparent difference, however, is that the leather cover of the original was adorned with a pattern of golden decorations, which we found excessively expensive to reproduce. The objective holder and the eyepiece holder are cylinders made as separate items. The tips of the tube are not covered with leather, so the holders can be inserted simply by pressure. The eyepiece itself is held by a smaller cylinder, placed inside the bigger one, which can slide in and out bring the image to focus. The overall length of the telescope is 960 mm, diameter of the tube is 35 mm. (eyepiece and objective holder, 50 and 61 mm).

MOUNT

In September 1609, a Venetian complained that ordinary spyglasses were almost useless: it took a lot to find "the object you want to see, and once you have found it, you have to keep [the instrument] firmly [in your hand] lest you lose it at the slightest movement. However, they say that those made by Galileo are not so imperfect". In this case, the "secret" of Galileo's telescopes was to put them on a firm mount. None of the mountings used by Galileo survived, nor do we have any description to make a replica on a scientific basis, so we decided to reproduce a model of 17th century mounting that is widely associated with Galileo's telescopes in iconography. It is a wooden alt-azimuth mount which can rotate freely on its vertical axis while a screw can tighten or loosen the horizontal axis. The telescope is placed on a saddle and fastened to the mount by a couple of leather strings, so that different tubes can be changed quickly. Unlike the tube, the mount looks quite aged: indeed, Mr. Pozzato was able to recover 18th century larch wood and iron screws from a dismantled bed!

Ivano Dal Prete, Lecturer
History Dept. - History of Science / History of Medicine Program

- Connecticut Space Grant Consortium Continued from page 5

for groups of Yale undergraduates that perform reduced gravity experiments under the auspices of various competitive NASA programs. The team is based in the Physics Department, although not all of its members major in physics. Last year, with the help from funding they received from the CT Space Grant Consortium, they participated in NASA's Microgravity University, which gave them the opportunity to design, construct, and execute a microgravity experiment.

Yale Astronomy graduate students were awarded funding for partial support of their PhD research. Fellowships were awarded to Lisa Esch for "Asteroseismology with NASA's Kepler Mission", and to Kate Whitaker for "The Morphologies of Quiescent Galaxies out to z~2 with NASA's HST/WFC3".

Faculty awards include: Daniel McKinsey (Yale Physics) and Moshe Gai (UConn Physics) who were awarded a Faculty Research Collaboration grant, and Karen Seto (Yale School of Forestry and Environmental Science) who was awarded a Faculty Curriculum Development Grant for "Remote Sensing of Land-Cover and Land-Use Change".

P * E * O * P * L * E

New Faculty

Debra Fischer
Professor


Debra Fischer

Debra Fischer joins the Yale Astronomy Department from San Francisco State University, where she was a faculty member for 7 years. Debra is one of the world's foremost planet hunters, and has discovered or co-discovered over half of the more than the 400 known exoplanets. Her goal is to not only find, but to characterize exoplanets so that we might understand the origin and evolution of planets and planetary systems. She is also knowledgeable about stellar astrophysics and has made contributions to that field.

Debra received her BS in Physics at the University of Iowa in 1975, and her PhD from the University of California at Santa Cruz in 1998. In the intervening years she raised a family. Before she was hired as a professor at SFSU, she completed a postdoctoral fellowship at the University of California at Berkeley while managing the Lick Observatory planet search program.

Debra's Favorite Planets

Here we reproduce an excerpt of an interview that Debra Fischer conducted with the founder of the online magazine "*Woman Astronomer*" Debra L. Davis (http://www.womanastronomer.com/dfischer.htm), in which Fischer discusses her "favorite planets," and why they are so special.

"In 1998, there was one star on the Lick program that was particularly special: Upsilon Andromeda. Geoff [Marcy] and Paul [Butler] had discovered a planet there that was incredibly close to the star. It took only four days for this giant planet, about 250 times the mass of our Earth, to complete one circle around Upsilon Andromeda.

However, they could see that there was something odd about the velocities — an upward trend that suggested the presence of a second, more distant planet.

