

# Department of PHYSICS *and* ASTRONOMY

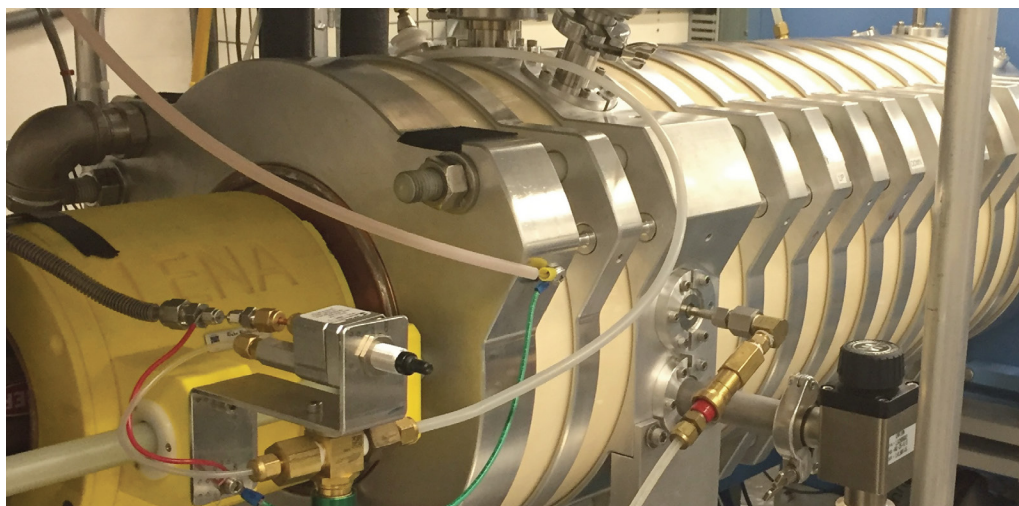


UNC  
COLLEGE OF  
ARTS & SCIENCES

THE UNIVERSITY OF NORTH CAROLINA  
AT CHAPEL HILL

SPRING 2017

## FORGING ELEMENTS IN STARS AND THE LAB



*A world-record holder in ion beam intensity: UNC's new ion accelerator designed to measure nuclear fusion reactions that occur in stars.*

**Y**ou've likely heard the late Carl Sagan's famous quote: "We are made of star stuff." It means that the elements we consist of were forged via nuclear fusion reactions inside stars of an earlier generation, before our solar system formed. What you may not know, however, is that many people said these words before Sagan. Perhaps the earliest example is from Ellen Fritzell Wyckoff, who wrote: "There was once a little girl who cried out with joy when she realized for one little moment that the earth is truly a heavenly body, and that no matter what is happening to us, we are really living right up among the stars. The sun is made of 'star stuff,' and the earth is made of the same material, put together with a difference." Wyckoff wrote these words in a weekly science column, called "Star Land,"

in the Greensboro Daily News, on June 15, 1913! What may astonish you even more is that the first nuclear reaction was only discovered in 1919, by Nobel Laureate Lord Ernest Rutherford.

The Triangle is home to one of the nation's leading research groups in nuclear astrophysics, which investigates nuclear fusion reactions that occur in stars. The group includes University of North Carolina-Chapel Hill Professors Art Champagne and Christian Iliadis. Carolina Professor Tom Clegg also has contributed significantly over the past decade. The youngest faculty member of the group is North Carolina State University Assistant Professor Richard Longland (a Carolina alumnus). About ten graduate students work under the direction of these faculty members.

*(continued on page 2)*

## Service Course Changes Fully Implemented



*An introductory Physics classroom under the new lecture/studio format.*

**O**ver the last decade, we've created four new introductory courses that now provide more than 1600 students each year with education in exciting and relevant physics topics using effective, research-validated pedagogy. Every student now benefits from active learning guided by the findings of physics education research. These lecture/studio classes spend two-thirds of class time each week in small-group, hands-on, "minds-on" activities in classrooms renovated for the purpose. Our data (analyzed in a recent MS thesis by David Guynn) show that significant learning gains result from the new mode of instruction, for all student populations and regardless of the instructor. By working together as a department to undertake these changes, we've made them comprehensive and sustainable. In so doing, we have taken as scientific an approach to our teaching as we do to our research, in order to benefit our students.

