Researchers for the first time have identified Earth-sized planets within the habitable zone of a Sun-like star. Images of the star taken by University of Notre Dame astrophysicist Justin Crepp rule out alternative explanations of the data, confirming that five planets orbit Kepler-62, with two located in the habitable zone. The results were published in *Science* magazine. A five-planet system with planets of 1.41 and 1.61 Earth-radii in the habitable zone of a K2V star has been detected with the Kepler spacecraft and validated with high statistical confidence,” the paper reports. Those two, named Kepler-62 e and f, are the outermost of the five observed planets and receive a solar flux from the star similar to that received from the Sun by Venus and Mars. Their size suggests that they are either rocky, like Earth, or composed mostly of solid water. A planet discovered more than a year ago in the habitable zone of another Sun-like star, Kepler-22, has a radius 2.4 times the radius of Earth, leaving researchers less sure of its composition.

“From what we can tell, from their radius and orbital period, these are the most similar objects to Earth that we have found yet,” said Crepp, the Freimann Assistant Professor of Physics. Crepp noticed a faint dot near Kepler-62 a year ago, leading to months of detailed study to confirm the planet interpretation.

“From what we can tell, from their radius and orbital period, these are the most similar objects to Earth that we have found yet,” said Crepp, the Freimann Assistant Professor of Physics. Crepp noticed a faint dot near Kepler-62 a year ago, leading to months of detailed study to confirm the planet interpretation.

Researchers use fluctuations in the brightness of a star to identify the presence of a potential planet whose transit periodically dims the light of the star. Crepp uses large ground-based telescopes to image the host star and analyzes the system to make sure other astronomical phenomena, such as nearby eclipsing binary stars, are not causing the fluctuation, a common “false positive” encountered in the research. Crepp noticed a faint dot near Kepler-62 a year ago, leading to months of detailed study to confirm the planet interpretation.

“What really helped is that this star has five planets,” he said. “You can mimic one planet with another event, but when you have five of them and they’re all periodic, that helps to put the nail in the coffin. It’s hard to make that kind of signature with anything else that you can dream up.”

**Sigma Pi Sigma induction**

The Department of Physics at the University of Notre Dame inducted 11 undergraduate physics majors and 2 professors into Sigma Pi Sigma on Friday, April 26. Professor Peter Garnavich, faculty advisor of the Society of Physics Students, and Professor Mitchell Wayne, Department Chair, presented the inductees with their honor cords.

Sigma Pi Sigma induction is the official honor society of the physics profession. Through election to Sigma Pi Sigma, distinctive achievement and high scholarship in physics is recognized and celebrated.

Students inducted were: Shannon Hughes, Kevin Kelly, Kevin McDermott, Patrick McIntyre, Bailey Moser, Vu Nguyen, Timothy O’Brien, Stanislava Sevova, Brandon Summa, Amanda Williams, and Owen Zeng. The professors inducted were Kevin Lannon and Xiao-dong Tang.
Faculty news & notes

Zoltán Toroczkai, professor of physics and concurrent professor of computer science and engineering, has been nominated to serve on the advisory board of Chaos: An Interdisciplinary Journal of Nonlinear Science. Chaos is a quarterly peer-reviewed journal that is published by the American Institute of Physics. The journal includes articles about the most recent developments in nonlinear sciences from the areas of physics, mathematics, chemistry, biology, economics, and social science.

As a member of the Chaos advisory board, Toroczkai will submit articles to the journal, solicit articles from other researchers, and provide ideas for the direction of future issues, including ideas for potential focus areas. He was selected for his stature in the field of nonlinear science and his areas of expertise. This appointment to the board began January 1, 2013 and will last three years.

Ani Aprahamian, Frank M. Freimann Professor of Physics, has been appointed to a three-year term on the Physics Policy Committee of the American Physics Society (APS). The appointment was made by APS President Michael S. Turner and is effective January 1. The Physics Policy Committee addresses science policy issues that affect the development of physics, the health of the institutions in which physics is practiced, the resources available to physics, and the balanced use of these resources for the nation's scientific and technological needs.

Professor Michael Hildreth has been named a 2013 CMS LPC Senior Fellow. The LHC Physics Center (LPC) at Fermilab is a regional center of the Compact Muon Solenoid (CMS) Collaboration. The LPC serves as a resource and physics analysis hub primarily for the 700 U.S. physicists in the CMS collaboration. During the coming year, Hildreth will be working with Fermilab experts on the study of the theories of SuperSymmetry (SUSY) to look for new physics in collider events involving high energy photons.

