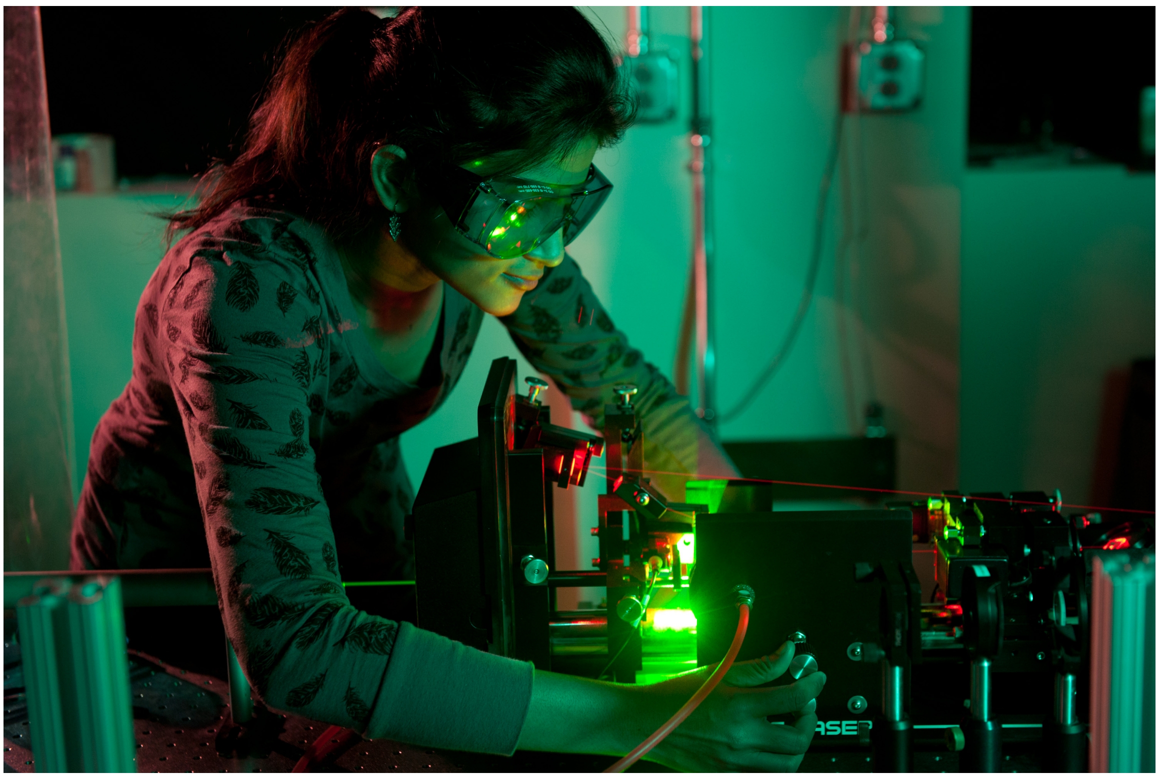
North Carolina State University Physics Program

2015 Comprehensive Department Review

Self-Study Report



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I. Department Description

Mission Statement

The NC State Physics Department is committed to providing outstanding educational and research opportunities. Our highest priority is to help all students achieve their educational objectives. We serve the people of the state of North Carolina by

- developing world-class research programs that advance scientific knowledge, contributing to the needs of the nation and the state, and meriting national and international recognition for their high quality;
- providing educational opportunities to undergraduate and graduate students in physics, through high-quality curricula, faculty, and research facilities;
- providing high-quality physics instruction to the university community; and
- supporting outreach activity that fosters improved public awareness and understanding of science.

Vision Statement

We envision North Carolina State University's Department of Physics and Astronomy as performing creative, highly visible research in fundamental and applied science. Our vision blends fundamental physics and applications, theory and experiment, and integrates research and innovative teaching to create a vibrant intellectual atmosphere within a welcoming and collegial environment.

To achieve this vision:

- We will identify and organize around intellectual themes that emphasize existing departmental strengths, leverage complementary expertise within the University and the College, and embrace the most exciting emerging directions within the broader physics community.
- Within this structure, we will encourage and reward activities that cross the boundaries of these different themes, promote discoveries that arise from such interdisciplinary studies, and create synergies through outreach to industry and to the public.
- We will continually pursue innovations in instruction and administration that improve the quality of our educational mission and facilitate our ability to pursue cutting-edge, highly-visible research.

- Within the University and the College, we will make our department the place where scientists and engineers acquire a firm knowledge of the fundamental laws of physics, providing the foundation for tackling fundamental and interdisciplinary questions that lead to a deeper understanding of the world and to innovations that serve society.

Institutional Context

North Carolina State University is a research-extensive land-grant university dedicated to excellent teaching, the creation and application of knowledge, and engagement with public and private partners. "The Pathway to the Future: NC State's 2011-2020 Strategic Plan" has five overarching goals: enhance the success of students through educational innovation; enhance scholarship and research by investing in faculty and infrastructure; enhance interdisciplinary scholarship to address the grand challenges of society; enhance organizational excellence by creating a culture of constant improvement; and enhance local and global engagement through focused strategic partnerships.

The Department of Physics strategic plan (a working draft of which is included in Appendix A) is being shaped by these goals. Moreover, reflections of these goals can be found throughout this self-study. Evidence of the departmental commitment to these goals includes the 2014 APS award for Improving Undergraduate Physics Education, the investment in EaRL to integrate the educational and research experiences of our students, the emergence of ORaCEL as a hub of trans-disciplinary scientists driving a revolution in carbon-based electronic materials, and the NIH support awarded to our young biophysics group. In addition, our recent faculty hires reflect our commitment to diversity as well as to both convergence science and disruptive discovery.

A Brief History

The following are brief excerpts from *History of the NC State University Department of Physics,* written by former faculty members Jap Memory and Ray Fornes and recently updated in 2013.

Physics has been taught at NC State for well over a century, and the Department of Physics has been an increasingly important center for research and graduate education for more than 50 years. The first faculty member with instruction in physics as an explicitly stated duty was Lieutenant Richard Henderson, who joined the faculty in 1894, with the title professor of physics and military science. The early history of the

Department of Physics included homes in a School of Arts and Sciences, the School of Science and Business and for many years in the School of Engineering. In 1948 a recommendation was made to focus attention on nuclear physics and nuclear technology, followed by the construction of the first nuclear reactor in an academic setting. In 1953 permission was granted to offer the doctorate with majors in engineering physics and nuclear engineering.

In 1960, the School of Physical Sciences and Applied Mathematics (PSAM), which has evolved into the College of Physical and Mathematical Sciences (PAMS) and now the College of Sciences (COS), was established at NCSU. The Department of Physics was then split, with some faculty establishing the Department of Nuclear Engineering and others following the Department of Physics to the new college. Four new faculty were recruited in 1964 to broaden the research portfolio of the department. Ed Manring and Dick Patty initiated an experimental program in atmospheric physics with NASA support. Jap Memory and George Parker began studies of organic molecules using NMR techniques with NIH support. The following decade saw additional hires in atmospheric physics, condensed matter physics, field theory, nuclear physics and plasma physics.

Five new faculty were recruited in 1975 (Haase, Cotanch, Mowat, Risley, and Sayers) in the existing research areas of atomic, nuclear, and condense matter physics. The next 15 years saw a gradual addition of 10 more faculty, including the first one in physics education research and the first two in astrophysics. In 1982, the National Research Council published reviews of United States doctoral PhD programs in a wide variety of disciplines, including physics. The NC State physics faculty was ranked 75th overall, but perhaps more importantly, was ranked in the top five in the country on recent improvement. Another burst of 7 faculty hires in 1992 increased the department size to 33 tenured/tenure-track faculty. During this epoch research funding increased from $300K to well over $4M, and five faculty received the Alumni Association Distinguished Research Award. Comments from an external review in 1988 acknowledged the key role of Dick Patty, who served as Department Head from 1976 to 1995:

“The Physics Department of North Carolina State University is widely recognized as having made extraordinary improvements during Professor Patty’s Headship. It has made a series of attractive appointments. The faculty has rapidly increased its research funding and research output and is generally very active professionally. It is a recognized center for research in condensed matter physics with especial strength in semiconductor physics and the related materials physics. To have achieved this improvement so quickly without sacrificing commitment to teaching, in the inadequate space, and without an increase in local support commensurate with the increase in activities is indeed extraordinary.”

Chris Gould served as Department Head from 1996 to 2005, during which time the department strengthened its role as a research leader. Professor David Aspnes in 1998 became the first member of the department to be elected to the National Academy of Sciences while at NC State. A new wave of hiring in nanoscale science and ultracold neutron physics rebuilt strong experimental programs on campus. Faculty strategic planning led to a focus on hires in soft condensed matter physics and biological physics as the electronic materials programs slowed down. The main nanoscience research groups moved to the Centennial Campus in 2002 along with the computational materials group (Bernholc, Roland, Buongiorno-Nardelli, Mitas and Lu) under the new umbrella of the Center for High Performance Simulation (CHiPS) – the first UNC System-recognized center directed by a physics faculty member. Biological physics emerged as a priority, first in computational work jointly with National Institute of Environmental Health Sciences (NIEHS) (Sagui), and then with the first experimental hire (Weninger) working closely with the Department of Biochemistry.

Michael Paesler served as Department Head from 2005 to 2012. During this time there was significant turnover in faculty through retirements, a few departures and spin-offs. The future strength of the faculty was assured; however, as mid-career faculty expanded their records of excellence and new hires quickly mounted strong research programs and garnered young researcher awards. Over the period 2005-2013 six Assistant Professors received highly prestigious young investigator awards including Karen Daniels, Dan Dougherty and Davide Lazzati (National Science Foundation CAREER Award); James Kneller, Carla Fröhlich and Dan Dougherty (Department of Energy CAREER Award) and Kenan Gundogdu (Office of Naval Research Young Investigator Award.) Key senior hires included Robert Golub and John Thomas.

The Physics Department moved into Riddick Hall in 2007, consolidating offices, labs and classrooms from a variety of buildings. In 2003, WebAssign spun off as the first major startup company by a department faculty member (Risley). By the fall of 2008, Advanced Instructional Systems (AIS), doing business as WebAssign, located on the NC State Centennial Campus, had a workforce in excess of 60 employees.

The department ramped up efforts to host meetings on campus. Since 2005 these have included: meetings of the *Southeast Conference for Undergraduate Women in Physics (2009, 2011, 2015); The Thirteenth Eastern Gravity Meeting (2010); The International Conference on Gamma Ray Bursts (2010);* Annual meetings of the *Southeastern Section of the American Physical Society (2008), NC Section of the American Association of Physics Teachers (2013), Physical Electronics Conference (2013); Fifty-One Ergs (2013); LightCone2014.* In addition, in 2009, Professor Cheung Ji, as President–elect of the *Korean-American Scientists and Engineers Association*, hosted the *US-Korea Conference* *on Science, Technology and Entrepreneurship* that brought several thousand Korean and Korean- American scientists to the Raleigh Convention Center.

John Blondin took over as Department Head in 2013. This transition was accompanied by a significant changeover in staff, with the hiring of Leslie Cochran, Rhonda Bennett, and Blair Nail as well as the departure of all three IT staff members. David Haase was appointed Associate Department Head. He asked to step down after one and a half years. David Brown became Director of Undergraduate Programs and Cheung Ji became Director of Graduate Programs. Betsy Alexieff was hired by the college as an academic advisor for math and physics, and has taken on a key role supporting David Brown. A significant effort was initiated to build the research enterprise in Partners III on Centennial Campus. These labs were left underutilized by the departures of Nemanich and Pearl and the decisions of Ade and Clarke to set up labs in Riddick. Aspnes, Ade and Gundogdu have moved their labs to Partners III and Abay Dinku was hired as a Research Assistant Professor to support the research activities in Partners III.

Program Quality

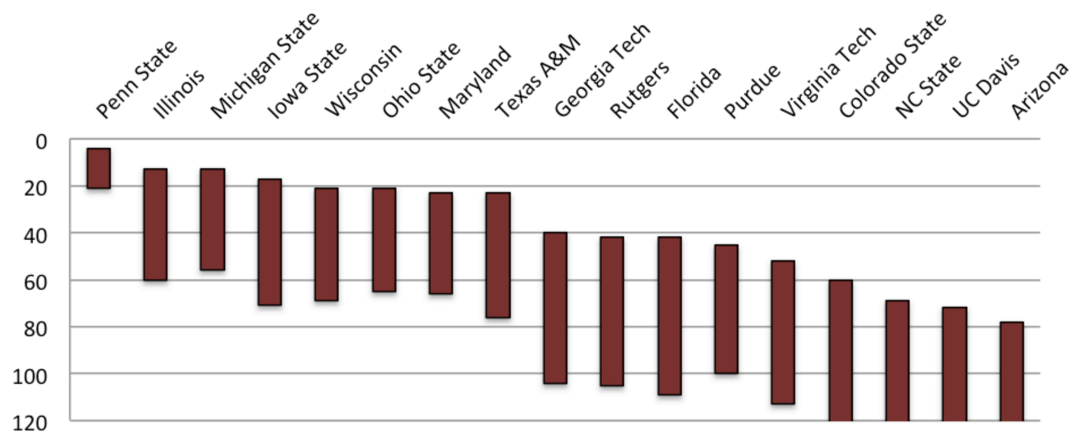
One can attempt to make quantitative and qualitative comparisons to other physics departments using national rankings such as the US News and World Report, the National Research Council reports, and the Academic Ranking of World Universities (ARWU, aka Shanghai ranking). Taken in their totality, the rankings indicate that we have not managed to achieve a relative improvement in our standing in the last 10-15 years and that we are not ranked in the top 50 US programs.

Here and throughout this report we will use physics departments in our official peer institutions for direct comparison. In 2011, in concert with UNC General Administration, NC State selected 16 similar institutions for benchmarking its performance. These institutions, selected based on data published by IPEDS and other sources, are meant to be a meaningful comparison group, with a mixture of both comparable and aspirational peers.

Institution Name	Student Pop
Colorado State University	28,902
Georgia Institute of Technology	20,291
Iowa State University	27,945
Michigan State University	47,071
Ohio State University	55,014
Pennsylvania State University	45,185
Purdue University	41,052
Rutgers University	37,366
Texas A & M University	48,702
University of Arizona	38,767
University of California-Davis	31,247
University of Florida	50,691
University of Illinois at U-C	43,881
University of Maryland	37,195
University of Wisconsin-Madison	41,654
Virginia Polytechnic University	30,870
North Carolina State University	33,819

US News and World Reports - NCSU physics is currently ranked in the 54-60 group. We do not have ready access to annual records of past rankings, but the 2007 departmental self-study reports that our ranking was 55-61 in 2005.

NRC ranking - Our department ranked 51 in the 1995 NRC report. The 2010 NRC assessment ranked the top 161 physics graduate programs in the US using 21 different criteria that included quantitative measures such as papers/faculty and citations/faculty. This most recent NRC report provided multiple methodologies for ranking programs. NC State was ranked similarly in most (best as seen in the S-rank wherein programs are ranked highly if they are strong in the criteria that scholars say are most important). Below we show the R-Rank wherein programs are ranked highly if they have similar features to programs viewed by surveyed faculty as top-notch.



NRC Ranking of Program Quality

ARWU - Only the top 200 programs world-wide are ranked. In 2014, there were 62 US physics programs in the top 200. We were not one of them. We have entered the 151-200 ranking range only in 2012, which implies that we are close to the top 200, but generally below that threshold.

The US News and World Reports ranking is a "reputation survey" only. As such, it might have a long lag time in response to significant change and or be influenced or even dominated by name recognition of the institution as a whole. Thus, the absolute ranking might be questioned. Still, the evolution over the years can be used as a separate metric about progress. ARWU focuses strongly on quantifiable indicators, such as awards, highly cited researchers, citation and publication record of the faculty. It ranks the whole program for impact, not the quality on a per faculty member basis. In contrast the most recent NRC report attempted to use at least some metrics normalized on a per faculty basis. It had strengths and weaknesses that were extensively debated within the department. Some uncorrected errors and use of aged and possibly non-uniform data might have resulted in it being minimized by faculty.