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# FROM THE CHAIR

I have been department chair for about 8 months now. The dean of the college asked me recently how things are going. I told him that I am still in the honeymoon phase, where faculty think it is cute to have a new chair. I hope that this phase will last for a few more months! I knew from the beginning that I would be stepping into big shoes. My predecessor, Chris Clemens, started to set the department on a new course. Under his chairmanship, the



*Christian Iliadis*

department grew in stature and reputation, both internationally and internally at Carolina. Thank you, Chris, for your hard work and dedication to the good of the department. While I have my own ideas and vision for the future, I am

dedicated to continuing the process of making Physics & Astronomy one of the premier science departments in the nation.

My high school in Germany was founded in the year 1354 (you can search for “Artland-Gymnasium”), and because of this early date, I have always been fascinated with the history of educational institutions. Carolina is the oldest public university in the United States, and instruction started here in 1795. It is no wonder then that our department is one of the oldest physics and astronomy departments in the country. The early history of our department is described in Professor Waldo E. Haisley’s (1914-1994) masterful account “Physics & Astronomy at Chapel Hill (1795-1946).” We posted this jewel of a document on our department website, and I am sure you will enjoy reading it.

In this issue of the newsletter, you will hear about world-class research in nuclear and astrophysics; you will also learn about the transformation of all our introductory physics courses to an interactive lecture-studio format, an effort that we are leading in the nation, and

you will read other news about our students, faculty, and staff. On behalf of all the Carolina Physics & Astronomy community, I thank you for spending the time to read our annual newsletter. I am also grateful to all of our donors for their generous commitment and support. Like all institutions of higher education, we rely on private donations to help facilitate many crucial activities for our undergraduates, graduate students, and faculty.

I am always happy to talk with friends of Carolina Physics & Astronomy. We enjoy hearing from you. Please know that you are always welcome to visit the department. Simply pick up the phone and call me. My door will always be open to you.

Best wishes,

A stylized, handwritten signature in black ink that reads "Iliadis".

**Christian Iliadis**

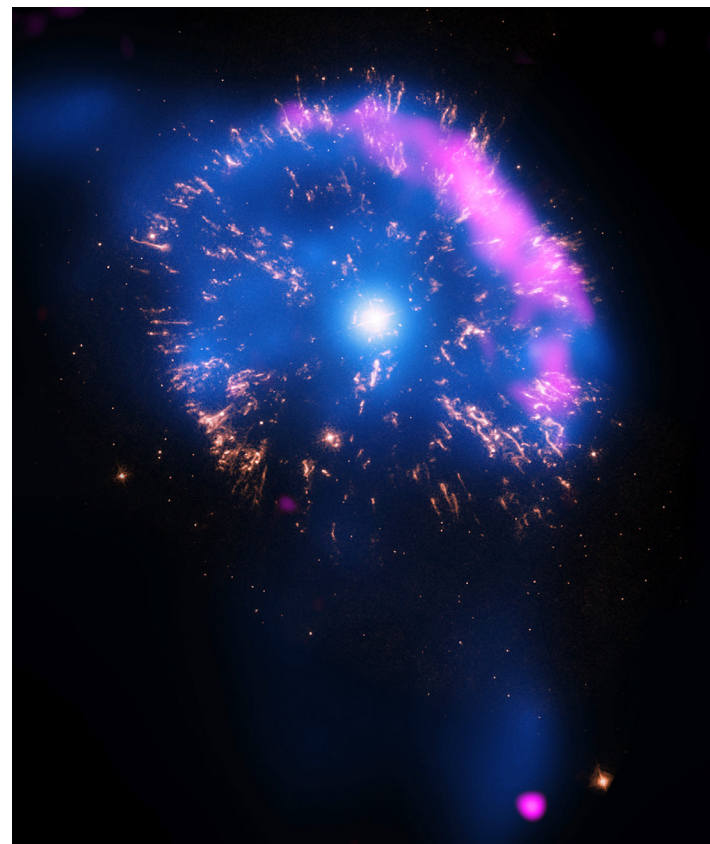
*Chair, UNC-CH Physics & Astronomy*

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The nuclear fusion reactions are measured at the Triangle Universities Nuclear Laboratory (TUNL), one of the U.S. Department of Energy’s “Centers of Excellence.” Several sub-laboratories of TUNL are utilized for nuclear astrophysics research. One of these is the Laboratory for Experimental Nuclear Astrophysics (LENA), which was built by the UNC-CH group. This unique facility holds the world record in proton beam intensity (2 mA on target) for nuclear astrophysics research.