Don Lincoln, guest professor of physics and staff scientist at Fermi National Accelerator Laboratory, was the featured “hero in education” on the Daily Edventures blog on February 23. The blog features an educator every day for 365 days and comes from Microsoft Partners in Learning, a global wide initiative focused on improving teaching and learning by helping educators and school leaders connect, collaborate, create, and share ideas so students can reach their full potential.

Professor J. Christopher Howk has been appointed to a three-year term on the Space Telescope Users Committee. The Committee serves to advise the Space Telescope Science Institute (STScI) and Goddard Space Flight Center on the scientific operations of the Hubble Space Telescope and is jointly chosen by the STScI Director and Hubble Space Telescope Project Scientist at Goddard. Howk will serve a three-year term, effective April 25. The Committee is charged advising the Hubble teams on normal operations of the observatory and with recommending changes that will maximize its scientific productivity.

Professor Grant Mathews has been selected to receive a U.S. Faculty Scholar Grant from the Vietnam Education Foundation (VEF) for the 2013-14 academic year. Mathews will be part of the sixth group of faculty selected. The VEF was established by the U.S. Congress in December 2000 as an independent federal agency. VEF’s primary purpose is to promote the bilateral relationship between the United States and Vietnam through educational exchanges. This faculty visit by Mathews from January to June 2014 will contribute to scientific education capacity building in Vietnam through teaching of two modern courses in astronomy and relativity/cosmology and also through collaborative research with Vietnamese faculty in cosmology and astrophysics.

Professors Carol Tanner and Steven Ruggiero received an award from the Office of Research as part of the Faculty Research Support Initiation Grant Program.

The objective of the work is to create a powerful new optical cancer diagnostic instrument for the diagnosis and study of cancer. Their goals are to create a new means to study the fundamental physical properties of cancer cells, and a highly sensitive and quantitative diagnostic tool for early cancer detection. This new instrument will be used to obtain the wavelength-dependent (ultraviolet to infrared) optical properties of cancer cells and the number, size, and geometry of organelles within the cells. This work is motivated by substantial evidence showing both significant optical changes in cancer versus normal cells, a propensity for abnormal/enlarged organelles (especially mitochondria) in a wide variety of cancer cells, and the recognized diagnostic value of identifying both changes in optical properties generally and changes in organelle morphology specifically in cancer cells.

The work currently represents a collaboration between the Department of Physics (N. Sun, C. Tanner, and S. Ruggiero) and the Harper Cancer Research Institute (J. Johnson and S. Stack).
Graduate student news

### Hayden earns Rodger Doxsey Prize

*Brian Hayden* has been awarded the Rodger Doxsey Prize from the American Astronomical Society (AAS). The prize provides graduate students or postdoctoral researchers, within one year of receiving or receipt of their Ph.D., a monetary prize to travel to the AAS winter meeting to give an oral presentation of their dissertation.

Hayden, who works with *Professor Peter Garnavich*, studies type Ia supernovae (SNe Ia), which are important cosmic distance indicators. These supernovae were also pivotal in the discovery of Dark Energy, the mysterious force that drives the acceleration of the expansion of the universe. He has examined SNe Ia from a cosmological perspective, in order to improve estimates of the distance to each supernova, and has studied their progenitor systems, since the nature of the stellar system that produces these explosions is not fully understood. Hayden’s current research focuses on the environments of SNe Ia, particularly looking at the evolution of their host galaxies to gain more knowledge about the expansion of the universe. He is working towards determining what effect a supernova’s environment has on distance estimates, and what the environment can indicate about their progenitors.

### Lyons founds AWIS at Notre Dame

*Stephanie Lyons* is a founder and the current president of the Notre Dame chapter of American Women in Science.

“My goals for our local chapter,” she says, “are to establish a community of support for women in the science. In some fields—like physics—we are an underrepresented group. We are establishing a forum for our women graduate students to discuss topics of common interest.”

### 2013 Graduate Student Teaching Award Winners

The 2013 Outstanding Graduate Student Teaching Award, which is given annually by the Notre Dame Graduate School and the Notre Dame Kaneb Center for Teaching and Learning, honors graduate student instructors and teaching assistants whose teaching demonstrates excellence in the classroom or laboratory. The 2013 award recipients from the Department of Physics are William Bauder, Karen Ostdiek, and Allison Showalter.

Two special spring lectures

*George Crabtree*, Director of the Joint Center for Energy Storage Research (JCESR) at Argonne National Laboratory and Professor at the University of Illinois visited campus on Friday, April 19. **Beyond Lithium-Ion Batteries** was the title of this special Nieuwland Lecture Series event.