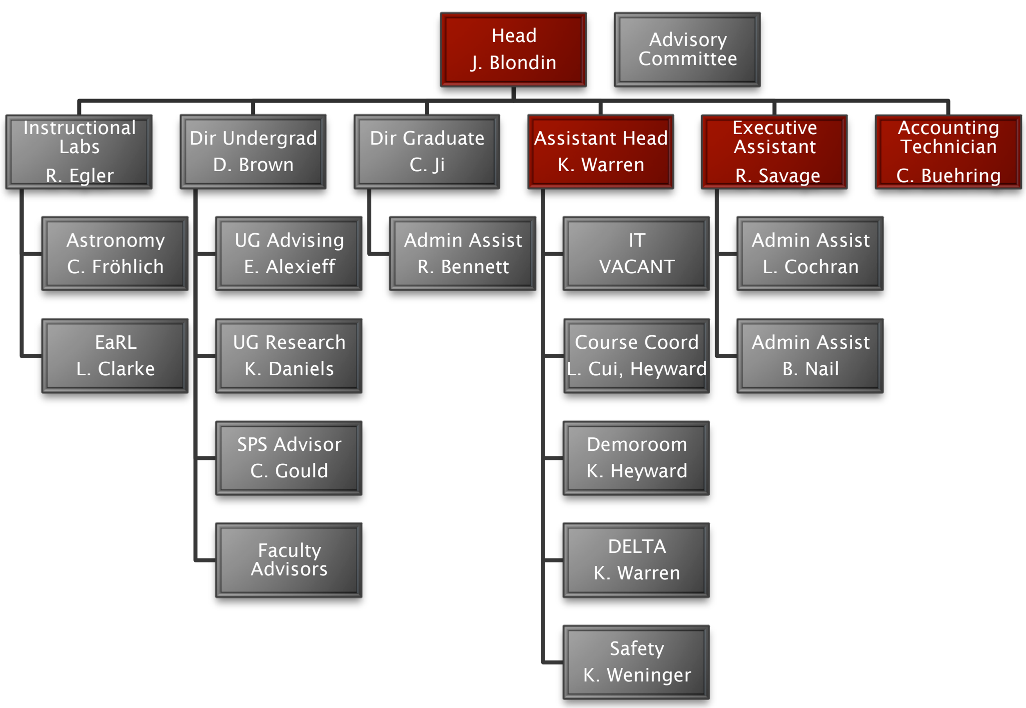
Administration

Organization

The Department Head assumes overall responsibility for all aspects of the department, and is aided by a faculty advisory committee that meets twice per month, a full staff meeting held once per month, and a weekly meeting with the leadership team highlighted in red in the organizational chart below (Warren: Facilities & Course Management; Savage: HR & Budget; Buehring: Financials).

The Assistant Department Head (Keith Warren) assumes many of the operational duties of the department. He is the Department Scheduling Office who schedules all classes and is the primary point of contact with the University Registrar; He supports the research enterprise by serving as building liaison and the Facilities representative for all lab renovations and repairs as well as the point of contact for lab safety and any interaction with Environmental Health and Safety. He is the Capital Assets Management Coordinator for the department. In addition he is the department lead for online education. (And he teaches one class a semester.)

The Executive Assistant (Becky Savage) assists the department head and serves as the principal administrative support. Responsible for all personnel actions in the department (hiring, termination, payroll, visas); supervises department staff; works with the college personnel and other University units on campus to stay informed of policies, rules and regulations; coordinates the business functions of the department including budget monitoring and management.



The Accounting Technician (Chastity Buehring) reconciles all department accounts including external contracts and grants. She manages purchases, travel reimbursements, interdepartmental transactions; orders supplies; processes biweekly payroll. She provides budget reports and assists with department budget planning.

Department Committees

The membership of department committees is determined by the department head in consultation with the advisory committee. Specific rules are given in the department bylaws for appointing members to the advisory, RPT, and CR committees.

Advisory Committee: Meets regularly with the Department Head to provide input on a variety of topics from space allocation to committee assignments. *Gundogdu*, Young, Daniels, ex officio: Brown, Ji.

Comprehensive Review Committee: Perform duties as outlined in Physics Department Post Tenure Review Standards and Procedures, RUL 05.67 and University Regulation 05.20.4 for tenured faculty once every five years. *Lee* (2015), Mitas (2016), Aspnes (2017)

Reappointment, Promotion, and Tenure Committee: Perform duties as outlined in Physics Department RPT Standards and Procedures, RUL 05.67.704 and University Policy 05.20.1. Each spring the committee will review upcoming RPT actions for the following year. *Huffman,* Ade, Schäfer, Sagui, Aspnes, Haase, Hallen, Beichner

Course and Curriculum Committee: Advise the Department on all undergraduate and graduate curriculum matters, carry out course reviews and curriculum reviews in a timely fashion; initiate new course action forms; review course scheduling to minimize conflicts and to ensure balanced fall and spring offerings in specialty areas. *Hallen,* (GPSA rep), ex officio: Brown, Ji.

Personnel Committee: Oversee faculty recruitment for 2014-2015. Advise Department Head on target-of-opportunity hires for 2014 and beyond. *Thomas,* Mitas, Ade, Kneller

Graduate Admissions Committee: Review all graduate applications, assist with Skype interviews and on-campus visits, recommend list of admissions to DGP. *Riehn*, Wang, Ünsal, Gundogdu, Golub, Ji

Graduate Recruiting Committee: Develop and update recruiting material, manage student ambassador program, attend national recruiting events. *Paesler*, Dougherty, Weninger, Ji

Faculty Recognition Committee: Regularly identify physics department faculty candidates for recognition in the form of awards, prizes, fellowships, etc. and develop strategies for lobbying for each such recognition. *Reynolds,* Aspnes, Longland, McLaughlin

Colloquium/Lecture Committee: Plan weekly colloquia and the named lectures (L. H. Thomas, John B. Derieux, Dale Sayers). *Lim,* Fröhlich, Paesler

Our department often has one or more task forces operating in any given semester. These are intended to be short-lived (< 1 yr) groups with a specific charge. In the current year we have two such task forces:

- **Strategic Planning:** *Thomas,* Kneller, Dougherty, Weninger
- **Graduate Curriculum Review:** *Mitas,* Hallen, Kneller, Ade

Past committees that have been abolished in recent years include:

- Computing Committee – will need to be reconstituted.
- Gateway Liaison Committee – Communication handled by DH and DUP.
- Safety Committee – Handled as a specific assignment by Keith Weninger.
- Teaching Assignment Committee – Managed by DH.
- Space Committee – Allocation and planning by DH and Advisory Com.
- Staff Liaison Committee – DH meets monthly with all staff.

Internal and External Administrative Relationships

Listed here are a few key organizations on and off campus that have direct connection with the Department of Physics. A more comprehensive list of facilities used by physics faculty and students is provided in Section III.

CHiPS – The Center for High Performance Simulation brings together expertise present in the Colleges of Engineering and Sciences at NC State in electronic, atomic, meso-scale and macroscopic simulation methods and offers advanced training and research to graduate students. CHiPS is co-directed by physics professor Jerzy Bernholc and Keith Gubbins in Chemical & Biomolecular Engineering.

TUNL – The Triangle Universities Nuclear Laboratory, a consortium of NC State, UNC-CH, and Duke is a U.S. Department of Energy Center of Excellence that focuses on low-energy nuclear physics research. Professor Calvin Howell of Duke presently serves as director, and Professors Paul Huffman and John Wilkerson from NC State and UNC-CH respectively serve as Associate Directors.

ORNL – We have strong ties with Oak Ridge National Laboratory through collaborative research programs, joint faculty, and NC State's partnership with the lab. We currently have two faculty on Joint Faculty Agreements, professor Paul Huffman (nuclear experiment) and research associate professor Wengchang Lu (computational materials) and are actively exploring additional JFAs. We have faculty and students actively engaged with ORNL collaborators in astrophysics, nuclear physics, and computational materials. Professor Jerzy Bernholc is a Visiting Distinguished Scientist at ORNL. He has served as the chair of CNMS' Science Advisory Committee and currently chairs the Advisory Committee of the Computing and Computational Sciences Directorate. He is also a member of ORNL's Science Advisory Board.

II. Physics Faculty

The Department of Physics is currently comprised of 36 tenured/tenure-track (T/TT) faculty, which includes 3 on phased retirement, 1 Associate Dean for Research, 1 with a 75% appointment in the provost's office as Director of the STEM Initiative, and 1 on a Joint Faculty Agreement with ORNL. Thus, counting fractions, we have 32.25 full-time equivalent faculty supported by the department. Brief curricula vitae for all T/TT/NTT faculty are included in Appendix B.

Examples of faculty excellence include:

- 23 of 24 full professors are Fellows of the American Physical Society
- At least 1 Fellow of the AAAS, AAPT, OSA, AVS, MRS, NSSA
- 6 Career Awards (NSF, DOE, ONR) amongst our Assistant & Associate Professors
- 1 member of the National Academy of Sciences
- 6 Alumni Distinguished Undergraduate Professors
- 2 Alumni Distinguished Graduate Professors
- 3 recipients of the UNC Board of Governor's Award for Teaching Excellence

Full Professors

Harald Ade	David Aspnes	Robert Beichner
Jerzy Bernholc	John Blondin	David Brown
Robert Golub	Chris Gould	David Haase
Hans Hallen	Paul Huffman	Chueng Ji

Jackie Krim	Dean Lee	Gerry Lucovsky
Gail McLaughlin	Lubos Mitas	Michael Paesler
Steve Reynolds	Chris Roland	Celeste Sagui
Thomas Schäfer	John Thomas	Albert Young

Associate Professors

Laura Clarke	Karen Daniels	Robert Riehn
Mithat Ünsal	Keith Weninger	Dan Dougherty

Assistant Professors

Carla Fröhlich	Kenan Gundogdu	James Kneller
Shuang Fang Lim	Richard Longland	Hong Wang

In addition to these T/TT faculty, we have 4 non-tenure track faculty supported by the department: Two teaching assistant professors, one research assistant professor, and one research associate professor (jointly supported by ORNL). We also have three research faculty supported by external funding and three lecturers supported by the department. We are fortunate to have several unsupported senior scientists actively engaged with the department, including Jack Rowe, Russell Philbrick, and Jimmy York.

Research Professors (all ranks; full-time support only)

Kazimierz Borkowski	John Kelly	Wengchang Lu
Miroslav Hodak	Abay Dinku	

Teaching Professors and Lecturers (all ranks; at least ¾ time support)

Lili Cui	Keith Heyward	Robert Egler
Keith Warren	Vijaya Mehta	

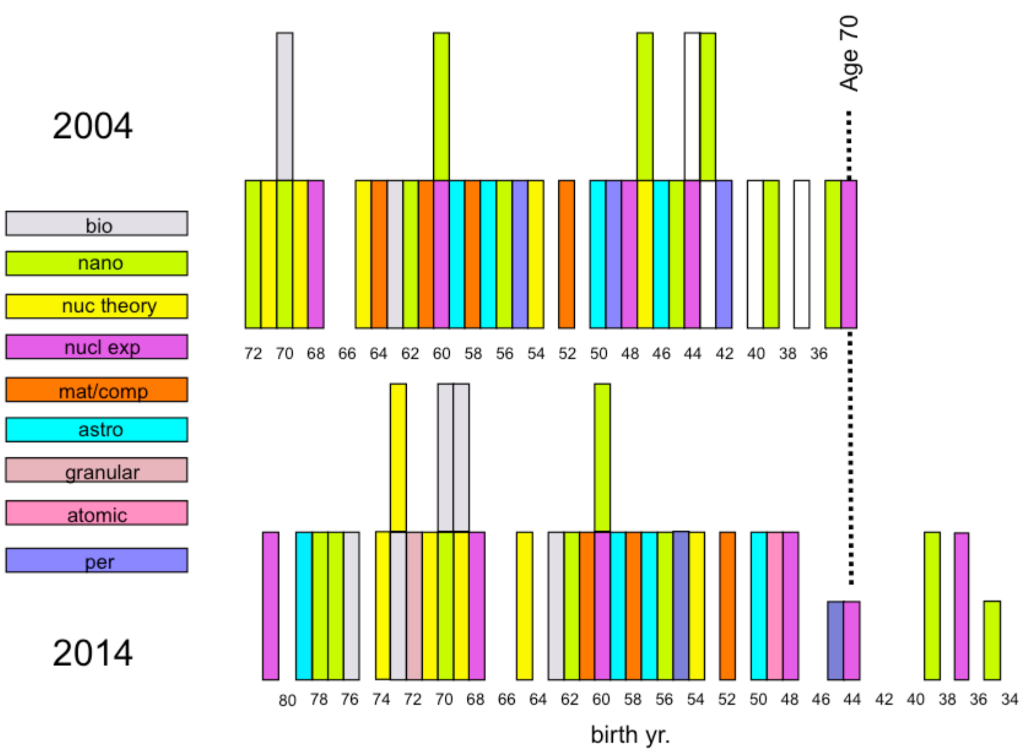
The number of postdocs in our department has grown dramatically in recent years. Most of these positions are funded by external grants; some are supported through startup funding. One is a Hubble Fellow who chose to work in the astrophysics group at NC State. The list below includes one postdoctoral teaching scholar – a position we created that gives a recent Ph.D. one or two years of teaching experience.

Postdoctoral Scholars

Ilya Arakelyan	Marcus Bluhm	Ted Brzinski
Jordi Bustamante	Andri Chyzh	David Fallest
Bhoj Gautam	Adrian Hunt	James Joseph
Parminder Kaur	Juhyun Kim	Kent Leung
Jiangguo Lin	Hai Pan	Viet Man

Subhrangsu Mukherjee	Evan O'Connor	Tin Sulejmanpasic
Daavid Väänänen	Janina Wirth	

The distribution of T/TT faculty has not changed much in the past decade, with a steady replacement of retiring faculty by junior hires as dictated by the college standard operating procedures. The chart below includes three faculty on phased retirement (shown as half-height bars) in 2014. Comparing the two distributions, one can see that we no longer have faculty without a research focus (all but one T/TT faculty is currently associated with an external grant), the presence of physics education researchers has decreased, and there has been a (planned) surge in hiring biophysicists.



Faculty Development

Hiring of new faculty has followed a set of guiding principles first set forth in the first department strategic plan in 2000.

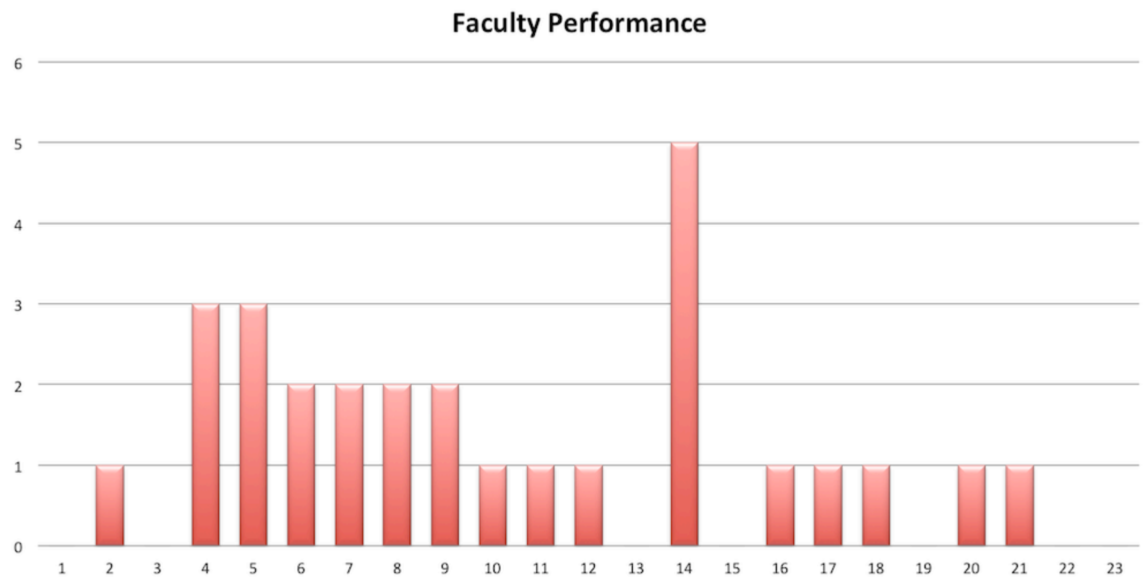
- The concept of "replacing" a faculty member who is leaving will be abandoned. Hiring within a particular targeted research area will occur over an extended time period to secure a superior candidate.
- The fact that a target area has been specified in no way guarantees that we will hire in that area.
- Faculty from under-represented groups, as well as other "targets of opportunity", is welcomed at any time.
- Decisions on hiring new faculty and promoting existing faculty will incorporate our commitment to excellence in undergraduate and graduate teaching.
- The distribution of faculty research areas will reflect a balance between fundamental, applied, and interdisciplinary areas of physics.
- The plan will be reviewed on a regular basis, in connection with annual retreats and in consultation with an External Advisory Committee.

The past decade has seen eleven new faculty hired at the junior level (ten through open searches) and two senior hires as "targets of opportunity." At the same time we have had nine retirements, one death, and four leave for other universities (two spousal issues, one senior faculty left to become department head elsewhere, one untenured), for a net loss of one.

Faculty Assessment

All of our faculty participate in an annual review process that includes the preparation of an annual *Achievement Report* (see Appendix C), a one-on-one meeting with the Department Head, and a written review letter signed by the DH and the faculty member and placed in the personnel file of the faculty. In addition, tenured faculty undergo a comprehensive post-tenure review every five years. Faculty performance is measured against an individual's *Statement of Mutual Expectations*, which is first written during the initial year of employment and subsequently amended as responsibilities evolve (e.g., moving effort from teaching to directing a center, or from research to teaching as a research career winds down).