A recent highlight of this research was the measurement of the fusion of oxygen-17 with hydrogen (PhD project of Matt Buckner, now at Lawrence Livermore National Laboratory), a process important for explaining classical nova explosions. Another highlight was the measurement of neon-22 fusion with hydrogen (PhD project of Keegan Kelly, now at Los Alamos National Laboratory), a reaction crucial for shedding light on ancient stars and the evolution of the early Milky Way.

Major parts of the accelerator have been replaced after these experiments, with the goal of increasing the ion beam intensity by another order of magnitude. This major modification is part of the PhD thesis of current UNC-CH graduate student Andrew Cooper. The new machine is being commissioned at this time. If everything goes according to plan, the group will be able to perform fusion measurements that are out of reach for any other accelerator facility in the world. A textbook recently published by Carolina faculty (“Nuclear Physics of Stars,” by Christian Iliadis, Wiley-VCH, 2015) provides a comprehensive source for the field of nuclear astrophysics and this type of research.



*Nova Persei 1901, one of the brightest classical novae of modern times. The composition of the ejecta reflects the nuclear fusion reactions that occurred during this titanic explosion.*



## UNC PHYSICS

# Facts

In 2016, there were **82 graduate students** and nearly **200 physics majors** in the department.

UNC-CH Physics and Astronomy Professor **Art Champagne** has been named the new director of the Triangle Universities Nuclear Laboratory (TUNL). He is the sixth director of TUNL and the first director with a primary faculty appointment outside of Duke University.

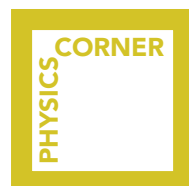
**Phillips Hall** has new artwork displayed in the halls created by first graders from Carrboro Elementary School. Their paintings are inspired by a "Meet the Scientists" event in the department, which they attended in January 2017.

Professor **Chris Clemens** has been named the Jaroslav Folda Distinguished Professor of Physics and Astronomy.

**Kent Price**, former UNC graduate student and now Associate Professor at Morehead State University, was awarded the 2016 Pegram Award for outstanding contributions to undergraduate physics education.

UNC-CH Physics and Astronomy has been named an American Physical Society Bridge Program Partnership site. The program seeks to increase the number of underrepresented minorities with physics PhDs.

Professor and former Department Chair **Tom Clegg** retired from the department in 2016. Enjoy your retirement, Tom!



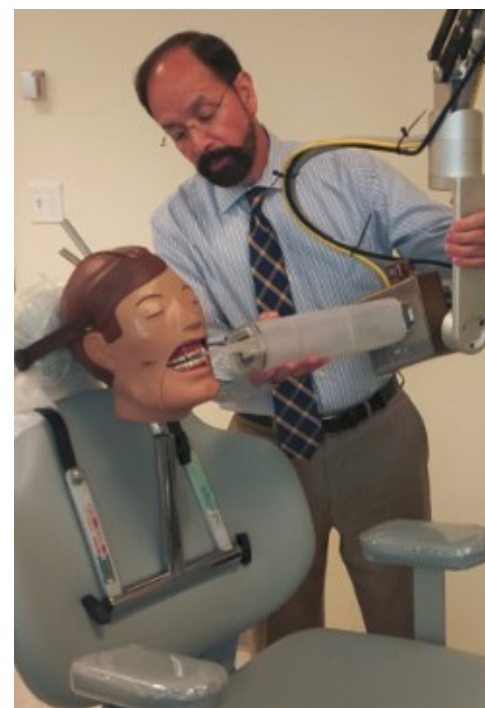
## CARBON NANOTUBE BASED 3D DENTAL IMAGING PROVIDES HIGH DIAGNOSTIC ACCURACY AT LOW DOSE

**C**aries – more commonly known as cavities, or tooth decay - is the most common dental disease. The World Health Organization estimates that 60-90 percent of children and nearly all adults have caries at some point in their lives. The current clinical gold standard for detection, 2D intraoral x-ray, has a surprisingly low diagnostic sensitivity. When undetected, caries progresses into more serious and destructive conditions that require extensive and costly treatments.

Our translational research team, in collaboration with the maxillofacial radiologists at the UNC School of Dentistry (Professors Enrique (Rick) Platin, Andre Mol, and Laurence Gaalaas), recently developed a new 3D intraoral imaging device that has demonstrated the largest increase in caries detection sensitivity without increasing radiation dose or compromising specificity when compared to 2D intraoral x-ray. We anticipate this device will also significantly improve the diagnosis of other common dental conditions. Early detection and treatment of oral disease will improve quality of life and oral health worldwide.