I was under orders to be vigilant in collecting data on this star, and I took this very seriously. As the outer planet was completing its orbit, I would work during the day in my office and dash up to the Observatory — a 2-hour, winding drive. We were losing Upsilon Andromeda — from our perspective, it was moving behind the Sun (of course it is really the Earth that was moving around the Sun). So, I would take all the calibration images before sunset and set the telescope on the star. As soon as the Sun set, I opened the camera shutter and began collecting starlight that the instrument turns into a spectrum. This became a personal quest — me against the star. I would immediately run the analysis and plot up the next velocity point.

"With the data in hand, and Upsilon Andromeda finally behind the Sun, my next job was to create a mathematical model that described the velocity measurements. At the same time a team at Harvard, led by Bob Noyes, called Geoff Marcy and said that they had data also showing the second planet and they decided to write a joint paper. But, I was struggling with the 2-planet model and feeling quite dejected because I couldn't get a good fit. To look at the noise in my fit, I subtracted my best 2-planet model from the real data and couldn't believe my eyes. A clear, coherent wiggle remained, looking for all the world like another planet. I changed my model to include three planets and found a perfect fit. The three planet model also worked better on the data from the Harvard team.

"The result was picked up in the newspapers. Perhaps the best part of the story is that I then received a letter from a 4th grade class in Moscow, Idaho. They had been studying astronomy, and their teacher told them about the discovery. The students wondered if we had named the planets yet — of course, they had suggestions. The "little" planet in the system was the one found by Geoff and Paul in 1996 and the students wanted to call this 250-earth mass planet "Dinky." The next planet (the unexpected third planet I had modeled) was two times the mass of Jupiter so they suggested "Twopiter" as a name. And the outer planet that caused me to chase the star as it fell behind the Sun was four times the mass of our Jupiter (more than 1200 Earth masses) so they recommended "Fourpiter." The names were so clever that they stuck!

"The thing I loved about this discovery, beyond the fact that I finally succeeded in modeling it, was that it was the first star where more than one planet had been found. It showed us that gravitational domains (kind of like personal space for people) were pushed close together, just like the planets in our solar system. It was our first clue that planet formation was truly a robust process."

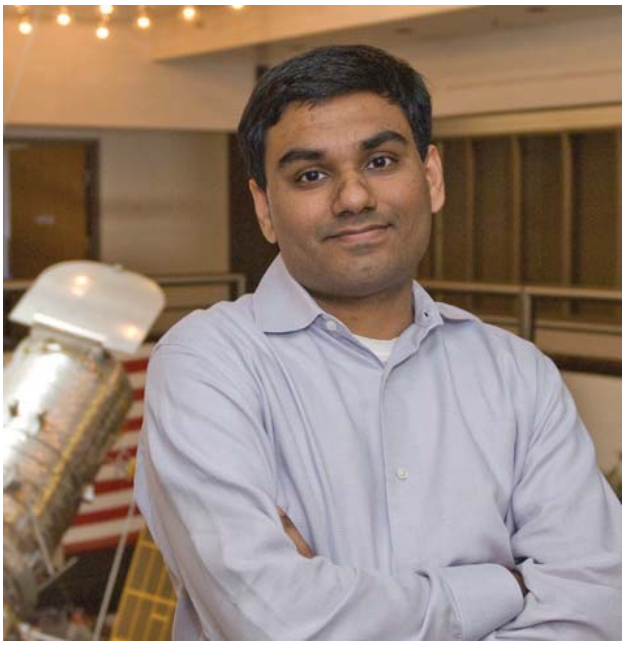
P * E * O * P * L * E

-New Faculty continued

Nikhil Padmanabhan
Assistant Professor

Nikhil Padmanabhan joined the Yale Physics and Astronomy Departments in 2009 from the Physics Division of the Lawrence Berkeley Laboratory, where he was both a Hubble Postdoctoral Fellow & Chamberlain Fellow. Nikhil has a BS in Physics from Stanford University and received his PhD in Physics from Princeton University in 2006.