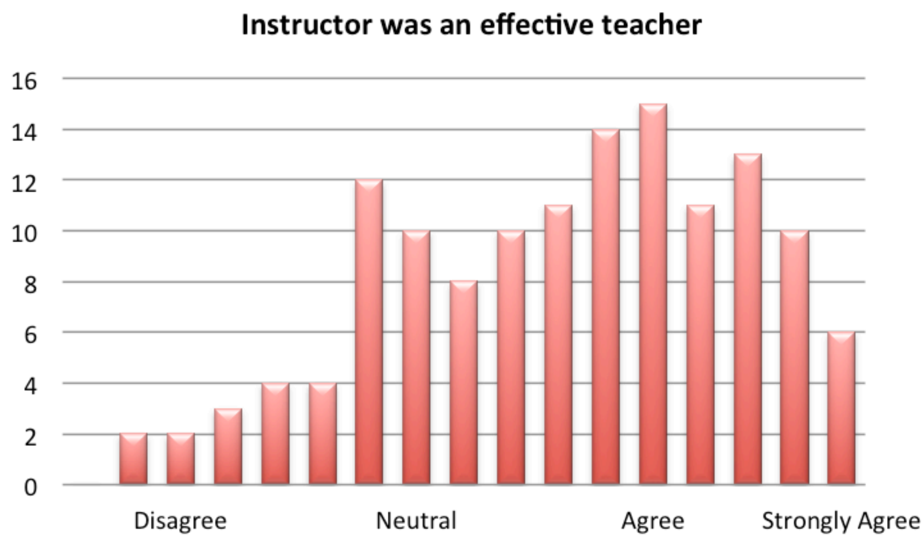
While this process is inherently subjective and varies substantially from person to person, an effort is made to use quantitative metrics as much as possible. For example, to assess the research and mentoring responsibilities, metrics used include (1) publications in peer-reviewed journals with an impact factor greater than one, (2) graduate students mentored *and* supported on external funds, (3) invited talks beyond the NC State campus, and (4) research expenditures from external funding. The following chart shows the distribution of faculty output as measured by a linear combination of these four metrics.



Faculty performance using a combination of research and graduate mentoring metrics.

The bottom 5 of the distribution is made up of junior faculty just getting started and a few senior faculty whose research has been diminished (their contributions to the department show up in other metrics). The high end is dominated by experimentalists (4 out of the top 5) while the spike at 14 is dominated by theorists (4 out of the 5).

Excellence in teaching is stressed at every level in our department, and is a key component of the annual review process. Teaching effectiveness is assessed primarily through annual peer reviews and online student evaluations done for every class, every semester. University policy mandates annual peer reviews for all Assistant and Associate Professors, and at least once every three years for Full Professors.

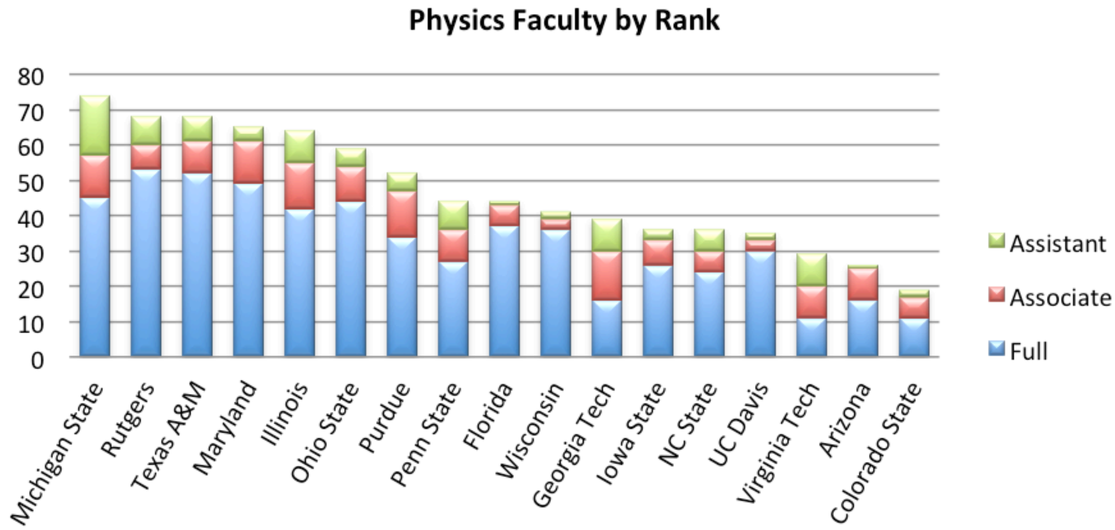


Results from three years of ClassEval results for PY instructors

The cumulative results from three years of student evaluations are shown above. Similar histograms are presented in physics faculty meetings following each semester and are referred to in individual annual reviews.

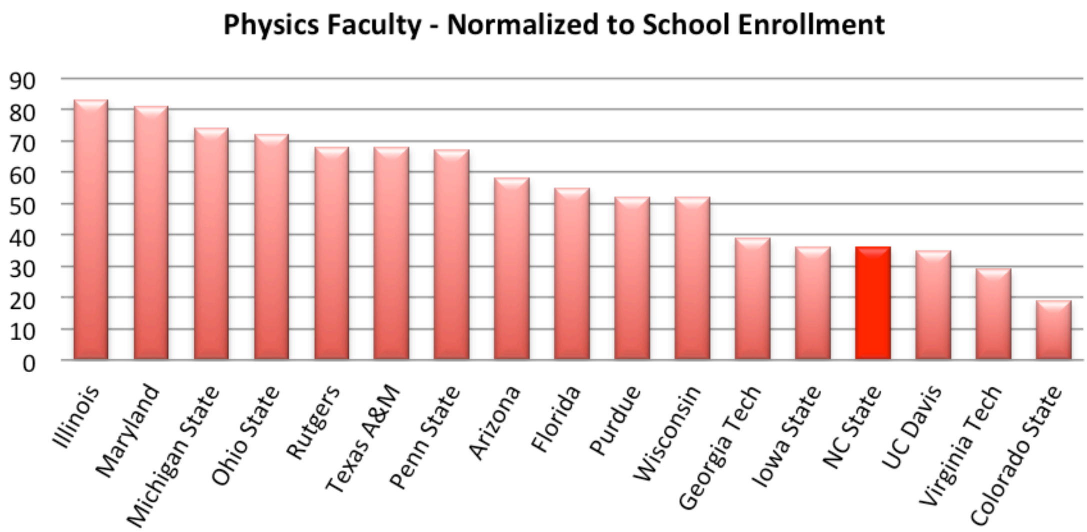
Peer Comparisons

Compared to our peers, we rank 12th in absolute numbers of faculty, with a more-or-less typical distribution by faculty rank. The number of T/TT faculty in our department is the same as it was in 1993 following a burst of hires. In that same time frame the service role of teaching introductory physics to engineers and life-science majors has grown moderately while the undergraduate and graduate physics enrollment has more than doubled.

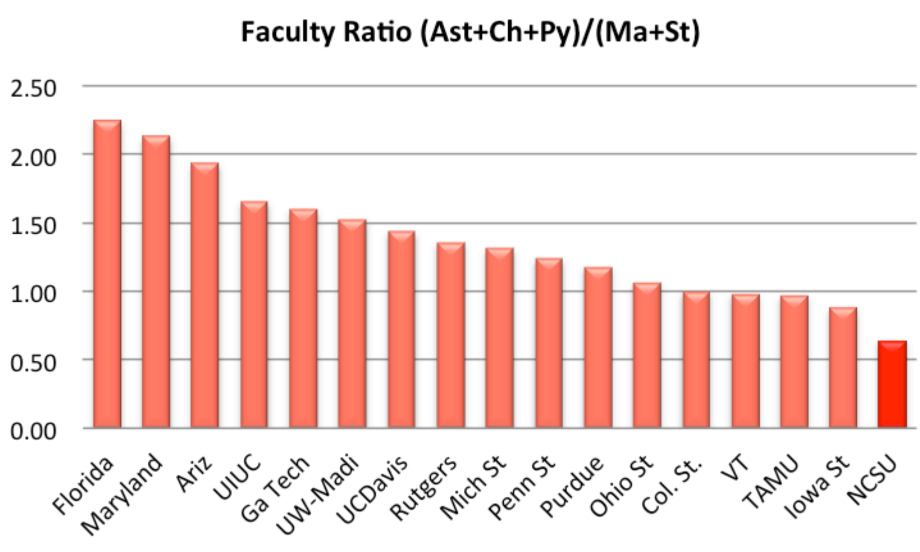


Number of T/TT physics faculty at peer institutions

Making sense of this data requires some form of normalization given the range of size and mission of these schools. One can simply normalize to the total student population as illustrated in the chart below. Here we added in the T/TT faculty in astronomy for the seven of these peer institutions that have separate astronomy departments.

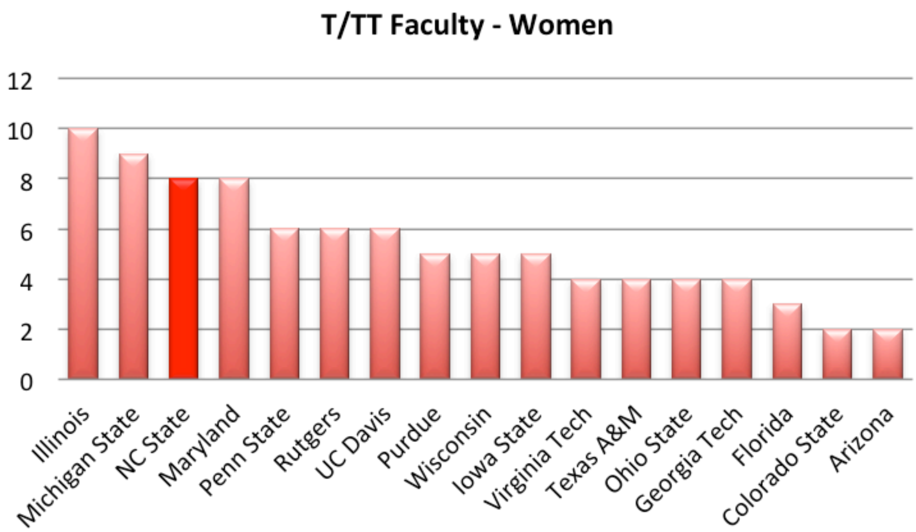


For better or worse, there is a perceived imbalance between physical sciences and other sciences on the NC State Campus. If we compare the ratio of T/TT faculty in the departments of physics, chemistry, and astronomy to departments of mathematics and statistics, we find that NC State is an outlier among our peers.

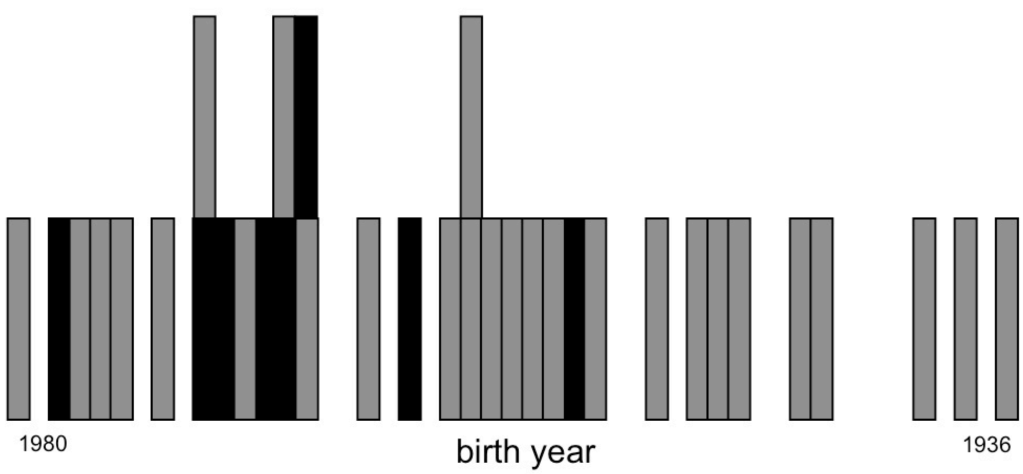


Women in Physics

Our college and department have been focused on improving the historically poor gender balance of physics departments. For several years we have been near or at the top of US physics departments in terms of the number of women in T/TT faculty positions. The chart below shows absolute numbers. With 22% women, we are far above any of our peers in terms of numbers of women relative to faculty size.



Given the age distribution, this situation will certainly improve as long as we remain diligent in hiring outstanding women as well as men. The chart below highlights the women T/TT faculty in black. Of the youngest half of our faculty, 39% are women.



This relatively large number of women professors has not (yet) led to a significant increase of women physics students. To enhance the experience for women in our department and to hopefully grow the number of women students, postdocs and faculty, Karen Daniels has created a Women in Physics group (go.ncsu.edu/ncsuwip). Activities include a journal club that reviews scholarly work regarding women in science, occasional lunch discussions and research presentations, and a monthly newsletter. This group helped organize the 2015 Southeastern Conference for Undergraduate Women in Physics (Karen co-hosted CUiP in 2010 and 2011).

In 2014 our department participated for a second time in the APS Climate for Women in Physics Site Visit. Some of the actions recommended by this external committee include

- Faculty need to take note of inappropriate behavior among students and stop it.
- The department should be more active in monitoring the SPS lounge.
- Race/Gender sensitivity orientation is recommended for the whole department.
- Head and faculty need to set the tone for professional behavior among students.
- Provide more informal opportunities for colleagues to interact with each other and for students to interact with faculty.

III. Research

The Physics Department boasts a wide variety of cutting edge research ranging from basic to applied; from the nano scale to the cosmic scale; from table-top experiments to monumental team efforts; and from pure theory to concrete experiment. Our success is based on an outstanding faculty dedicated to research, access to critical facilities on and off campus, and a continuing record of strong external support. Research on campus is housed primarily in Riddick Hall on the main campus and Partners III on Centennial Campus.

The research portfolio of the department has grown and evolved over the last couple decades as described in Section I. Twenty years ago a significant fraction of the physics faculty was not actively involved in research. Today virtually everyone is active in research to some degree. Some areas have remained strong: Experimental Nuclear Physics remains a keystone of our department with international recognition for their work with ultracold neutrons. Other areas have evolved: our expertise in traditional silicon-based electronics has morphed into a new generation of condensed matter experimentalists working with graphene and organic molecules; A key hire at the intersection of our astrophysics group and our nuclear theory group has lead to a very strong research group in nuclear astrophysics; Strategic planning by the physics faculty lead to a vibrant group in single-molecule biophysics.

Focus Areas

The research thrusts of our department are organized into three broad concepts listed below. These divisions are somewhat arbitrary. While we have only listed each research-active faculty member once (including T/TT and NTT faculty), there is significant overlap between the areas. For example, some recent work by Jerzy Bernholc and his group includes biophysics applications; Albert Young's research includes atomic physics; some of the faculty in organic electronics work with polymers and materials that overlap with the faculty in soft condensed matter.

Quantum Science

Quantum physics connects diverse fields of fundamental science and is the microscopic cornerstone for our understanding of nature at all length and energy scales. Our well-balanced program in *Quantum Science* includes both purely fundamental research and applied research that connects fundamental physics and technology.

- *Atomic, molecular and optical physics:* connections from ultracold atoms to condensed matter and nuclear matter systems, opto-mechanical quantum systems, quantum information processing, fundamental symmetries.

  Thomas

- *Computational physics:* High performance calculations of structure and physical properties in condensed matter. Modeling many-body cold atom systems, action and function of biomolecules, and multi-scale bio-molecular simulations.

  Bernholc, Hodak, Lu, Mitas

- *Organic electronics:* Studies of structure, electron spin and charge transport in organic materials using STM microscopy and spectroscopy, ultrafast optical techniques, and X-ray microscopy and resonant scattering using national synchrotron facilities.

  Ade, Dinku, Dougherty, Gundogdu, Krim

Physics of the Universe

The study of the *Physics of the Universe*, from quarks to quasars, using experiment, observation and theory, continues to be an endeavor strongly associated with the physics department at NC State. This includes well-known groups in nuclear and astrophysics theory as well as experimental nuclear physics.

- *Experimental Nuclear Physics:* Fundamental symmetries of neutrons and nuclei, particle astrophysics, and a variety of applied topics in nuclear structure and nuclear technology. A focus on ultracold neutrons including a key role in the nEDM experiment, high-precision measurements of neutron beta-decay, and developing the next generation of UCNs.

  Golub, Haase, Huffman, Kelley, Longland, Young

- *High-Energy Astrophysics:* Space-based observations, analytical and numerical modeling, and large-scale numerical simulations of high-energy events including supernovae and gamma-ray bursts, supernova remnants, and accreting compact objects.

  Blondin, Borkowski, Reynolds

- *Neutrino and Nuclear Astrophysics*: Neutrino mixing, neutrino interactions with nuclei, nucleosynthesis is stellar evolution, supernovae, gamma-ray bursts and the early universe.