JCESR develops concepts and technologies for portable electricity storage for transportation and stationary electric storage for the electricity grid. Electrified transportation replaces foreign oil with a host of domestic electricity sources such as gas, nuclear, wind and solar, and utility-scale electric storage enables the grid to bridge the peaks and valleys of variable wind and solar generation and of consumer demand. JCESR looks beyond Li-ion technology to new materials and phenomena to achieve the factor of five increases in performance needed to realize these transformational societal outcomes.

On Monday, April 29, *Prof. S. James Gates, Jr.* presented a talk as part of the Lynch Lecture series. Gates is University System of Maryland Regents Professor, John S. Toll Professor of Physics, Center for String & Particle Theory Director, and a 2011 National Medal of Science Recipient.

His lecture was titled **The ABEGHHK’tH Resolution**. The observation by CERN of the Higgs boson was hailed as one of the most significant scientific events of recent times. What is the Higgs boson, why is it so important, and what does the observation of this particle mean for our understanding of the universe? These questions and more were addressed.

Gates’ visit was organized in part by the Society of Physics Students undergraduate group.
Professor Peter M. Garnavich, and physics graduate student Brian Hayden are members of the CANDELS+ CLASH Supernova Project that recently discovered a supernova that exploded more than 10 billion years ago. The Type Ia supernova, part of a class used for measuring the expansion of space, is the farthest yet found by NASA’s Hubble Space Telescope. Garnavich and Hayden are co-authors of a paper announcing the discovery which has been accepted for publication in The Astrophysical Journal.

Since 2010, Hubble’s Wide Field Camera 3 has surveyed faraway Type Ia supernovae to determine whether they have changed over the 13.8 billion years since the Big Bang. The Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS) and the Cluster Lensing and Supernova Survey with Hubble (CLASH) have studied thousands of galaxies.

“We realized that in building up the deep images, we could take data every few months, and by staggering the visits we could search for fresh exploding stars,” Garnavich said, adding that Hayden’s dissertation is on the study of Type Ia supernovae. “Brian and I have great fun searching for supernovae in the Hubble data, and we have personally found a few. We have also contributed to the ground-based follow-up studies including observations with the Large Binocular Telescope (LBT).” The LBT, which is partly funded by Notre Dame, is one of the largest telescopes in the world.

“These supernovae are important tools for studying the dark energy that is speeding up the expansion of space,” said census leader Adam Riess of the Space Telescope Science Institute in Baltimore and Johns Hopkins University. “This study gives us a chance to ‘stress test’ the supernovae themselves to test how well we understand them.”

The supernova is named SN Wilson after President Woodrow Wilson. The CANDELS+CLASH collaboration has found more than 100 supernovae, including SN Wilson, 350 million years older than the previous record, and seven other Type Ia supernovae that exploded more than 9 billion years ago.

Among other things, the study has provided evidence that supernovae result from the merger of two white dwarfs, rather than the explosion of one white dwarf that was feeding from another. Understanding supernovae explosions can also provide insight into the nature of dark energy and the production of iron and other heavy elements in the universe.

“The addition of the new infrared camera on Hubble has made this supernova search and study of early galaxy formation possible,” Garnavich said. “But NASA’s Shuttle program has ended, so that was the last visit by astronauts to improve the Hubble. We will need new telescopes in space if we want to continue to understand the early universe.”

Toroczkai publishes paper in Proceedings of the National Academy of Sciences of the USA journal

Professor Zoltán Toroczkai has co-authored a paper in March 26 issue of Proceedings of the National Academy of Sciences. The paper, “The role of long-range connections on the specificity of the macaque interareal cortical network,” was written in collaboration with a group of neuroanatomists from Lyon, France.

The group investigated the influence of interareal distance on connectivity patterns in a database obtained from the injection of retrograde tracers (experiments performed by the French group) in 29 areas distributed over six regions in the brain—occipital, temporal, parietal, frontal, prefrontal, and limbic.

Their findings showed that long-distance connections in the primate brain make important contributions to the specificity of the cortical networks. Although the axons of these neurons are only about one micrometer thick (10^-6 m), they can make connections across the whole brain reaching to areas many centimeters away.

The weight of the pathways that link the cortical areas likely plays an important role in determining the physiological function of each cortical area. Long-distance connections are in low abundance and also weak, but they are highly consistent across brains. Their observations suggest that these connections have a prominent role in brain-wide communication and information integration.

Photo: Surface maps of cortical connectivity for an exemplar injected area (area F2, in black). (Upper) Known connections; (Lower) NFPs. (Left) Flat maps; (Center) lateral inflated maps; (Right) medial inflated maps. Connection strengths are color coded as values of log_{10}(FLNe), varying from 0 (red) to −6 (yellow). Area injected is in black. Image courtesy of www.pnas.org.