Nikhil studies the large scale structure of universe, the cosmological parameters, and probes of dark matter and energy. He is both a theorist and a miner of galaxy surveys. For this thesis he studied the clustering of luminous red galaxies in the Sloan Digital Sky Survey (SDSS), and explored the cosmological implications. With the SDSS data, he created the largest three-dimensional map of the universe ever constructed. This wedge-shaped slice of the cosmos spans a tenth of the northern sky, encompasses 600,000 uniquely luminous red galaxies, and extends 5.6 billion light-years deep into space, equivalent to 40 percent of the way back in time to the Big Bang. Within this 3D map, he detected the non-random clustering of galaxies on gigaparsec scales for the first time, and also detected the imprint of acoustic oscillations in the plasma of the early Universe on the clustering of the luminous red galaxies. In addition to these impressive scientific results, Nikhil also developed improved data analysis algorithms and calibration techniques for the SDSS imaging data that have benefited the broader astronomical community.



Nikhil Padmanabhan

Recent Graduates

Andrew Cantrell, '09 PhD

Andrew is currently a Post-Doctoral Associate at Yale University's Department of Astronomy. His dissertation was "*Phase Shifts and Nonellipsoidal Light Curves: Challenges from Mass Determinations in X-ray Binary Stars*"

Accreting binaries consist of a normal star and a compact object (black hole, neutron star, or white dwarf), in which there is a steady flow of matter from the star onto the compact object. Efforts to understand these accretion flows and compact objects have often given contradictory and apparently nonphysical results. He demonstrated that these apparent contradictions are the result of an asymmetrical accretion flow and that accounting for this flow allows for unprecedented precision in determining the properties of black holes.

Dr. Cantrell's advisor was Professor Charles Bailyn.

Kathy Vieira, '09 PhD

Kathy is currently a Postdoctoral Associate at CIDA in Venezuela. Her dissertation was "*Proper Motion Study of the Magellanic Clouds using SPM Material."*

For her thesis, Kathy investigated the proper motion of the Magellanic Clouds using photographic plates and CCD images from the Yale-San Juan Southern Proper Motion Program. The main goal was to obtain an independent measurement of their motion in the sky, in view of recent space-based studies which suggest that these two dwarf irregular galaxies are passing by the Milky Way very fast, to never come back. She obtained a very precise measurement of the proper motion of the Small Magellanic Cloud with respect to the Large Magellanic Cloud. The results indicate that the Clouds can be in a marginally bound, very elongated, but still periodic, orbit around the Milky Way. The findings stress the importance of having accurate (and not just precise) proper motion measurements for the calculation of the Clouds orbits, as these calculations are extremely sensitive to proper motion errors.

Dr. Vieira's advisor was Professor Bill van Altena.

MORE P * E * O * P * L * E

Retiring Faculty

Sabatino Sofia
Professor of Astronomy,
Emeritus

Prof. Sabatino Sofia ('63BS '65MS, '66PhD) officially retired in January 2009, after 25 years as a Professor of Astronomy at Yale. Sabatino is a true "Yale man", as he was also both an undergraduate and graduate student at Yale. To the dismay of his wife Tara (who should not be reading this!) Sabatino remains active in research. Over the next few years he will be enthusiastically comparing his models of the Sun to new data obtained by the PICARD satellite and the Solar Dynamics Observatory. For further career highlights, we reproduce this tribute to Sofia, written largely by Prof. Charles Bailyn, and entered into the minutes of the Yale College faculty meeting upon the occasion of his retirement.

Sabatino Sofia, B.S. Yale College, Ph.D. Yale University, faculty member at Yale since 1984, you are one of Earth's foremost students of the Sun. Your pioneering early work with Endal and with Chan illuminated the complex effects of rotation and convection on the internal dynamics of the Sun. These efforts were far ahead of the computational capabilities of the time, and continue to form the basis of work being carried out now.

After teaching in Florida and serving at NASA, you returned to Yale to help lead the Center for Solar and Space Research, carrying out a vigorous research program including both theoretical work and a highly successful program of balloon-borne measurements of the precise shape and size of the Sun. These experiments will culminate soon in the launch of the PICARD satellite, which will use approaches you have pioneered to make definitive measurements of variations in the radius and temperature of the Sun.

Recently you have devoted great effort to unraveling the effects of solar variability on the climate of the Earth, significantly reducing one of the great uncertainties in understanding the effects of human activities on climate.