  Fröhlich, Kneller, McLaughlin

- *Nuclear and Particle Theory:* Fundamental interactions of matter including QCD, the quark structure of mesons and baryons, hadronic interactions, hadronic matter under extreme conditions,nuclear structure, light-front quantization, effective field theory, and non- perturbative lattice methods.

Ji, Lee, Schäfer, Ünsal

Physics of Life and Complexity

The *Physics of Life and Complexity* studies how the complex world we live in arises from a basic set of laws of physics through interactions at many scales. Our broad program encompasses strong research groups in experimental and computational biophysics, nanoscale science, physics education research, and athermal statistical physics.

- Biophysics: Biological phenomena at the molecular level, addressing questions relevant to human health that include protein folding, structural biology, enzymatic biochemistry, protein-DNA interactions, cell signaling pathways and epigenetics.

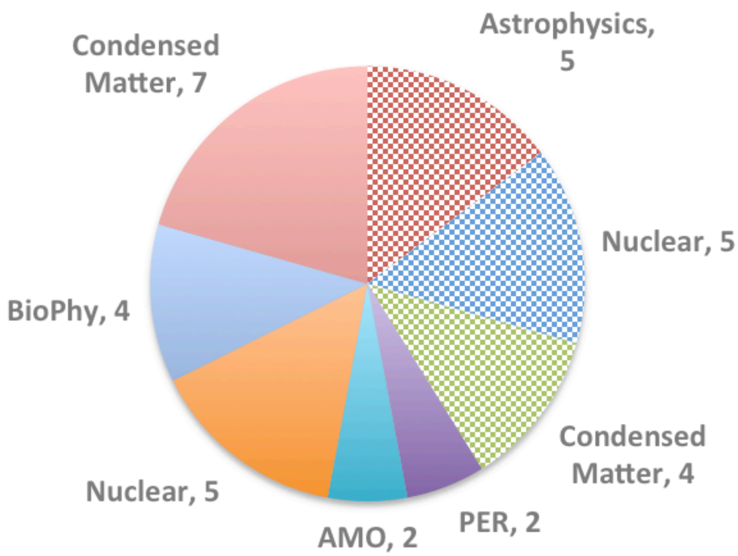
  Lim, Riehn, Roland, Sagui, Wang, Weninger

- *Soft matter physics*: Mechanics and dynamics of biologically- and industrially-relevant materials which are neither ordinary liquids nor crystalline solids: polymers, colloids, membranes, gels, fiber networks, granular materials, and lipid layers. Use of statistical mechanics to capture the heterogeneous and fluctuating behavior of these materials.

  Bochinski, Clarke, Daniels, Hallen

- *Physics Education Research*: Impact of technologies (including student-owned devices) on learning, design of educational environments, factors affecting dissemination of educational innovations, use of portable laboratory equipment, categorization of communications between instructors and students, development of research-based curricular materials, instruments for assessing student learning.

  Beichner, Paesler



The distribution of research-active T/TT faculty (not including emeritus or NTT faculty) is shown above, with theory represented by the hatched areas and experiment by the solid colors. Note again that these divisions are not clearly defined – the boundaries between Astrophysics and Nuclear Theory and between Experimental Condensed Matter and Biophysics are certainly 'fuzzy.'

Interdisciplinary Research

Interdisciplinary research has always been ubiquitous in our department. Past examples include Hans Hallen working with Nina Allen (Plant Biology, NCSU) to develop in-situ optical probes for plant cells, John Blondin working with Kwan-Liu Ma (Computer Science, UC-Davis) to develop tools to interactively visualize massive data, Harald Ade working with Natalie Stingelin (Materials Engineering, Imperial College) designing organic photovoltaics, and Steve Reynolds working with Rebecca Willett (Electrical Engineering, Duke University) to develop new statistics for analysis of x-ray observations of supernova remnants. The following paragraphs describe a few examples of ongoing interdisciplinary research in our department.

Since 2007, physics faculty Laura Clarke and Jason Bochinski have had an active collaboration with Russell Gorga in the Textile Engineering department, focusing on polymer nanocomposites and nanofibers. While Gorga provides knowledge on polymer processing and an awareness of issues of industrial importance, Clarke and Bochinski have addressed related physics problems such as the response of ionic fluids to strong electric fields and development of ensemble optical measurements of temperature at the nanoscale. The collaboration has resulted in 13 publications, 1 invention disclosure, the education of 3 PhD students (1 in physics, 2 in Fiber and Polymer Science) and 5 M.S. students (Textile Engineering Chemistry and Science), and many lively and interesting discussions at their weekly interdisciplinary group meetings. The collaboration is funded by the National Science Foundation.

Assistant Professor Kenan Gundogdu studies photo excitation dynamics in reduced dimensional materials. He works with Wei You in the Chemistry Department at UNC and Natalie Stingelin in the Department of Materials at Imperial College to study exciton dynamics in polymer-based photovoltaics and with Linyou Cao in MSE at NC State to investigate spin processes in dichalcogenides. He has also worked with Michael Escuti in ECE at NC State to develop a novel femtosecond pulse shaping method and is developing a collaboration with Ahmed El-Shafei in Textile Engineering at NC State to develop dye synthesized solar cells. His collaboration with all these research group resulted in 6 published or submitted journal publications during 2014.

Associate professor Karen Daniels is collaborating with seismologists and structural geologists to conduct and analyze laboratory experiments to inform our understanding of the nonlinear dynamics underlying seismic activity. Deformation and seismicity within the Earth's crust have many characteristics in common with human-scale granular systems, including granular fault rocks, shear localization, and stick-slip dynamics. The associated dynamics involve interactions spanning a huge range of length and time scales. These collaborative efforts will ultimately improve estimates of seismic hazard.

Biophysics is by its very nature interdisciplinary. As just one example, professor Keith Weninger combines expertise in biophysical characterization of protein structure with cell biology specialists and urologists at Medical Schools at Johns Hopkins University and at New York University. The focus of the project is a protein named Prostate-Associated-Gene 4 (or PAGE4) that is not normally present in most human tissues, but that is found in prostate tissue both during in utero development and also in prostate cancer (as well as a few other cancers). The collaboration connected structural properties of PAGE4 to functional impact in cells, all the way to distributions of these protein interactions in tissue samples from patients. The collaboration resulted in a detailed picture of the aberrant signaling that PAGE4 caused within the intracellular stress-response pathway and explained the role of PAGE4 in generating the metabolic switch within cells that contributes to the emergence of prostate cancer.

Examples of Excellence

There is a wealth of exciting, excellent research going on in our department. In order to avoid any appearance of bias, we will use an external quantitative metric of research excellence to choose highlights: highly cited papers in the past two years as defined by Web of Science.

High Performance Polymer Solar Cells (several papers in Advanced Materials and other journals). ***Harald Ade***'s group, along with collaborators around the world, have 11 papers currently (1/2015) listed as highly cited papers. Using soft x-ray scattering and other characterization techniques, they have made tremendous strides in understanding the morphology in bulk heterojunction solar cells and using that knowledge to improve the quantum efficiency of solar cells.

Classical Electrostatics for Biomolecular Simulations (Chemical Reviews). ***Celeste Sagui*** and colleagues published a review of contemporary numerical methods.

Asymmetries in Core-Collapse Supernovae (Nature). ***Steve Reynolds*** and his collaborators on the NuSTAR hard x-ray space telescope mapped out the large-scale structure of the cold ejecta thrown out in the supernova explosion through radioactive decay of ^{44}Ti. The asymmetries on large scales suggest an explosion mechanism driven by low-order turbulence and/or the spherical accretion shock instability (discovered at NC State).

Many-Body Effects in Valleytronics: Direct Measurement of Valley Lifetimes in Single-Layer MoS_2 (Nano Letters). ***Kenan Gundogdu*** and his group, along with collaborators in MSE and ECE at NC State, used ultrafast transient absorption spectroscopy to study valley population dynamics.

Ab Initio Calculation of the Spectrum and Structure of ^{16}O (Physical Review Letters). ***Dean Lee*** and collaborators used lattice effective field theory to reveal how the nuclear shape of ^{16}O changes depending on its state, even though other attributes such as spin and parity don't appear to differ.

Axisymmetric Ab Initio Core-Collapse Supernova Simulations of 12-15 Solar Mass Stars (Astrophysical Journal Letters). ***John Blondin*** and collaborators presented results from high-fidelity two-dimensional supernova simulations, showing that models with detailed spectral neutrino transport exhibit shock revival driven by neutrino energy deposition.

Development

Research excellence is promoted through a variety of mechanisms at the department, college, and university level. The university provides competitive internal funding programs including Faculty Research and Professional Development grants and Research and Innovation Seed Funding. Roughly half of our faculty have received FRPD funding to explore new research ideas. Harald Ade received an RISF in 2013 to help build a research cluster in carbon electronics. This funding was used to host a successful workshop in the Research Triangle that has spawned several exciting opportunities including the establishment of ORaCEL and a recent award of $2.8M from the UNC General Administration to foster game-changing research in carbon electronics.

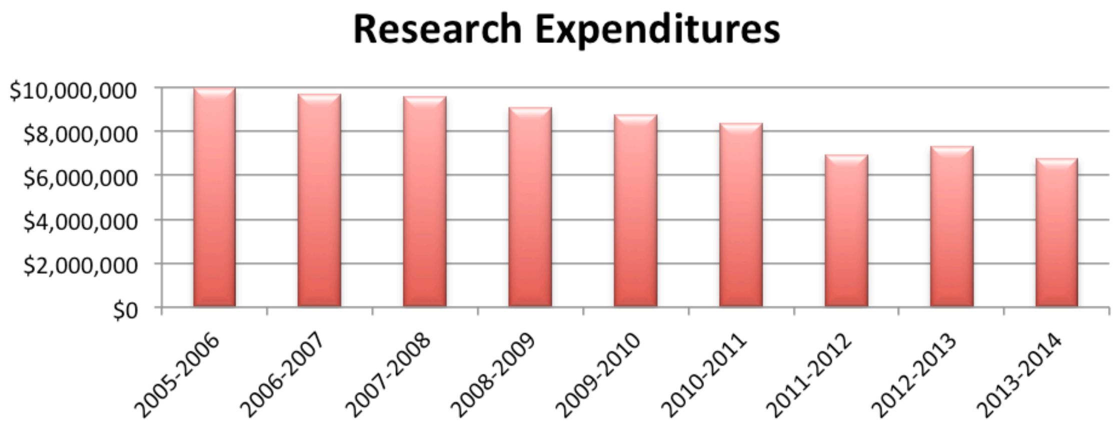
A major investment at the university level in recent years has been the Chancellor's Faculty Excellence Program that supports targeted cluster hires. Our department was unsuccessful in the first round (2012), but has a strong proposal in the current round that grew out of the RISF mentioned above.

At the department level we have invested in a major shuffling of research labs, co-locating all faculty associated with the organic electronics initiative in Partners III on Centennial Campus. The result is ORaCEL – the Organic and Carbon Electronics Lab. The department has also invested in shared equipment, both in Partners III and in the Education and Research Laboratory (EaRL) in Riddick Hall.

A non-trivial contribution to research development has been the recent policy to return some fraction of overhead to the department and through to the PIs. The department keeps a few percent to support research infrastructure like the RO water system in Riddick as well as helping PIs with equipment repairs and renovation.

External Funding

The total research expenditures in our department has hovered around the 7 to 9 million mark for two decades. The somewhat steady decline seen in the plot below is due in part to the departure of some successful senior faculty as well as the overall decrease in federal funding over the past few years. We fully expect this trend to rebound in the coming year, given recent awards from NSF, DOE, and NIH (two R01 awards).



Research expenditures by physics faculty for the past nine years.

Virtually all of our faculty are research active. We are currently in a situation where only one full-time faculty (Brown) does not have active research funding, but he just had two students complete their Ph.D.s in 2014. We also have two retired faculty (Ellison, Mitchell) who continue funded research. A list of sources of external funding, ranked by the current amount of funding to the department, is given in the table below.

External Funding Agencies
US Department of Energy
National Science Foundation
National Aeronautics and Space Administration
National Institutes of Health
Army Research Office
Office of Naval Research
Air Force Office of Scientific Research
James S McDonnell Foundation
American Cancer Society
Research Corporation for Science Advancement

Facilities

On Campus

EaRL: The Education and Research Laboratory in Riddick Hall is a 1600 sq. ft. shared user (50% classroom education; 50% research) facility in the Physics Department. EaRL's core concept is to enable undergraduate students to work side-by-side with faculty/graduate students on modern, research-quality equipment. EaRL contains a modular cleanroom (a low dust environment, similar to that utilized to fabricate microelectronics), some of the experimental tools for uv-lithography, a high quality fluorescence microscope, a research-grade atomic force microscope, and other equipment.

ORaCel: The Organic and Carbon Electronics Laboratory in Partners III provides shared facilities for sample preparation (glove boxes, CVD graphene growth, pulsed laser deposition) and characterization (x-ray photoelectron spectroscopy, electrical transport probe station, AFM) as well as synergistic activities for NC State faculty across several colleges.

Machine Shops: The Sciences Instrument Shop in the College of Sciences is a full-service machine shop. A team of highly skilled machinists work closely with the faculty and students in the construction, fabrication, repair or modification of scientific instruments and equipment. In addition, the department of physics provides a machine shop in Riddick Hall for a more hands-on approach to fabrication.

High Performance Computing on campus is supported at the university level by a campus linux cluster with 1000 dual-socket servers. Several physics faculty participate in their Partner Program wherein researchers purchase one or more IBM Blades to add to the campus cluster and in return are given a priority queue for access to their fraction of the system. More locally, the Physics Department maintains a server room in Riddick Hall, with power, cooling, and networking to house three racks of servers.

PULSTAR is a 1-MW pool-type nuclear research reactor administered by the Nuclear Reactor Program and located in Burlington Laboratory, across the street from Riddick Hall. The relatively large leakage of epithermal neutrons is advantageous for situating a source of ultracold neutrons in the thermal column of the reactor. The PULSTAR UCN source is designed to provide densities of about 30 UCN/cm^3 to the entrance of an external guide system where experiments can be performed in the reactor bay. At present, the first experiment to be mounted at the PULSTAR source will be a test facility for the neutron static electric dipole moment project.

AIF: Analytical Instrumentation Facility is a resource for materials characterization that is available to the entire university and to external parties. AIF operates a number of major analytical instruments providing quality analyses for all who require it. These instruments are operated and maintained by a professional staff. For those who desire hands on involvement in their analyses, AIF staff trains users to operate facility analytical instrumentation, to design efficient analytical experiments, and to properly interpret the resulting data. In addition, AIF provides short courses as well as formal classroom instruction. Usage fees apply.

NNF: The NCSU Nanofabrication facility is located in the Monteith Engineering Research Center on Centennial Campus and it occupies a 7400 square feet class 100 and class 1000 cleanroom. The facility has a full range of micro and nano-fabrication capabilities including: photolithography, reactive ion etching (RIE), deep RIE, low pressure chemical vapour deposition (LPCVD), plasma enhanced CVD, rapid thermal anneal, thermal oxidation, solid source diffusion, thermal and e-beam evaporation, sputtering, chemical mechanical polishing, various wet etching and cleaning processes, along with various characterization tools. Many of the tools are capable of processing on a broad range of substrates such as semiconductor glass, ceramics, and plastics with sizes from small pieces to 6" wafers. Usage fees apply.

Off Campus

The ***NIST Center for Neutron Research*** is part of the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. Its activities focus on providing neutron measurement capabilities to the U.S. research community. It is a national center for research using thermal and cold neutrons, offering its instrumentation for use by both academia and industry. NC State researchers collaborate with the Neutron Physics group in the studies of the weak interaction by performing measurements at the neutron physics beamline, the Neutron Interferometry and Optics Facility, or the Ultracold Neutron Facility.

Triangle Universities Nuclear Laboratory provides an intellectually and technically rich environment for educating graduate students in experimental nuclear physics through conducting research on projects that pursue answers to questions at the frontier of physics. TUNL operates three accelerator facilities: the High Intensity Gamma-ray Source (HIGS), the Laboratory for Experimental Nuclear Astrophysics (LENA) and the tandem accelerator laboratory. In addition, there are a variety of specialized laboratories used by TUNL research groups for equipment R&D on all three campuses.

Los Alamos Neutron Science Center (LANSCE) provides the scientific community with intense sources of neutrons with the capability of performing experiments supporting civilian and national security research. The ultracold neutron source in Area B was developed by NCSU faculty as a part of the UCNA collaboration, and is, at present, the most powerful ultracold neutron source in the world. Experiments to perform high precision measurements of neutron beta decay (UCNA, UCNB and UCNtau), the static electric dipole moment of the neutron and other fundamental and applied physics phenomena are underway at the LANSCE source.

Jefferson Lab is a DOE nuclear physics research facility located in Newport News, VA (about three and half hours by car from NCSU). Our graduate students have received JSA/JLab fellowships and participated in the Hampton University Graduate Studies (HUGS) summer school at JLab in recent years. In anticipation of opportunities afforded by the 12 GeV Upgrade of the Continuous Electron Beam Accelerator Facility (CEBAF) at JLab, our department hosted the international conference LIGHTCONE 2014 to highlight current development in nuclear, hadron and particle physics.