The invention led to a new start-up company, XinVivo, based in Research Triangle Park, to commercialize the technology. A prototype device manufactured by XinVivo has been installed at the dental clinic at UNCH for clinical evaluation through IRB-approved patient imaging studies. The WRAL-TV Health Team has reported this development: <http://www.wral.com/lifestyles/healthteam/video/14923978/>.

The research was supported by NIDCR, NCTraCS, and XinVivo.



*Dr. Rick Platin is shown positioning the 3D intraoral source.*

## STAFF MILESTONES

### 10 YEARS OF STATE SERVICE

**Shane Brogan** Laboratories Manager (6/1/2016)

**Cassandra Houston** Business Services Coordinator (9/1/2016)

### 5 YEARS OF STATE SERVICE

**Shannon Isley** Administrative Services Manager (1/1/2016)

**Antoinette Setari** Accounting Technician (7/1/2016)

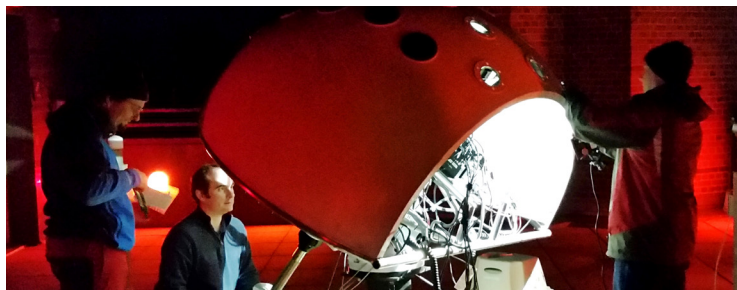
**David Norris** Specialty Trades Technician (10/1/2016)

**Jennifer Nickerson** Administrative Assistant (1/1/2017)

*Staff expected to achieve milestones this year include Department Manager Beverly Loftin, who will reach 10 years of service in April.*



## IN THE LAB



**P**rofessor Nicholas Law's group recently deployed the Evryscope, the first gigapixel-scale all-sky telescope. The Evryscope (from the Greek for "wide-seer") has roughly the same field of view as the human eye, but can detect objects 10,000 times fainter in every two-minute exposure. The Evryscope is building a movie of events in the entire sky: exoplanets crossing distant stars, stars doing exotic and dangerous things, massive stars exploding as supernovae, and even possible visible-light counterparts to gravitational wave events detected by the LIGO observatory.

The telescope is actually an array of 23 individual telescopes in a common mount and is based on commercially available digital-imaging parts. The first Evryscope is at the CTIO observatory in Chile and will be joined shortly by an identical system in California, to give simultaneous coverage of both the northern and southern skies.

Additionally, the Evryscope is a massive software project, generating around 600 million star measurements each night - all of which need to be stored in a database for later scientific enquiry. The two Evryscopes together will generate about a petabyte of data every two years, requiring a robust and powerful "big-data" infrastructure. Together with experts at RENCI, the Renaissance Computing Institute, the Evryscope team has built a pipeline that can process data in real-time, allowing the detection of a multitude of events in the local Universe. The team is already finding new variable stars and planet candidates but is just starting to scratch the surface of this enormous dataset.



## STUDENT SPOTLIGHT

**Roseanne Cheng** (PhD 2012), presently a postdoc at Johns Hopkins University, has accepted a postdoctoral fellowship at Los Alamos National Laboratory to start in August 2017.

**Kathleen Eckert** (PhD 2016) began a postdoctoral position in observational cosmology and galaxy evolution with Gery Bernstein at the University of Pennsylvania in 2016.

**Erik Forseth** (PhD 2016) is a quantitative analyst with Graham Capital Management in Norwalk, CT since April 2016.

**Seth Hopper** (PhD 2011), presently a postdoc at Instituto Superior Tecnico, Lisbon, Portugal, has accepted a tenure-track assistant professorship at Earlham College to start in August 2017.

**Arada Malekian** (PhD 2016) is working in Data Science and Web Design.

**JoEllen McBride** (PhD 2016) is currently working as a science journalist.

**Amanda Moffett** (PhD 2013) has finished her first postdoctoral position at the International Centre for Radio Astronomy Research at the University of Western Australia and is currently a Stevenson Postdoctoral Fellow at Vanderbilt University.