Originally from Italy, your early education was in Venezuela, and your devotion to Yale's connections to Latin America has continued throughout your career. As chair of the Department of Astronomy in the 1990s, you initiated and nurtured close links to Venezuela and Chile that have benefitted many astronomers in both the north and south. In particular, the Yale-Chile program that you began launched the next generation of Chilean astronomers on their careers, and has resulted in ambitious joint programs of research in stellar, galactic and extra-galactic astronomy.

Nor have you neglected education closer to home. You also created a popular Yale course on Life in the Universe for Yale undergraduates, and for over twenty years you have led seminars of New Haven teachers. Across New Haven classrooms, remarkable models of the solar system bear a genealogical relationship to you, and untold numbers of paper and papier-maché flying machines have sailed off into sunsets under your influence.

"The best thing you can give to anyone is what you do best," you once said about your work for the Teacher's Institute. Your efforts to forge connections between the northern and southern parts of our planet, between scientists and the public, and between the Earth and its parent star, surely is that best, and will form a firm foundation on which future generations will build. Yale trained scientist who was global in every respect well before Yale had global aspirations, we are proud and deeply grateful for your efforts on behalf of science and of Yale, and we wish you sunny skies in all your future endeavors.

New Staff

Heidi Herrick
Planetarium Instructor

Ms Herrick manages K-12 public school programs at the new Leitner Family Observatory and Planetarium (LFOP). During a typical school visit she performs a live planetarium show on tonight's sky, runs one of the four professionally produced shows, gives a tour of the telescopes and exhibits, and answers students' questions. In addition, Ms Herrick staffs the Tuesday Public Nights, mentors high school students, develops student activities to meet State of Connecticut Science Standards, manages the school visit scheduling, and coordinates events at the LFOP.

Nicole Whitcher, Chair's Assistant

Nicole started in the Department of Astronomy in December of 2008 as the Chair's Assistant to Jeff Kenney. Nicole has a variety of responsibilities including coordinating IYA events and faculty appointments. She also assists Professor Kenney in many projects such as tracking students class attendance and summarizing statistical information.

When Nicole is not working, she enjoys spending time with her husband and daughter, swimming, and being outdoors.

AWARDS AND HONORS

Héctor Arce, Assistant Professor of Astronomy at Yale has learned that he will be awarded an NSF Career Grant.

Charles Bailyn, '81 BS, Thomas E. Donnelley Professor, Astronomy & Physics, and DUS, Astronomy was awarded the Bruno Rossi Prize from the American Astronomical Society for his research on the masses of black holes. Other recipients of the Rossi Prize were Jeffrey E. McClintock and Ronald A. Remillard.

Bethany Cobb, '08 PhD was awarded the Dirk Brouwer Memorial Prize for her thesis "Long-term observations of GRBs: the complex connection between GRBs and SNe".

Marla Geha, Assitant Professor of Astronomy at Yale University has been selected by Popular Science magazine as one of their 2009 "Brilliant Ten" young scientists. This honor recognizes outstanding creativity, risk-taking and scientific achievements among young researchers.

Priya Natarajan, Professor of Astronomy at Yale, was awarded a John Simon Guggenheim Fellowship, in its eighty-fifth annual competition for the United States and Canada. The John Simon Guggenheim Memorial Foundation awarded 180 Fellowships to artists, scientists, and scholars. The successful candidates were chosen from a group of almost 3,000 applicants.

George Preston, '52 BS, (Yale Physics major) was awarded the Henry Norris Russel Lectureship from the American Astronomical Society.

Kevin Schawinski, '08 PhD, a researcher at Yale University was awarded a 2009 Chandra Fellowship.

C. Meg Urry, Ireal Munson Professor of Physics and Astronomy, and chair of the Physics Department at Yale has received an honorary doctorate of science from Tufts University.

Shanil Virani, '05 MS, '07 MPhil won the American Astronomical Society's Chambliss Astronomical Achievement Award Medal. The Astronomy Achievement Student Awards are given to recognize exemplary research by undergraduate and graduate students who present at one of the poster sessions at the meetings of the AAS.