Oak Ridge National Laboratory has a very active interaction with NC State, and with our physics department in particular. ORNL facilities used by our faculty and students include Titan, a 27-petaflop supercomputer, and the Spallation Neutron Source, a 1.4 MW spallation neutron source. As the largest university collaborator on the ORNL-based neutron electric dipole moment experiment, NC State plays key roles in both the development of the project and providing leadership roles in the collaboration.

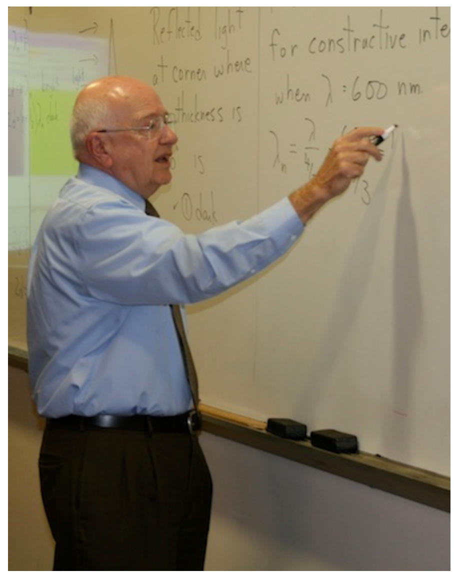
Advanced Light Source at the Lawrence Berkeley National Lab is a synchrotron user facility funded by the DOE Office of Basic Energy Sciences. Harald Ade has Approved Program status to study a variety of important meso- and nano-structured organic materials systems. Ade has led development of a scanning transmission x-ray microscope at beamline 5.3.2.2.

Space-Based Observatories are routinely used by Borkowski and Reynolds. These include NASA's Chandra X-Ray Observatory, Spitzer Space Telescope, and most recently NuSTAR, as well as Japan's Suzaku X-Ray Observatory and ESA's XMM-Newton and Herschel Observatories.

High Performance Computing is accessed by physics faculty through a variety of national and international resources, including the National Institute for Computational Sciences and the Texas Advanced Computing Center (NSF), the Oak Ridge Leadership Computing Facility and the National Energy Research Scientific Computing Center (DOE), NASA's High-End Computing Capability, and the Jülich Supercomputing Centre.

IV. Teaching

A Record of Excellence



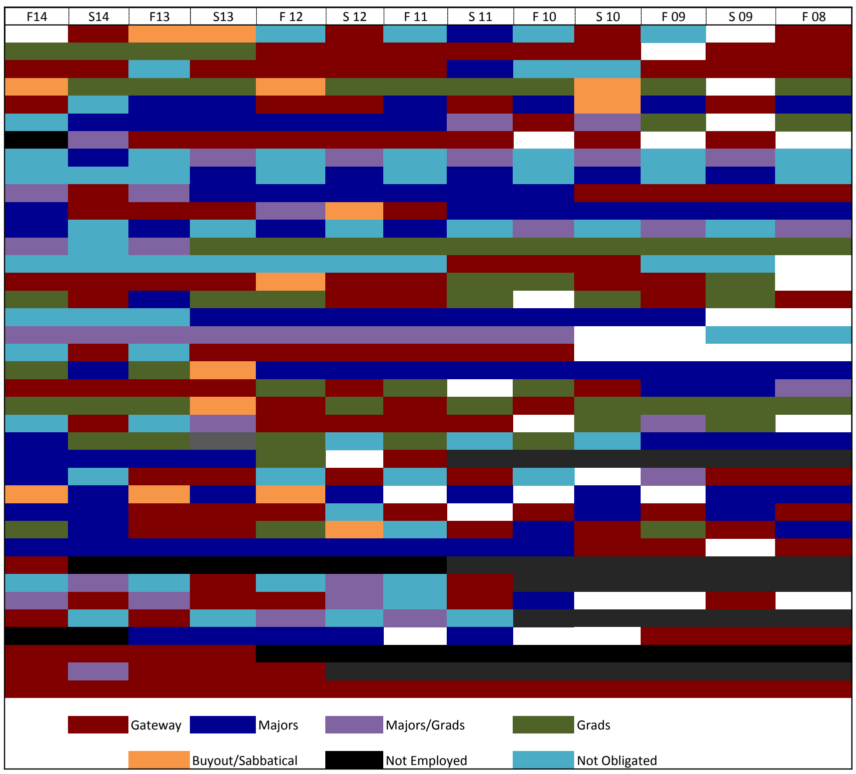
The Department of Physics has a strong history of teaching excellence, exemplified by Dick Patty. He not only led the department as Head for 19 years, he taught physics classes for 50 years. In his last semester in 2014 he was still the favorite instructor, receiving the highest student evaluations in our department. As a department we have been recognized in 2003 by NC State University for our Teaching and Learning Excellence and in 2015 by the APS Committee on Education for our efforts at Improving Undergraduate Physics Education.

Two of our faculty (Beichner and Hubisz) have been named inaugural Fellows of the American Association of Physics Teachers and two (Beichner and Haase) have received Pegram Medals for Excellence in Education from the Southeast Section of the APS. Bob Beichner has won numerous awards from the Carnegie Foundation for the Advancement of Teaching, the Society of College Science Teachers, the National Science Teachers Association, as well as the McGraw Prize.

NC State University Awards	Current Physics Faculty
Academy of Outstanding Teachers	Beichner, Blondin, Clarke, Gould, Haase, Lee, Paesler, Reynolds
Alumni Distinguished Graduate Professor	Aspnes, Lucovsky
Alumni Distinguished Undergraduate Professor	Beichner, Blondin, Gould, Haase, Lee, Reynolds
UNC Board of Governor’s Award for Teaching Excellence	Beichner, Reynolds, Haase
Martin Award for Teaching Excellence	Daniels, Clarke

Distribution of Teaching Load

The nominal teaching obligation of research-active faculty is one course a semester. The standard operating procedure is to teach the same course three times (four for graduate core courses) before rotating to something else. To the extent possible, all faculty rotate through all levels of courses - some faculty were allowed to teach the same course indefinitely in the past. Teaching assignments are made by the Department Head in consultation with the faculty during the annual review process.



The graphic above illustrates the distribution of teaching assignments, with each horizontal row representing a faculty member. The preponderance of 'not obligated' stems from faculty doubling up in a semester, several faculty having negotiated semesters off either through start up or retention, and faculty who are not obligated to teach on the basis of their administrative duties in the department or college. Note that 70% have taught at least one gateway course in this time period and almost everyone has taught a mix of lower and upper level courses.

Part-Time Instructors

Graduate courses in physics are only taught by T/TT faculty with graduate status.

Driven in large part by the demands of teaching the gateway courses, we typically recruit part-time instructors to teach roughly 8 undergraduate class sections each semester and to teach summer classes. Often these part-time instructors are our recent graduates, postdocs, or graduate students near the end of their program who want to get teaching experience. This is normally done on a class-by-class basis, but in recent years we have hired recent graduates of our Ph.D. program as postdoctoral teaching scholars and had them teach multiple class sections each for one or more years.

The use of part-time instructors is limited almost entirely to 100 and 200 level classes. In addition, we have used outside instructors for PY 328 and PY 301.

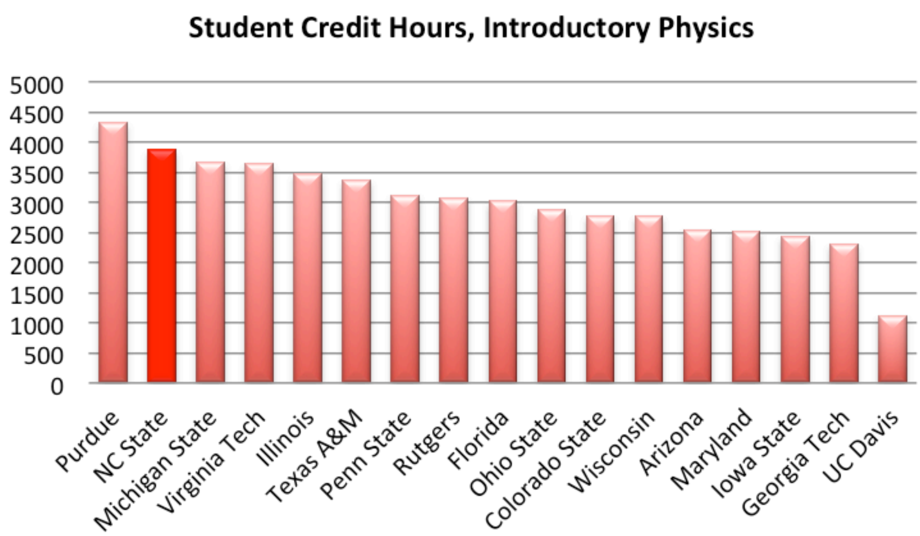
Buy-Outs and Sabbaticals

University regulations suggest that departments and colleges “foster, when possible, scholarly reassignments for their faculty members at intervals of about seven years.” A faculty member may be granted a scholarly reassignment for one semester at full salary or for one academic year at half salary. Roughly one faculty member is on sabbatical in a given year.

Faculty can use external funds to buy out their teaching obligation at a rate of 1/6 of their 9-month salary per semester (with a cap of $15,000). A couple of faculty use this option on a regular basis, but most have never done it. Faculty can also ‘double-up’ by teaching two classes (typically two sections of the same gateway course) one semester and no teaching the other. Several of our faculty have used this option.

Service Teaching

NC State Physics ranks #10 out of 752 physics departments in the United States in terms of student credit hours in introductory physics courses, and second among our peer institutions. This service teaching includes a few hundred students a semester in conceptual physics and astronomy classes (stars and galaxies, solar system), 900 a semester in the algebra-based sequence, and roughly 1600 a semester in the calculus-based sequence.



The two introductory sequences are taught in coordinated fashion, with Teaching Assistant Professors providing the oversight and coordination of the teaching (Heyward for 211/212; Cui for 205/208). The course coordinators draft a common syllabus and the schedule of lecture topics, create homework assignments through WebAssign, lead the writing of the common tests and final exam, as well as providing assistance with using classroom clickers, setting up moodle pages and other course logistics. These gateway courses are also supported by a tutorial center run by the physics department and staffed by graduate and undergraduate physics students.

Each section of a gateway course is taught in a classroom that holds from 107 to 146 students. Occasionally we use a large lecture hall that seats 280 students. For example, in Spring 2015 we have 10 different sections of the first semester calculus-based physics (PY 205) plus an honors section and an online section. Two of these sections are taught by a part-time instructor, the rest by T/TT/NTT faculty.

Laboratories for these sequences are taught in Fox Labs by graduate TAs. The labs and the TAs are managed by a lecturer, Bob Egler (his only other duty is teaching an astronomy course). We have recently separated the lab for the calculus-based sequence into separate courses, PY 206 and PY 209. This provides a much more manageable operation and opens up a significant number of seats because students can pass the lab even if they failed the lecture class.

We occasionally teach PY 205 or PY 208 in a SCALE-UP mode, a studio physics format pioneered by Bob Beichner. Of our current faculty, only Beichner and Daniels have used this format. Albert Young developed a SCALE-UP version of modern physics, but this has not been adopted by subsequent instructors.

The labs for the algebra-based sequence are still coupled to the lectures, and we are only teaching 6 labs per semester in order to double up lab rooms and TAs. Given the reduction of lab seats needed in 206 and 209, we should have the lab space to move to weekly labs in 211 and 212 (if given resources to hire more lab TAs). This would allow us to decouple the lab from the lecture in the algebra-based sequence as well.

We added weekly problem-solving sections to PY 205 in 2013 with the goal of reducing the DFW rate in this critical introductory course for engineering students. We have been tweaking these problem sessions based on student feedback the first few semesters, and will be integrating concepts from the university's Critical and Creative Thinking Program (The Quality Enhancement Program developed for the SACS review) in the coming year.

One glaring absence from our teaching portfolio is a 'stars and galaxy' class for non-science majors. Despite the fact that the university General Education Program requires that all students take at least two science courses, we do not provide many class seats for non-science majors. Due to funding constraints, we have not taught our stars course for two years (since an astronomer became department head), and only offer one section of our 'sun and planets' class.

Physics instructors in all courses are supported by a demoroom that provides one-click ordering of a wide variety of classroom demonstrations. The demoroom is managed by one of the NTT faculty and staffed by undergraduate students.

PhysTec

The Physics Department and the Department of STEM Education received a PhysTEC (phystec.org) grant. This supports Learning Assistants who help graduate Teaching Assistants in leading sections of about 30 students in PY 205 (Physics for Engineers) through extended group problem solving exercises. The LA's have generally worked quite well with the TA's undergraduate students and helped lead the sessions, answered student questions and facilitated group work. Each Learning Assistant takes a one credit hour seminar entitled Introduction to Teaching Physics. The course is based on the University of Colorado Learning Assistant program and is co-taught by Physics and STEM Education faculty. A Learning Assistant receives a stipend from the PhysTEC grant and from department funds, and may continue as an LA if he or she enrolls in an Education course. The program has supported 5 to 9 LA's for each of its first four semesters. The NCSU PhysTEC program has raised the visibility of physics teaching as a career option, it has provided much needed help for the PY 205 recitation sections (over 45 sections!), and it has fostered collaboration with the Department of STEM Education.

V. Service/Outreach/Extension

Consulting

External consulting has only a minor role in our department. Only Jerzy Bernholc has a steady consulting relationship, working with Oak Ridge National Laboratory. Other faculty who have engaged in external consulting in the past several years include Beichner (education consulting), Aspnes (Kyung Hee University), Daniels (Proctor & Gamble), and Haase (McGraw-Hill publishers).

External Service

In the past five years our faculty have served on the editorial boards of *Science, Physical Review Letters, J. of Physics G, J. of Vacuum Science and Technology, J. of Electron Spectroscopy and Related Phenomena, Computing in Science and Engineering, Computational Science and Discovery J.,* and the *International J. of Polymer Science, Physical Review Special Topics: Physics Education Research.*

Several of our faculty have been recognized by the APS Outstanding Referees Program: Aspnes, Bernholc, Ji, Krim, Schäfer and Thomas.

Other external service appointments in recent years include

- Chair of Class III, National Academy of Sciences (Aspnes)
- Governing Board of AIP (Aspnes)
- Executive C. of High Energy Astrophysics Division of AAS (Reynolds)
- General Councilor of APS (McLaughlin)
- Nominating C. of DAMOP, APS (Thomas)
- APS C. on graduate education (Paesler)
- NRC Task Force on Discipline-Based Education Research
- Trustee for Fritz London Prize in Low-Temperature Physics (Haase)
- President of Association of Korean Physicists in America (Ji)
- Science Advisory Board, ORNL (Bernholc)
- Advisory C., Institute for Nuclear Theory (McLaughlin)
- Scientific Advisory C., Advanced Light Source (Ade)
- Scientific Advisory C., ORNL Computing and Computational Sciences (Bernholc)
- Scientific Advisory C., Helmholz Zentrum (Ade)

Outreach

Our faculty participate in numerous public science presentations on campus and around Wake County, including visits to K-12 schools. Some of the more regular, organized outreach activities include

- Astronomy Days at the NC Museum of Natural Sciences
- Science Cafés – public science presentations held at local restaurants and pubs
- Astronomy Open House – open our teaching telescopes to the public
- Southeastern Conference for Undergraduate Women in Physics (3 times)
- Astronomy Night at Centennial Campus Middle School (10+ years)
- Family Science Night at Washington Elementary School (16+ years)
- Boy Scouts / Girl Scouts / Odyssey of the Mind / Expanding Your Horizons
- Science Day at Raleigh Charter High School

VI. Graduate Program

The NC State graduate physics program is committed to world-class research, mentoring, and teaching. We strive to provide an exciting and fertile intellectual climate. This includes pioneering research in pure and applied physics, weekly research seminars and colloquia, a large and diverse graduate physics curriculum, and individually tailored graduate plans for entering graduate students.

Program Description

Exact Title of Program: ***Physics***

Department Authorized to Offer Degree Program: ***Physics***

Titles of Degrees Granted: ***Master of Science in Physics***

Doctor of Philosophy in Physics

College: ***Sciences***

Program Objectives and Outcomes:

Objective: To develop students as professionals for successful careers in physics in industry and the academy.

Outcomes: Physics graduates are expected to…

a. pass the final exam of thesis or dissertation defense without any condition at the master's or doctoral level.
b. present their research to local, regional, national, and international audiences through publication in professional journals and at professional conferences.
c. become members and actively participate in professional organizations in physics.
d. take full advantage of professional development activities encouraged by the program, such as teaching, internships, grant applications, research seminars, and professional development workshops offered by Preparing Future Leaders.
e. demonstrate an understanding of different kinds of careers in physics, to set career goals, and to outline a plan for preparing to achieve career goals.

Objective: To develop students as successful researchers in physics.