**Thomas Osburn** (PhD 2016) is a tenure-track assistant professor at Oxford College of Emory University since August 2016.

**Jack Silano** (PhD 2016) has accepted a fellowship at the Lawrence Livermore National Laboratory and will begin in March 2017.

**Elaine Snyder** (M.Sc. 2016) currently works as a Research and Instrument Analyst at Space Telescope Science Institute working with the Hubble Space Telescope Cosmic Origins Spectrograph team.

**Ryan Tanner** (PhD 2016) began working as a lecturer at Augusta University in August 2016.

**Yanqian Wang** (PhD 2016) is currently a Quantitative Research Associate at JPMorgan Chase & Co. in NYC.

**Kevin Wierman** (PhD 2016) is currently in residence at Fermilab as a Pacific Northwest National Laboratories postdoctoral fellow.

## STAFF NOTES

Three staff members were recognized for their contributions to the department with achievement awards at the close of 2016. Accounting Technician **Antoinette Setari** earned the Donna Braxton Staff Excellence award, while Specialty Trades Technician **Cliff Tysor**, from the department's Instrument Shop, earned Team Player of the Year. **Greg Smith**, Executive Assistant to the Chair, received the Personal Achievement Award. "I was very humbled to hear the comments that were provided by the nominators," Setari said. Anyone – staff, faculty or student – can nominate a staff member for the annual awards, which were inaugurated in 2014 to recognize superior service. The recognition comes with a monetary bonus. "It was a great honor – I was really not expecting it," Tysor said. The awards are announced each December. The 2016 winners will serve with faculty representatives on the awards committee that chooses the 2017 recipients. "Receiving the award made me feel that my work is truly appreciated," Smith said.



Antoinette Setari



Cliff Tysor



Greg Smith



The CoSMS Institute held a "Naturalness" workshop in October 2016.

## CoSMS NEWS – SPECIAL VISITORS, COLLOQUIA, AND WORKSHOPS

In October 2016, CoSMS Institute held a workshop on "Naturalness," the sense in which the energy scales of the Standard Model of fundamental interactions and cosmology are robust against quantum effects at shorter distances. An international group of theoretical and experimental experts from diverse subfields discussed topics including searches for supersymmetry from particle accelerators to table top experiments, new models and signatures for dark matter, and particle physics and cosmological scenarios motivated by string theory constructions. In addition to the workshop, a school for students and postdocs was conducted, providing an introduction to this fast-developing area.

In November, as part of the Distinguished Colloquium series, Professor John Lattanzio from Monash University in Victoria, Australia, engaged the question, "Has Kepler Found Aliens?" providing an analysis of a region of Kepler data in an informative and entertaining talk.

Earlier, at the 2016 April APS meeting in Salt Lake City, the Institute hosted a reception honoring Professor Art McDonald, co-recipient of the 2015 Nobel Prize in Physics, and Professor Neta Bahcall of Princeton University. In the coming year, CoSMS will host and sponsor the 20th Capra Meeting on Radiation Reaction in General Relativity, to be held June 19-23.

Check our webpage at [cosms.unc.edu](http://cosms.unc.edu) for upcoming events, or email [cosms@unc.edu](mailto:cosms@unc.edu) to request being added to our listserv.



Department of

# PHYSICS *and* ASTRONOMY

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

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## GREETINGS FROM CHAPEL HILL!



My name is Halie Sue Clifton, and I am delighted to have the opportunity to work directly with the department of Physics and Astronomy on behalf of the College of Arts and Sciences Foundation. My mission is to help Physics and Astronomy accomplish its goals by working with alumni and friends like you to raise private support for the Chair, Christian Iliadis, to make

strategic investments in the department. Private philanthropy plays a critical role in the department's ability to maintain its stature of excellence. For gift options, including multi-year pledges, stock donations, or planned gifts, please do not hesitate to contact me. I hope to meet many of you in the year ahead.

### Halie Sue Clifton

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physics and astronomy with a  
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The Department of Physics and Astronomy Excellence Fund helps enhance our world-class programs in research and education by supporting visiting speakers, providing seed funds for new instrumentation, and expanding research experiences for our students.

Gifts of any size will greatly increase our ability to support outstanding faculty and students.

To give online, visit [www.physics.unc.edu/donate/](http://www.physics.unc.edu/donate/)

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Thank you!