Kathy Vivas, '02 PhD was awarded the Premio Fundación Polar Lorenzo Mendoza Fleury Prize for her work on the RR Lyrae Variables and the Substructure in the Galaxtic Halo. It is the top prize in Venezuela!!

Pictured from top left to bottom right: Héctor Arce, Charles Bailyn, Bethany Cobb, Marla Geha, Priya Natarajan, George Preston, Kevin Schawinski, C. Meg Urry, Shanil Virani, & Kathy Vivas

Alumni

Douglas A. O'Handley '64 MS, '67 PhD is currently a member of the Board of Governors of the Association of Yale Alumni. He writes "I am still teaching in the Physics Department of Santa Clara University and have now assumed the roll of Director emeritus of the NASA Ames Academy for Space Exploration. I am slowly drifting into retirement. Last summer we spent a month in Europe while attending the International Astronautical Congress in Glasgow, Scotland. Cruising back on the QM 2 and enjoying the tandem crossing with the last voyage of the QE 2 before the ship was moved to Dubai. The year was completed with a three week cruise on Silverseas expedition ship the Prince Albert II to Antarctica. This was by far the most exciting trip we have ever taken. The sheer scenery, abundance of penguins and seals, and the magnificent icebergs made everyday a sensory overload."

Bill Jefferys '64 MS, '65PhD writes "I retired from the University of Texas in 2004 after almost 40 years there, having served as department chair and as the Hubble Telescope Astrometry Team Leader. I retain the title Harlan J. Smith Centennial Professor of Astronomy (Emeritus) as well as my email and web page at UT. Some will remember Harlan, who was an assistant professor at Yale but left for Texas in 1963. Sue and I moved to a family place in Vermont in 2005 (see my webpage http://bayesrules.net for pictures). I obtained a position as Adjunct Professor of Statistics at the University of Vermont, and from time to time teach a course there (when I feel like it). I'm working with a group including some students at UT, and others, using Bayesian methods for fitting color-magnitude diagrams and determining ages of open clusters. A number of papers have come out of our group, and others are in the works. Sue and I welcome visitors at our place so if you find yourself in central Vermont, look us up. Email to bill@astro.as.utexas.edu should always work."

Giorgio E. O. Giacaglia '65 PhD Is Coordinator of Graduate Programs in Aeronautical Engineering and Industrial Engineering at the University of Taubaté, São Paulo, Brazil, doing research in Artificial Satellite Theory and applications in cooperation with Prof. Bob E. Schutz of the Center for Space Research of the University of Texas at Austin. Prof. Giacaglia is a Member of the Brazilian Academy of Sciences and Founding Member of the Sao Paulo State Academy of Sciences. He is author of several technical papers published in International Journals and in Proceedings of International Congresses. He is also author and editor of books published in the US (Springer), Holland (D. Reidel), Germany (Springer), the former USSR (Moskva Nauk) and Brazil. Prof. Giacaglia is a member of the Honorary Aeronautical and Astronautical Society Sigma Gamma Tau, University of Texas at Austin Chapter and Professional Engineer with the Texas State Board of Registration of Professional Engineers in Aerospace Engineering.

Julian Palmore '67 PhD writes "I taught an interdisciplinary seminar in the Campus Honors Program on Spaceflight during spring semester 2009. We discussed spaceflight dynamics, celestial mechanics, space physiology and past and future NASA and Russian space programs. There were 18 honors program students who participated in the twice weekly seminar. Astronomy and astrophysics were used extensively and played a key role in the course. In January I was elected a Life Fellow of The Explorers Club."

Alan Hirshfeld '78 PhD has just completed his 30th year in the Physics Dept. at UMass Dartmouth. His latest popular science book, "*Eureka Man: The Life and Legacy of Archimedes"* will be published in September by Walker/Bloomsbury. About the book, Kirkus Reviews writes: "Thoroughly enjoyable look at the tumultuous life and resounding influence of a genius of antiquity." Also, his Astronomy Activity and Laboratory Manual, a history-based series of in-class exercises for college-level introductory astronomy courses, was published by Jones & Bartlett last September.