Outcomes: Physics graduates should be able to…

a. identify a novel research problem in physics whose solution could make a contribution to the field.
b. demonstrate mastery of the research literature in a particular area of the field.
c. apply appropriate methodologies to solving a research problem in physics.
d. analyze, interpret, and draw reasonable conclusions from data.
e. communicate research effectively in both oral and written modes.

Objective: To enhance the quality and national and international reputation of the program.

Outcomes: Physics faculty are expected to…

a. recruit and enroll high quality students.
b. foster an environment of effectively mentoring students.
c. graduate students in a timely manner.
d. place students in appropriate positions in industry and the academy.

Responsiveness to needs

In North Carolina and the Nation at large, economic advancement is highly dependent upon science and technology. The need for more research and education of a high quality workforce has been documented in a number of recent national reports including the NAS report “Rising Above the Gathering Storm”. Locally, for most of the 20th Century, the economy of North Carolina was built largely upon agriculture, especially tobacco, and the manufacture of textiles and furniture. During the previous two decades the state’s economy has been transforming rapidly with increasing emphasis on high technology industries. Physics is a discipline naturally associated with high technology and requires high level of analytical and problem solving skills on the part of the graduate students. Hence, our graduates acquire a set of technical and analytical skills that make them employable in a wide range of high technology industries and government laboratories.

Administration

The **Director of Graduate Programs** (Chueng Ji) is responsible for all aspects of the program and directs the daily administration of the program. The DGP oversees the recruiting and admissions processes, serves as the academic advisor for first-year students, monitors the progress of all students, and works continuously with the faculty to assess and improve the graduate physics program.

The **Graduate Services Coordinator** (Rhonda Bennett) serves as the principal administrative liaison between the student, the graduate program, and the Graduate School. The GSC supports students and faculty by handling inquires and requests from students and faculty concerning graduate academic requirements, procedures and policies, exam scheduling, GSSP, residency, RA and TA appointments, graduate school and university deadlines, and miscellaneous day-to-day problems, questions and concerns.

The **Graduate Recruiting Committee** is responsible for generating interest in the graduate program and increasing the number of applications. They update recruiting material, organize recruiting efforts and regional and national meetings, and work with the DGP, the GSC, and the graduate students on the graduate recruiting weekend held in February or March.

The **Graduate Admissions Committee** reviews all graduate applications and provides the DGP with a list of applicants recommended for admissions. This committee generally includes one faculty from each of the core sub-fields in the department.

Students

Recruitment

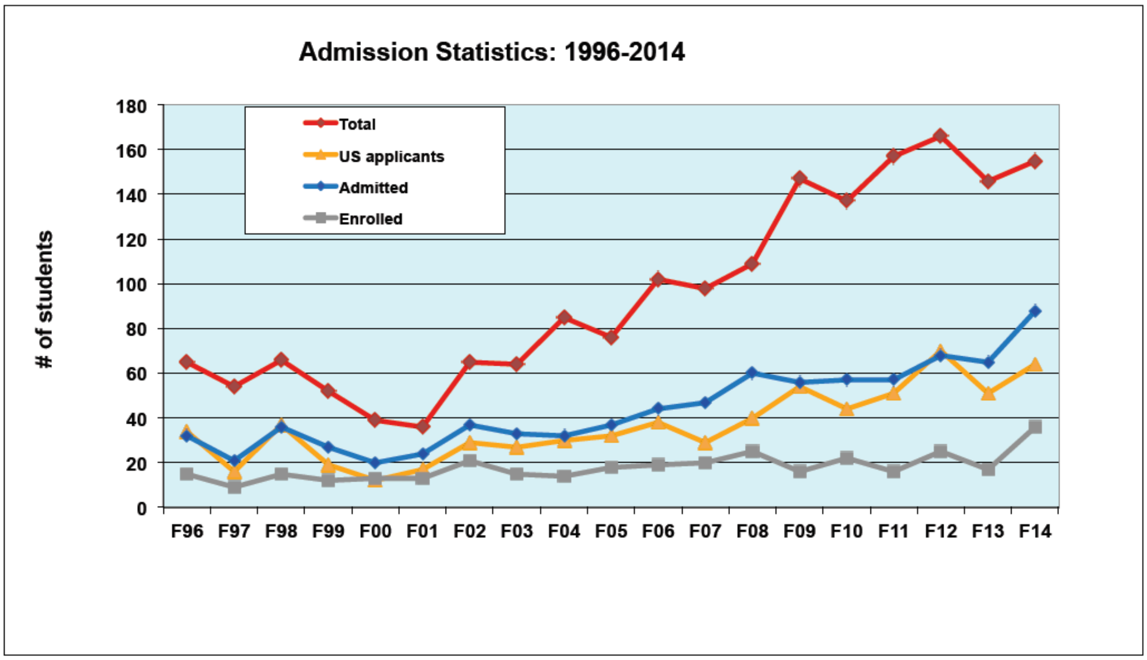
Growing the application pool of quality graduate students has been a long-standing challenge. A faculty task force was charged in 2012 with developing a strategy for doubling our graduate applicant pool. The two key priorities that came from this effort were (1) the need for yearly, active pursuit of recruitment and (2) the need to find avenues of financial support to facilitate recruitment of the top applicants.

Some of the action items identified by this task force include

- Produce a glossy short brochure, send to other programs (done)
- Revise long brochure (attempted but not sustained)
- Develop graduate ambassador program (done twice, not sustained)
- Ensure faculty take advantage of recruiting opportunities when they travel
- Invite undergraduate directors for colloquia and seminars (not done)
- Upgrade website (in progress, but not anybody's priority)
- Institute a graduate recruiting committee to lead efforts every year (done)

Admissions

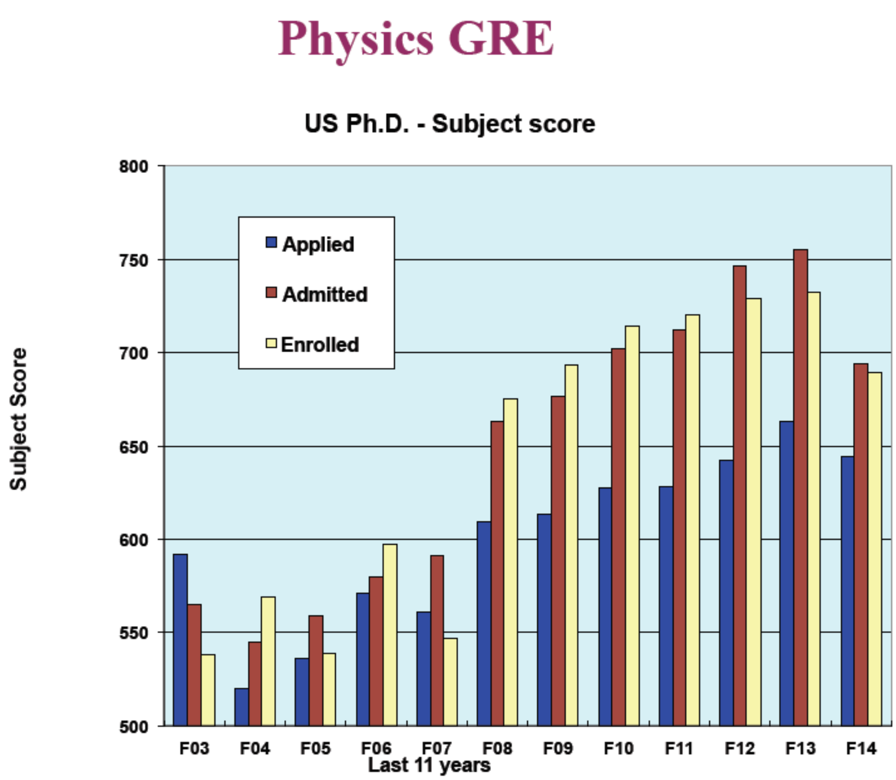
Historically, our graduate program has not been very selective given the small applicant pool relative to the size of the graduate program. The admission statistics for the period of 1996-2014 is shown below. Averaging over the last ten years, we admitted about 40% of all international students that applied and about 55% of all US applicants (in F14, the numbers were 47% and 70%, respectively).



Quality of Incoming

Graduate admission is based on an applicant's GPA, their institution, grades in the most relevant courses they have taken, GRE scores, letters of recommendation and any information we can find about the students suitability to our program.

The past decade has seen a significant increase in the physics GRE scores of our incoming students, as well as the applicant pool. This change in our graduate population has been reflected in the improved passing rate for the comprehensive exam and the decrease of students needing to take 500-level classes in their first year before taking our core graduate curriculum. We do note, however, that this same time period has witnessed a decrease in the diversity of our student population.



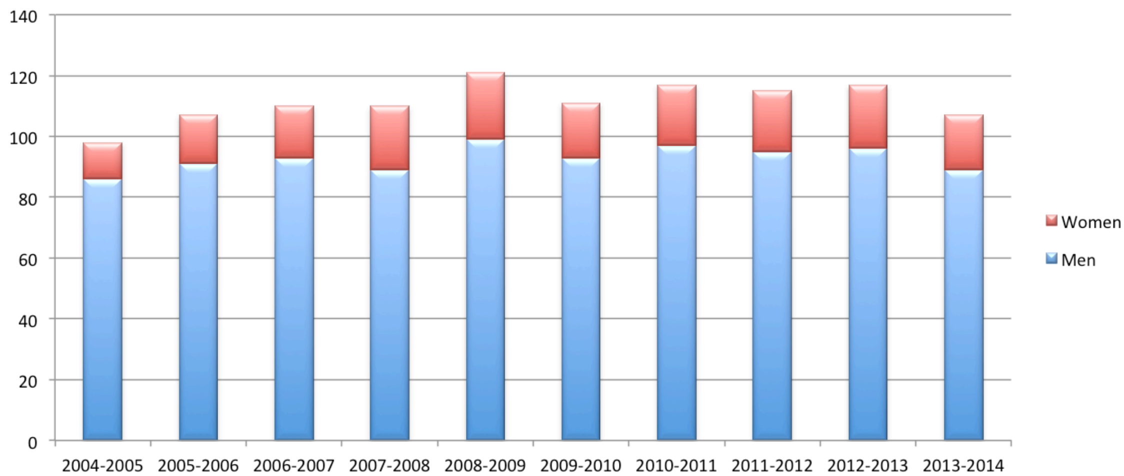
Although the GRE subject scores of the US students admitted to our PhD program have been improving in the last several years, the average score last year dropped below 700. This class was abnormally large, and several students ended up on academic probation after the first semester. We are taking immediate steps to prevent this from happening again – more scrutiny of applications, better matching of first-year courses with student ability, improved advising and mentoring.

We acknowledge risks and occasionally admit US students with a rather low GRE subject score, but for whom we feel we can offer an opportunity for the student to grow and become successful. For example, students are occasionally admitted from programs that have only taught one semester of advanced undergraduate quantum, E&M, and/or mechanics. In these cases we can enroll them in our 500-level core classes before they take the 700-level core classes.

Enrollment

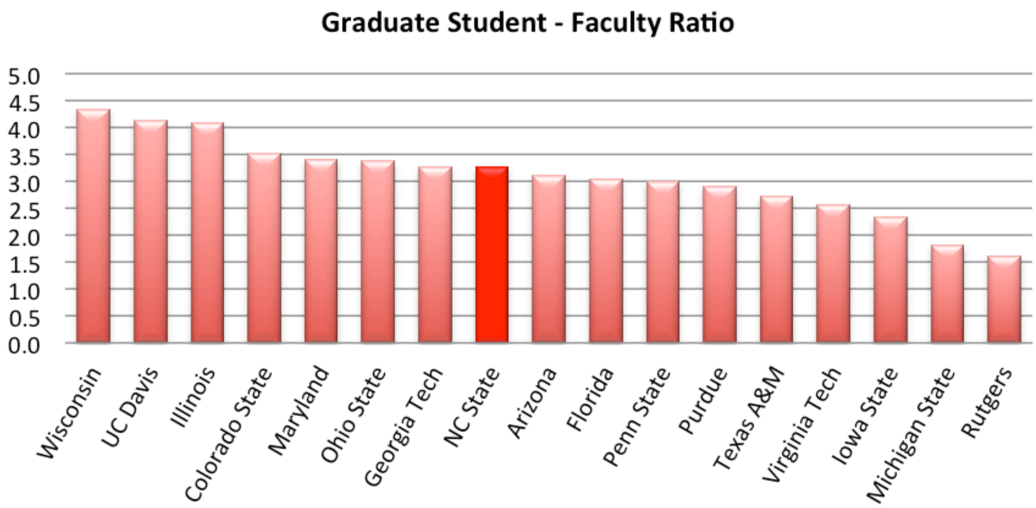
The enrollment in our graduate physics program has remained relatively steady at roughly 110 students for the past decade, with the fraction of women consistently at

17%. Almost all of these students are in the doctoral program. We occasionally admit M.S. students to the program, either because they are our own students wanting to get an M.S. before applying to Ph.D. programs elsewhere or because we are not yet confident they can succeed in our Ph.D. program.



According to the university strategic plan, the expansion of graduate education – particularly doctoral education – is the highest priority for enrollment growth. The goal is to increase graduate enrollment as long as there is sufficient demand that we can meet with resources adequate to sustain the quality of education. Based on the applicant/admission ratio (see next section), one could argue that the demand for our program is not very high, but is high enough though to fill all available RA and TA positions. The primary objective regarding graduate student enrollment will be moderate growth commensurate with the growth in the number of faculty and funding resources. Simultaneously, the goal will be to increase the quality of the students admitted.

We share with other doctoral institutions a responsibility for building a faculty diverse in background and perspective, ready to teach and mentor new generations of students, which will be increasingly diverse themselves. To that end, NC State seeks to recruit and mentor graduate students representing a variety of academic perspectives and racial, ethnic, gender, and geographic backgrounds. Our recent history, however, shows that the fraction of under-represented minorities among our graduate students has hovered around 5% for the past seven years. With several recent graduations, we currently have only one such student.



A simple metric for the size of a graduate program is the faculty-student ratio. This is particularly important for a Ph.D. program, where the number of students is constrained by the research opportunities provided by the faculty in the department. The above chart uses the number of graduate students as recorded by AIP together with the number of T/TT faculty as counted from department web sites.

Advising

The DGP serves as the primary academic advisor for all students. The DGP meets with every student each semester to discuss progress and plans, and to review course enrollment for the upcoming semester. In addition, each student beyond the first year provides a written progress report at the beginning of the spring semester. This report provides a mechanism for the student, research advisor and DGP to have some sense of agreement on the student's progress to degree. It also serves as a tool to usher students into a research group in a timely manner.

By the third year of graduate study, students are expected to have found a research 'home' and have identified a thesis advisor and graduate committee. A list of T/TT faculty in physics with the number of graduate committees they have chaired is given in Appendix D.

Quality of Ongoing Students

Our students show a very large range of capabilities and performance as a consequence of the spread in the applicant pool and the quality of incoming students over the last 10 years. The graduate courses and the Departmental Exam serve their function as a “high pass” filter and provide a minimum standard, but the spread in capabilities of those that remain is still very large. Although 80% of the first-year students enrolled in 2014 have been successful in their course works, about 20% of the first-year students have received their accumulated GPAs below 3.0. The department has identified individual faculty mentors for those students in academic difficulty.

Funding

Almost all students are provided financial support through TA and RA appointments and a few internal and external fellowships. Every effort is made to ensure that all students are supported. Only when a student has failed to demonstrate progress to a degree for multiple semesters do we consider removing financial support. Once students join a research group, they are typically supported by an RA in that program. In cases where the research is less well funded but the faculty advisor has maintained an active research program, the department will continue to support their study by providing a TA appointment beyond the second year.

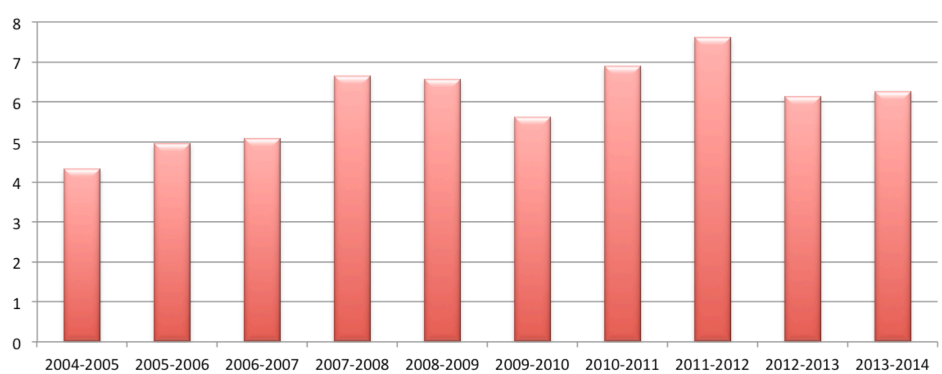
Several of our graduate students are supported by the U.S. Department of Education Graduate Assistance in Areas of National Need (GAANN) Fellowship Programs at NCSU, in the areas of Molecular Biotechnology, Computational Science, Nanoscale Electronic and Energy Materials (NEEM), and Nuclear Science and Engineering. Recent GAANN Fellows in the Physics Department include: Eric Raymer, Justin Edwards, Terry McAfee, Graham Medlin, Michelle Pine, Brittney VornDick, Kelly Patton, Eliot Gann, and Shawn Huston.

Year	All Enroll	All Supp	RA Only	TA Only	Fellow	Combo	Avg Stipend
04/05	98	91	49	34	1	7	$19,506
05/06	107	94	46	36	2	10	$19,790
06/07	110	99	57	25	2	5	$20,458
07/08	110	100	49	43	2	6	$20,968
08/09	121	114	50	53	2	9	$22,954
09/10	111	103	48	38	4	13	$22,421
10/11	117	110	54	42	5	9	$22,982
11/12	115	108	57	36	6	9	$22,782
12/13	117	110	43	50	7	10	$22,595
13/14	107	98	38	46	3	11	$23,278

Sources of financial support for enrolled graduate students.

Degrees Granted

The number of Ph.D. degrees granted has seen a surge in recent years, but this is in part due to a concerted effort to decrease the typical number of years to completion. The most recent AIP report states that the average length of time to earn a physics PhD for degree recipients in the combined classes of 2010 and 2011 was 6.3 years. As shown in the chart below, we still generally below that value.



Average Years to Completion for Ph.D. recipients by year of degree.

Year	Ph.D.	YTC	M.S.	YTC
04/05	13	4.33	4	2.35
05/06	6	4.96	3	4.01
06/07	13	5.08	7	3.78
07/08	13	6.65	7	2.56
08/09	13	6.58	4	3.54
09/10	16	5.63	10	2.46
10/11	6	6.89	17	2.38
11/12	15	7.61	4	
12/13	24	6.14	2	1.33
13/14	18	6.26	10	2.89

Need/Placement

In general, all our students find employment before or immediately after graduation. Many of those graduating with a solid state background go into industry. Other employment opportunities include post doc positions or academic appointments. We do not have a specific program that assists in finding employment. It does not seem to be necessary. – We have no formal assessment about the employee satisfaction with our graduates. Overall anecdotal evidence is very positive. Some of our best students are making major contributions in their careers.

Industry		Postdocs	
Analog Devices	Bloomberg	Duke	Chicago
Applied Research	GE	LANL	Arizona State
Teradata	Apple	Monash U.	Washington
NVIDIA	Intel	U. Penn	Columbia
CREE	Microstrategy	Boston U.	RIKEN, Japan
Epic Systems	US EPA	UCLA	Purdue U.

Employers of recent Ph.D. recipients

Type of position	Masters		Doctoral	
	In-State	Out-of-State	In-State	Out-of-State
Further graduate study	1	3		
Post-doctoral scholar			1	6
College/University faculty			1	1
Business or industry	1	1	4	11
Government				1
Unknown	2	5		3

Graduate student placement since spring 2013

Curriculum/Instruction

The following is a simplified guide to the policies and procedures of The Graduate School and the Physics Department concerning M.S. and Ph.D. degrees in physics.

Ph.D. Degree

The formal academic requirements for the Ph.D. degree includes 72 credit hours of course work and is defined by the following major parts:

- mastery of material covered in four core courses (grade of B or better)
- passing of the written departmental comprehensive exam
- mastery in four electives classes (grade of B or better)
- passing of a preliminary oral and final oral examination

Written comprehensive exam: This exam should be taken at the beginning of the 2nd semester. If additional preparation is required, taking the exam at the beginning of the 4th semester is acceptable. The examination covers Electricity and Magnetism, Classical Mechanics, and Quantum Mechanics at the advanced undergraduate level and E & M and Quantum Mechanics at the beginning graduate level: (E&M: PY 515, 785; Mechanics: PY 512; QM: PY 501, 502, 781). The three parts of the exam have to be passed separately. The exam can be repeated once. - As a practical matter, essentially all students find mastery of the material in these graduate courses to be the best preparation for the examination.

Core courses: Students are required to take Statistical Physics (PY 721), Advanced Quantum Mechanics (PY 782) and either Advanced E&M-II (PY786) or Advanced Classical Mechanics (PY783). A fourth course at the 700-level is required. In addition, most students take PY781 and PY785 in their first semester, but these do not count toward the four core courses.

	Fall	Spring
1st year	PY 801, PY 599	Departmental Exam
	PY 781	PY 782
	PY 783	PY 786 or PY 721
	PY 785	PY Elective
2nd year	PY Elective / Minor	PY 786 or PY 721
	PY Elective / Minor	PY 895 (Research)
	PY Elective / Minor	PY Elective / Minor
3rd year	9 credit hours PY 895	9 credit hours PY 895
		Prelim exam

Typical course schedule for graduate physics students

Minor/electives: Four more courses in Physics or related fields are required in addition to the core courses. A minor is optional. The most popular approach is the interdisciplinary minor: four or more courses in three different departments. The minor representative certifies the collection of courses as comprising a coherent minor.

First-year students must enroll in PY 601 (M.S. students) or PY 801 (Ph.D. students), which requires attendance at the weekly departmental colloquium and a weekly lunch presentation by physics faculty. A one-semester course in Research Ethics (PHI 816) is required of all doctoral and master students.

All first-time teaching assistants are required to take a one credit teaching pedagogy class (currently labeled PY 599) developed through our PhysTec program.

M.S. Degree – with thesis

The standard minimum M.S. program includes 24 credit hours (at least 18 credits in the Physics Department) of regular courses and 6 credits of PY 695/699 Research. An oral examination is required, normally emphasizing the thesis. The written comprehensive exam is not required.

M.S. Degree – without thesis

This option is normally exercised by Ph.D. students who obtain an M.S. degree *en route* to the Ph.D. degree. Requirements for the Option B degree include successful passing of the written comprehensive exam and completion of 30 total graduate credit hours.

Graduate Physics Courses

Courses at the 500-level target seniors and first/second-year graduate students and are intended to provide an introduction to the various research areas of physics. Courses at the 700-level are more rigorous, and constitute the core curriculum (QM, E&M, Classical Mechanics and Statistical Mechanics) and advanced courses (Field Theory, Condensed Matter, Stat Mech II). The total enrollment, by semester, for graduate-level physics classes is given in the table below.

	F09	S10	F10	S11	F11	S12	F12	S13	F13	S14	F14
506 Nuclear	16		17		15		19		19		2
507 Particle		0		4		8		8		13	
517 Atomic & Mol											
516 Optics	24		9		14		9		19		9
519 Biophysics								13		14	
525 Computation			19		15		20		23		19
543 Astrophysics		10				26				19	
552 Solids		7		12		19		18		11	
509 Relativity									18		14
711 Advanced QM I				8					16		
712 Advanced QM II										7	
721 Stat Mech I		21		28		16		22		18	
722 Stat Mech II	9						11				7
753 Solids II	12		8		9		7		5		8

754 Interfaces		6		7							
781 Quantum I	27		31		20		26		14		34
782 Quantum II		19		24		18		24		14	
783 Classical Mech	26		18		21	18	23		19		33
785 E&M I	24		26		16		26		17		33
786 E&M II		7		7		7		24		17	

Curricular Changes

Ten years ago, a change was made in the course requirements and the content and length of the comprehensive written exam, i.e. the qualifying exam. The original exam used to be given at the end of the spring semester and comprised the graduate level and undergraduate level materials in QM, EM, and CM in three full days of exam. The exam is now given just prior to the start of the spring semester and was shortened to three half-days. It now comprises material from undergraduate QM and the first semester graduate QM, undergraduate EM and the first semester graduate EM, and undergraduate CM. The intent was to get students into the research environment faster (possibly after the first semester, but certainly after the third semester) without watering down the core physics taught and expected from students. The earlier timing and reduced material covered was complemented by the requirement that 4 core courses have to be passed with a B or better.

In addition to this change, the entrance exam is offered to the incoming students just prior to the start of the fall semester so that the students who pass this exam without any condition will be eligible to place out the qualifying exam described above. In particular, students with Master degrees or equivalent mastery of core courses are encouraged to take this exam. The format of the exam is same as the qualifying exam.

Several new courses such as Biological Physics, General Relativity, Nonlinear Optics, and Organic Materials have been offered as Special Topics courses (PY 590) in the last few years. After being taught a couple of times with sufficient enrollment, these become permanent courses (PY 519 – Biophysics; PY 509 – General Relativity). Atomic and Molecular Physics (PY 517) and Statistical Physics II (PY 722) have been resurrected recently after many years of not being offered.

Relation to other programs

We do not have any formal connections with instruction in other units on campus, but we do frequently have graduate students from around campus taking our courses, particularly the 500-level courses. These students are typically from Electrical Engineering or Material Science and Engineering, but also Nuclear Engineering, Chemistry, and Aerospace Engineering. For example, this semester (Spring 2015) Kenan Gundogdu is teaching a 500-level course in nonlinear optics that includes eight graduate students from Electrical Engineering. Occasionally (one per year) a graduate student from one of these departments completes a minor in physics.

Program Assessment

In 2012, a Faculty Task Force was charged with reviewing all aspect of our Graduate Program (except for recruitment, which was examined in 2011) in connection with the appointment of Prof. Chueng Ji as the new DGP. This Task Force recommended the following after consultation with both the faculty and graduate students:

(1) Allow incoming students with an appropriate background to immediately take an entrance exam which if passed would count as their qualifying exam.
(2) Require all entering PhD candidate students to become associated with a research group by the end of their first year.
(3) Mandate each student to write a 1-2 page summary that is both backward and forward looking in regards to their research program.
(4) Change the current pass/fail grading scheme in the PY895/899 research courses to graded credit.
(5) Reinstate the “pizza lunches" as a formal one-credit hour class.
(6) Require all first and second year students to attend every colloquium.
(7) Develop a clear path of courses for each subfield of physics in which we offer graduate degrees.
(8) Implement what is presently written in regards to the course degree requirements to minimize varying concerns regarding student's course loads.
(9) Strongly encourage students to take the preliminary exam by the end of their third academic year.

Some of these have already been implemented (1, 3, 5), some are gradually becoming standard operating procedure (2, 6, 9), and some need further attention.

Summary of Past Biennial Assessment Reports

Biennial assessment reports were submitted by the former DGP, Prof. Harald Ade, both in Spring 2009 and Spring 2011. The main focus of the outcomes-assessment in those reports was to recruit and enroll high quality students, to graduate students in a timely manner and well prepared for advanced careers in physics, to foster an environment of effective mentoring of students, and to promote faculty investment and participation in the management of the graduate program. Collected data for these assessments were the admissions statistics (number applied, admitted, and enrolled, total and domestic and international; percentage of admitted to applied and enrolled to admitted; GRE scores of domestic students), amount of fellowship funding for new students, number of students who participate in recruiting activities, time and success rate for US students to pass written exam, average time to submission of plan of work, time to preliminary exam, time to degree for each graduate faculty member, number of student publications for each graduate faculty member, and six and eight year graduation rates. Major findings from these data were as follows.

(1) Applications from international students were much higher than US.
(2) Yield for international students was about the same but climbed over 20% for US.
(3) Performance on GRE subject test climbed.
(4) The time to pass the written exam has decreased significantly and overall success rate has improved. (NB: the base was all students, not those students attempting the exam. Some of the students who did not "pass" actually did not fail the exam but left the program to pursue alternative activities/occupations ranging from music to pottery).

The 2011 report pointed out that the less-than-stellar ranking in the NRC report released in that year (which might have been based on faulty data) could only hurt the program. It mentioned its impact such as the unusually low yield of US students enrolling in that year, and suggested that ways to overcome the NRC report should be devised since there seemed overall an issue of data management and reporting.

The report concluded that we had implemented the recommendation of the external review to increase the applicant pool, to broaden the course offerings, to create an admission/recruiting committee, to use Fellowships to attract better students, to provide formal orientation and TA training, to shortened the time to get into research, to provide more opportunity for professional development, to communicate a consistent set of high expectations, to provide more consistency of the timing of the preliminary exam, and to assess our outcomes.

Summary of Current Biennial Assessment Report

We have recently updated our outcome statements as well as the data to be collected for the assessment. In particular, we have mandated the annual progress report to all students in our graduate program starting from Spring 2014. Graduate students who have not yet joined a research group were asked to report their activities to join a research group and list the faculty members and timeline to join a research group. Graduate students who have already joined a research group were asked to report their research activities and list papers published, in preparation, presentations, etc. These data appear to be useful in individual advising session for the students who have significant challenges and issues in making progress of their graduate works.

We have also revised the evaluation rubric for the preliminary exam as well as the final defense and started collecting data. This is in accordance with a recent update on the standard operating procedure for reviewing academic program assessment reports.
The updated procedure designates the provost, college deans, and department heads as accountable for the effectiveness of outcomes assessment in improving programs. We will collect the evaluation rubric from the forthcoming preliminary exams and final defenses and analyze the data for the upcoming reporting period.

As in the previous reporting period, we will continue to focus on the recruitment and enrollment of high quality students. Although the numbers of applicants, admitted students and enrolled students all increased compared to previous years, the GRE subject scores of the US PhD applicants, admitted students and enrolled students went down substantially. With the appointment of the new chairs for the recruitment committee and the admission committee, we anticipate an improvement in enrolling high quality students. We will not only exploit the use of signing bonuses and fellowships but also take advantage of the Provost Doctoral Recruiting Fellowships (PDRF) offered recently from the Provost’s office to recruit high quality students. Although the PDRF is just for the first year, it appears very attractive to the admitted students. Since we have already appointed six incoming students for PDRFs this year, we will monitor their progress and prepare for the upcoming reporting period.

Summary and Vision

We strive to capitalize on our strengths with well-defined goals and metrics for measuring its success. Although we are still developing an identity for our program and defining our strengths and values, one of our most important goals is to gear towards the success of our students. For this aim, we would like to educate students to get in-depth knowledge in some areas of physics but also have a broad knowledge across the discipline. In particular, we want our students to be problem solvers with innovative ideas, rapid learners with intellectual agility and effective communicators with professional skills.

As the current students in our program show a very large range of capabilities and performance as a consequence of the spread in the applicant pool, we would like to provide a nurturing environment for a diverse group of students and take the mentoring of students seriously. During their time in the program, students face many challenges both professionally and personally. We think a welcoming and helpful climate is crucial for overcoming these challenges successfully.

In every case, however, we would like to provide students a clear idea of a timetable and milestones for completion of their degree. We think that setting expectations as soon as possible can lead to success in the graduate program. For regular formal tracking of progress, we require all students to submit an annual progress report. These individual reports are discussed in the one-on-one individual advising session between the student and the DGP. We also streamline the process by implementing early completion of the Plan of Work and by assuring that the preliminary exam is scheduled and completed early.

We will encourage faculty to further develop courses in keeping with a strategic effort to broaden physics course offerings. We will also identify the students with an incomplete academic background as early as possible and advise them to take appropriate courses to ensure their success. For example, incoming students with a weak math background might take MA 501 and MA502, Advanced Mathematics for Engineers and Scientists I and II, respectively.

It is also very important to mentor and monitor student progress in timely manner. We shall have an explicit mentoring plan that helps students from a variety of backgrounds thrive in the graduate program. In particular, the students who have not yet joined a research group will need a definite mentoring protocol that our program will provide. For the students who have already joined a research group, we will work with the faculty advisor to put in place a mentoring program for them.

Finally, we need a strategic plan for recruiting the best quality students to our program. Although the recent development of the PDRF from the Provost's office is helpful for the recruitment, the number of offers in each year appears uncertain and the offer has been contingent upon going over the target number of Ph.D. students. We ask that a few PDRF be allocated annually so that we may advertise these fellowships broadly and separately from our regular recruiting activities through brochures, ads in Physics Today, etc. We may then ask each faculty member visiting an institution to see the undergraduate advisors there, discuss our fellowship program and leave suitable brochures and information. This advertisement can be complemented with invited visits of the undergraduate advisors who actually advice undergraduate students from a number of targeted programs. A workshop for undergraduate advisors on a suitable topic such as curriculum development might also be a good vehicle.

VII. Undergraduate Program

The NC State undergraduate physics program is dedicated to excellent teaching and the creation and application of knowledge. We promote an integrated approach to problem solving that transforms lives and provides leadership for economic and technological development across North Carolina and the world.

Program Description

Exact Title of Program: ***Physics***

Department Authorized to Offer Degree Program: ***Physics***

Titles of Degrees Granted: ***Bachelor of Science in Physics***
Bachelor of Arts in Physics
Minor in Physics

College: ***Sciences***

Program Objectives and Outcomes:

Objective: Physics BS students will acquire knowledge and competencies that prepare them for varied technical careers, or pre-college teaching, as well as graduate studies in physics or related fields of science and technology.