Ed Seidel '88 PhD writes "After leading research groups in numerical relativity and computational science at the University of Illinois and the Max Planck Institute for Gravitational Physics (Albert-Einstein-Institute) in Germany, I moved to LSU in 2003 to become Director of the Center for Computation and Technology. In 2006 I was awarded the Sidney Fernbach Award of the IEEE. Last year, I was asked to come to the National Science Foundation to become the Director of the Office of Cyberinfrastructure, which oversees NSF's high-end computing programs. At the end of August I will take on the role of Acting Assistant Director for Mathematics and Physical Sciences (which includes AST!) until a full-time AD can be found, after which time I will return to OCI."

Andrew Jaffe '88 BS writes "I'm a Professor of Astrophysics and Cosmology at Imperial College in London. The most exciting news from me is the launch of the Planck Surveyor Satellite this past May, of which I'm a co-investigator!"

Sydney Barnes '90 BS, '98 PhD writes "I'm writing from South Africa, where I'm currently visiting SAAO, and attending the South African Institute of Physics 2009 conference. It's fascinating to be here this week, and the next, my wife Claudine and I — I got married in Sep 2008 — will be wandering through Kruger National Park. I'm still a staff astronomer at Lowell Observatory. As far as research goes, I'm very excited about two things: (1) The Kepler satellite, launched a couple of months ago, is transmitting fantastic data so far, with mind-boggling light curves, and (2) I'm

working on a generalization of gyrochronology, to include all rotating cool stars. I'm looking forward to a visit in September from Sabatino Sofia, who will be coming through Flagstaff, and later in the fall I'm hoping to visit Sukyoung Yi and Y.-C. Kim at Yonsei University in Korea."

Ben Mazin '97 BS writes "I was an undergraduate astronomy & physics major at Yale, graduating in 1997. I have recently taken a position as an assistant professor of physics at UCSB, focusing on Microwave Kinetic Inductance Detectors for UV to near infrared astronomy."

Eric Rubenstein '97 PhD Is a Director at Advanced Fuel Research Inc., that he and Gordon Drukier (Astronomy Dept. Lecturer and Associate Research Scientist, 2000-2007) are developing a gamma-ray detection system using optical security cameras. Funded by contracts from the National Academy of Sciences and the Domestic Nuclear Detection Office of the Dept. of Homeland Security, the technology was inspired by the routine cleaning of cosmic ray hits from ground and HST images. If you want to see how much harder it is to find gamma-ray hits on terrestrial video, take a look at the video of a successful test in the Washington, D.C. metro system at http://www.RedStarDetect.com. During a recent project on spacecraft radiation shielding, Eric has had a chance to play/work with nuclear accelerators at Brookhaven, Los Alamos, and Indiana University; beam-time is at least as fun as telescope-time! Being able to control the flux is such a relief compared to small telescopes and distant objects. Having joined the Navy Reserves in 2002, Eric is now a Lieutenant working with the Office of Naval Research — in his copious free-time. If you are near his lab in East Hartford, CT and would like to see RedStar in action, drop him a line at ericr@afrinc.com.

Kathy Vivas '02 PhD writes "Since my graduation at Yale in 2002, I am working as research scientist at Centro de Investigaciones de Astronomia (CIDA) in Merida, Venezuela. I continue working very closely with Dr. Bob Zinn, who was my thesis advisor at Yale. We continue exploring the halo of the Milky Way using RR Lyrae variable stars. On June 4th, I received the "Lorenzo Mendoza Fleury Prize" for scientific achievement. This is the top prize in science in Venezuela. It is awarded every two years by a private Foundation in the country, Fundación Empresas Polar. The 2009 edition of the prize was awarded to 5 researchers in Venezuela, including me. On a more personal note, I have two beautiful girls. Sofia just turned 5 and Julia is 2 1/2 years old."

Katherine Rhode '03 PhD writes "I joined the Indiana U. department of astronomy as a faculty member in 2007. I was recently informed that I've been awarded a National Science Foundation Career award. This is a 5-year grant for early-career faculty members."

Brendan Cohen '05 BA writes "This coming year will be my fourth year teaching physics, astronomy, and the history of science at the St. Paul's School, a 9th-12th grade boarding school in Concord, NH. The year after next (starting in the fall of 2010), I will be attending Stanford Law School, with the intention of studying intellectual property law."

Meredith Hughes '05 BS writes "I'm currently finishing up my PhD at Harvard, studying protoplanetary disks around young stars using millimeter-wavelength interferometry. I have five first-author papers submitted or published, plus a handful of nth-author papers (where n>1), and was awarded a certificate of distinction in teaching this year. I've continued to be involved with volunteer work at the Boston Museum of Science and public nights at the Center for Astrophysics, and this year I also started an outreach program that links my chorus with a teen music program in East Boston through joint rehearsals, workshops, and concerts.

Kathy Kornei '06 BS writes "I'm a current 4th year astronomy graduate student at UCLA. My research focuses on both super star clusters in nearby starburst galaxies and also Lyman break galaxies at z = 3. I look forward to presenting results at the January AAS meeting! Life in Los Angeles is good — enjoying beach volleyball, fresh produce from the farmer's market, and summer concerts at the Hollywood Bowl."

If you have news about yourself or others you would like to share, please E-mail it to **astro.newsletter@yale.edu**

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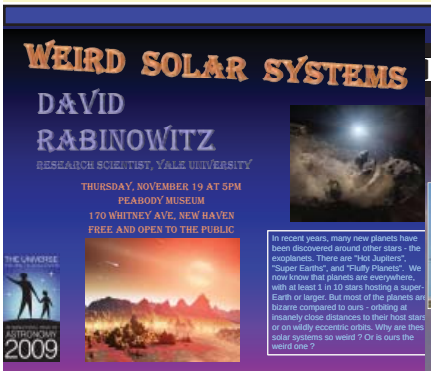

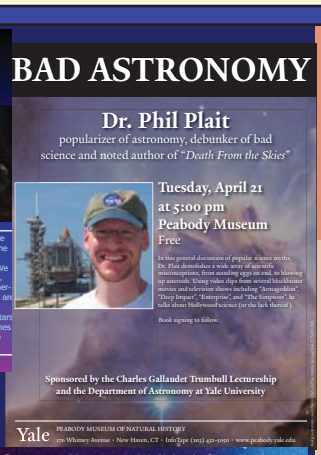

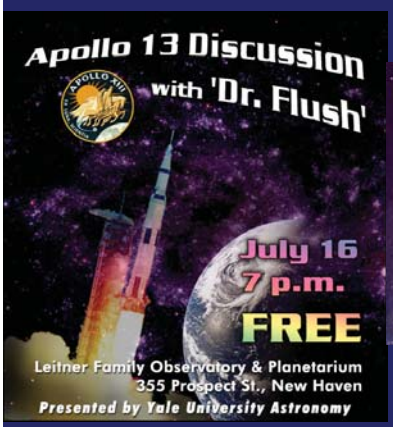

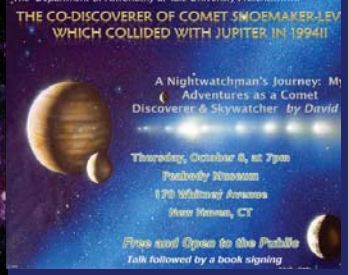

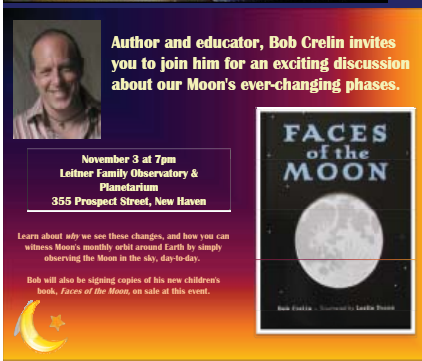

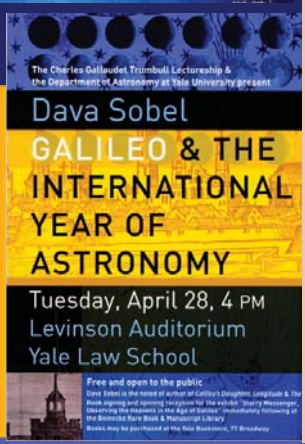

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