Outcomes: Physics BS graduates will…

a. be able to solve problems using the principles of classical mechanics, electrodynamics, thermal and statistical physics, and quantum mechanics, invoking general principles, applying specific mathematical techniques, making approximations, and judging validity of the results.
b. be able to apply appropriate mathematics and computer strategies required to solve physics problems, including demonstrating relevant programming skills.
c. be able to employ fundamental laboratory procedures in physics, and basic statistical principles of data analysis, such that they could successfully begin work at a commercial, government or university laboratory.
d. communicate effectively using formats and procedures appropriate for physics, such that they can effectively report their technical work to fellow scientists, co-workers and employers. In particular, students will be able to (a) Communicate in

the style of physics, on homework sets and laboratory reports; (b) Deliver coherent and intelligible oral and written reports on physics research.

Objective: The Physics BA graduate will have acquired knowledge and competencies that prepare her to succeed in fields that require technical knowledge and strong analytic skills.

Outcomes: The Physics BA graduate will…

a. be able to employ basic principles of classical mechanics, electrodynamics, thermal and statistical mechanics, and quantum mechanics at a level appropriate for success in industrial employment, in studies in related fields, and in precollege teaching. Students will, as appropriate, demonstrate skill in invoking general principles, applying specific mathematical techniques, making approximations, and judging validity of the results.
b. be able to use appropriate mathematical and computational tools to solve physics problems, including demonstrating relevant computer programming skills.
c. be able to employ fundamental laboratory procedures in physics, and basic statistical principles of data analysis, such that they could successfully begin work at a commercial, government or university laboratory.
d. communicate effectively using formats and procedures appropriate for physics, such that they can effectively report their technical work to fellow scientists, co-workers and employers. In particular, students will be able to (a) Communicate in the style of physics, on homework sets and laboratory reports; (b) Deliver coherent and intelligible oral and written reports on physics research.
e. demonstrate a broader knowledge of liberal arts, and of other technical fields, compared to the BS graduate.

Responsiveness to local and national needs

The national need to increase our workforce in the STEM disciplines has been apparent for some time. There is a need for more STEM expertise at the local level as well; the Raleigh and Research Triangle Park area is home to a large number of high-tech companies. Training for the next generation of STEM workers must take place at all levels, but is completed at the University level. The NCSU Physics Department helps to fill this need by preparing undergraduate students for careers in STEM fields, or for graduate studies in STEM disciplines. To raise the level of expertise in STEM fields, we must train new teachers. The NCSU Physics Department encourages students to enter the teaching profession through the PhysTec Learning Assistants program, and the Accelerated BS-Physics to MS-Teaching program.

Program Quality

The Department of Physics at NC State University has a long tradition of providing undergraduate students with a rigorous, traditional education meant to prepare them for top graduate schools. Direct comparisons of undergraduate physics programs are difficult to find, and of questionable merit. Nevertheless we have a good deal of indirect evidence to suggest that our undergraduate program is strong and vibrant.

The American Physical Society's Committee on Education named the NCSU Department of Physics as one of only four recipients of the 2015 Award for Improving Undergraduate Physics Education. This award recognizes physics departments that are committed to inclusive, high-quality physics education for all undergraduate students.

Our success is our students. In the past two years

- Five students have won NSF graduate fellowships (two in 2013, three in 2014)
- One student received the 2014-2015 Astronaut Scholarship
- Two students were named Goldwater Scholars (one in 2013, one in 2014)

Our current group of students includes 6 Park Scholars, 8 Goodnight Scholars, and 2 Caldwell Fellows. The Park and Goodnight Scholarships are the two most prestigious university-wide scholarships awarded to select incoming freshmen at NC State. The Caldwell Fellows program is a distinctive, merit-based award given to a select few current NC State students each year. One of our graduates, Christina Hammock (physics BS 2002), was named to NASA's astronaut class of 2013 and recently came back to inspire students at the Southeast Conference for Undergraduate Women in Physics (co-hosted by NC State).

One of the strengths of our program is our support for undergraduate research. Approximately 3/4 of our students have some experience with independent research before they graduate, and roughly 3 per year have co-authored a peer-reviewed paper based on their undergraduate research. One of our current students won the most recent Outstanding Undergraduate Presentation award at the Fall 2014 meeting of the Southeastern Section of the American Physical Society. Our physics undergraduates include one Leroy Apker award winner (Charles Brabec 1991) and three Apker award finalists (Michael Fulbright 1989, Michael Binger 2000, Adam Keith 2012).

Approximately half of our graduates continue their education in graduate school in physics or a related field. We currently have graduates attending some of the strongest graduate programs in the country, including

- Berkeley
- CalTech
- Colorado
- Cornell
- Chicago
- Harvard
- Illinois
- MIT
- Ohio State
- Stanford

By all accounts these students are thriving. Many of our former students have told us that their undergraduate education at NC State prepared them very well for graduate school.

The undergraduate physics program at NC State is important to the faculty. We take pride in our undergraduates. This attitude is part of the culture within the department, developed over many years. Our students like being part of the NC State physics community. They are comfortable with the faculty and enjoy working and socializing with each other.

Administration

The Director of Undergraduate Programs (David Brown) serves as the coordinator for student advising, oversees the physics curriculum, supervises programs within the curriculum (honors, scholarships, undergraduate research, etc.), monitors degree requirements, and maintains connections with the undergraduate administration in the College and the University.

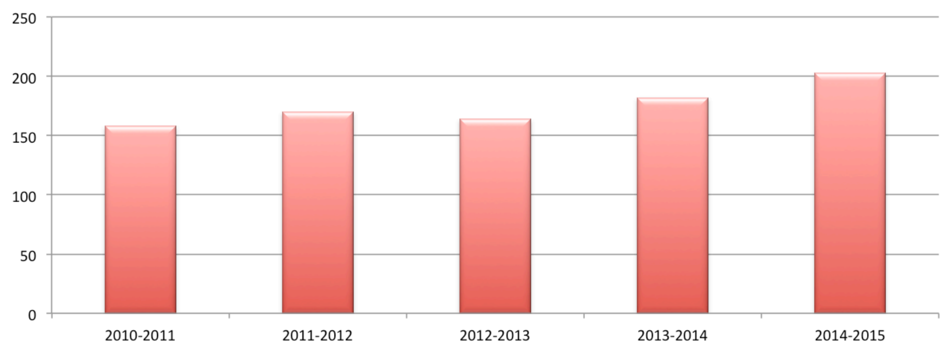
A professional advisor (Betsy Alexieff) is shared with the Department of Mathematics. She serves as the freshman advisor and advises many of the physics majors who are planning to transfer out of physics. Ten faculty members serve as undergraduate advisors. Typically, students are assigned to a faculty advisor after their first semester and continue with that same faculty advisor until they graduate.

Karen Daniels serves as the Coordinator for Undergraduate Research. Chris Gould serves as the advisor to our chapter of the Society of Physics Students.

Students

Enrollment

The numbers of students enrolled in our BS or BA programs as of census date, about 10 days into the Fall semester, are shown below.



We currently (January 2015) have 207 active undergraduates in our programs, including 10 designated as black, 2 as Hispanic, and 16 as multiracial. Of these 207 current students, 51 have a second (or third) major in addition to physics. Of these, 26 have their second major in mathematics or applied math. The breakdown by gender and degree for current students is shown in the table below. Note that almost all students enter the BS program, with a few switching to the BA in their junior or senior year.

	Total	BS	BA
Total	207	199	8
Female	31	28	3
Male	176	171	5

Quality of Incoming Students

Students come into the physics program in one of three ways, as (1) freshmen, (2) external transfer students, and (3) internal transfer students. The University Admissions office controls the freshman and external transfers, whereas internal transfers are determined at the departmental level by the Director of Undergraduate Programs. As a general rule the Admissions office makes their decisions without any input from the Physics Department or the College of Sciences, although they do follow guidelines established in consultation with the College.

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Freshmen Applicants	129	115	149	138	170
Transfer Applicants	17	32	32	36	30
Selectivity	62.3%	59.9%	49.2%	62.1%	62.5%
Yield	48.4%	52.3%	42.7%	44.4%	46.4%

Our incoming freshmen have strong high school records. The average high school GPA (4.6) and SAT scores (676 math; 641 verbal) for freshmen who entered the physics program in 2014 where all higher than freshmen (in all majors) who entered the university in 2014 (GPA of 4.45; 636 SAT-math; 604 SAT-verbal). In spite of their strong credentials, we find a very wide discrepancy in ability among our incoming freshmen. The best students are truly outstanding; at the opposite end of the spectrum are students who lack either the aptitude or the discipline (or both) to succeed in physics. Many of these students are quite bright, and more than capable of earning a University degree. They simply lack the specific skill set needed to succeed in physics. We encourage these students to transfer to another major where they can be more successful.

The majority of external transfer students come from the North Carolina Community College system. Some of these students are good---in many cases they chose to begin their college career at a Community College to save money, or to stay close to home. Other students attend community college because their high school records were not sufficiently strong to allow them admission into a larger university like NCSU. The Admissions office evaluates transfer students solely on the basis of their college/university records; they do not consider the students' high school records or SAT scores. Although the number of external transfer students is small, and meaningful statistics are lacking, the success rate for external transfer students is low. In many cases these students find the jump from community college classes to our physics majors' classes to be too high. We have recently discussed this problem with the

Admissions office, and they have agreed to raise the criteria for admission for external transfer students.

Internal transfer students come to the physics department from another major within the university. This group includes students who want to add physics as a second major. We generally require these students to satisfy two conditions before they are accepted into physics. First, they should have a 3.0 or better GPA in all physics courses (at the 200 level and above) and math courses (calculus I and above). Second, they should enroll in a physics major's course (PY201, 202, 203, or 411, depending on their background) and pass with a B- or better. These criteria were developed through years of collective experience by the physics undergraduate directors. The B- cutoff is supported by our data, which show that historically, very few students who make a grade of C+ or lower in PY201 succeeded in completing a physics degree. Most of our internal transfer students do well in our program.

Quality of Ongoing Students

At all levels, from freshmen to seniors, we see a wide discrepancy in the abilities among our students. We have a large number of excellent students, and an equally large number of weak ones. We make a conscious effort to identify the weaker students early on, beginning with our first physics majors' course PY201, and help them find a more suitable major within the university. In spite of those efforts, we continue to uncover students who have survived the program up to a point, but finally hit a wall in one or more of the upper level classes. These students are particularly difficult to advise, since they often feel they have invested too much time in the physics program to change majors. In between the extremes, we have many students who work their way through the physics program with a B average in the majors' courses. These students are bright, hard working, are well deserving of a physics BS or BA degree.

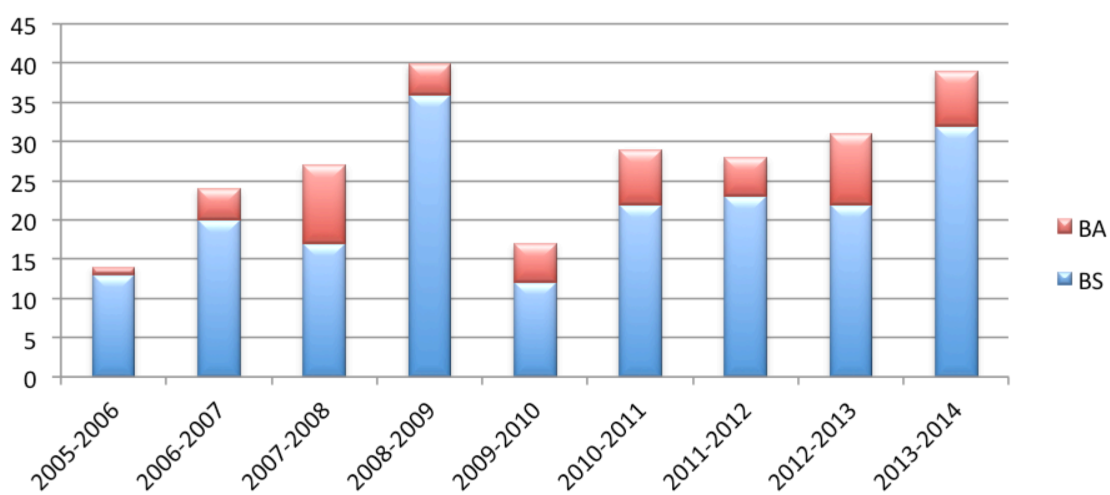
The population of undergraduate physics majors is in constant flux. Historically, the number of students who graduate each year is about the same as the number of students who come into the program. However, less than half of the graduates enter the program as freshmen.

The large flux of students is not a problem, in itself. To a large extent, it is a reflection of the fact that many bright 17 and 18 year-olds do not yet know what they want to do with their education and carriers. However, our concern is that the flux is not steady; there appears to be a net influx during the freshmen and sophomore years. The net outflow occurs later, with too many students giving up on their college career and not completing a degree in any major. One indication that the flux is out of balance is the enrollment in PY411 (Mechanics I, taken in Spring of the sophomore year) and PY414 (Elecrodynamics I, taken in Fall of the junior year). These courses often contain as many as 60 students. If we eliminate the few non-physics majors and the majors who are taking the course for a second time, the numbers drop to about 50. This is still well above the average number of students who graduate with a physics degree.

We make a conscious effort to identify the at-risk students. We intentionally make the introductory majors' courses PY201 and PY202 (University Physics I and II) very demanding. We are up front with our students, and let them know early on if they would be better off in another major. We are hopeful that our new professional advisor Betsy Alexieff (shared with mathematics) will help on this front. Our current practice is to assign Ms. Alexieff as the advisor for incoming freshmen. After their first semester, those who do well in PY201 are moved to a physics faculty advisor. Those who have difficulty with PY201 remain with Ms. Alexieff. These students are actively encouraged to develop a “plan B” and to begin considering other majors.

Degrees Granted

The total number of bachelor degrees granted in physics has doubled in the past 15 years, and appears to be on track to stay above 30 for the next few years.



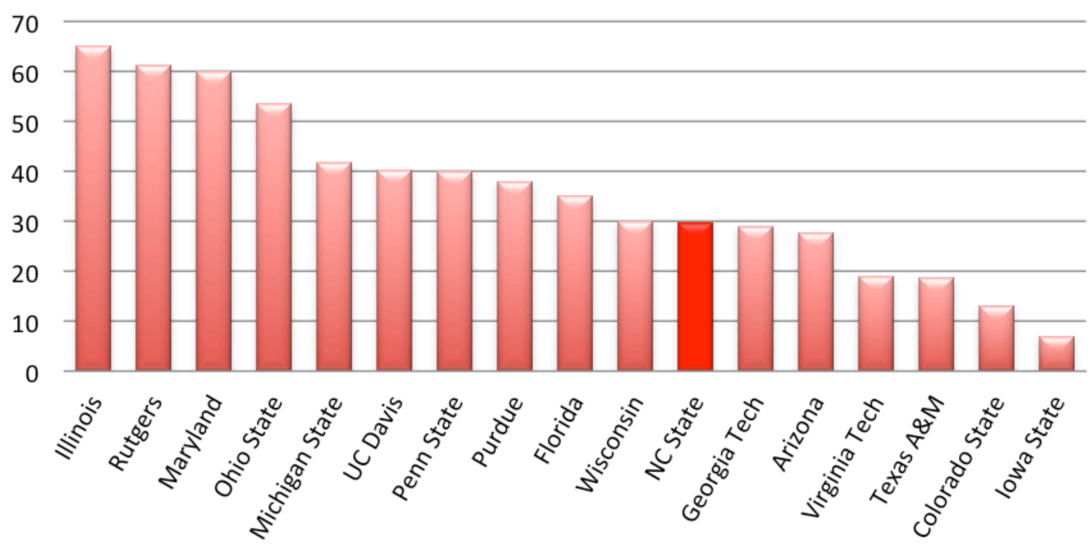
The table below separates the students who entered the physics program as freshmen, external transfers, and internal transfers in a given calendar year. The table gives the number of students who completed a degree in physics, the number who completed a degree in another field (but not in physics), and the number who did not complete any degree at NC State. Note, prior to 2009 the data for internal transfers did not include students who added physics as a second major.

	Freshmen			External Transfers			Internal Transfers		
	Physics	Other	None	Physics	Other	None	Physics	Other	None
2004	8 (35%)	9 (39%)	6 (26%)	3 (43%)	1 (14%)	3 (43%)	6 (100%)	0 (0%)	0 (0%)
2005	15 (50%)	6 (20%)	9 (30%)	1 (20%)	2 (40%)	2 (40%)	6 (100%)	0 (0%)	0 (0%)
2006	10 (48%)	4 (19%)	7 (33%)	6 (55%)	1 (9%)	4 (36%)	3 (43%)	1 (14%)	3 (43%)
2007	12 (33%)	11 (31%)	13 (36%)	2 (67%)	1 (33%)	0 (0%)	7 (87%)	1 (13%)	0 (0%)
2008	13 (48%)	5 (19%)	9 (33%)	0 (0%)	2 (29%)	3 (71%)	3 (60%)	2 (40%)	0 (0%)
2009	16 (47%)	6 (18%)	12 (35%)	7 (54%)	2 (15%)	4 (31%)	23 (68%)	8 (24%)	3 (9%)

These data show that typically less than 50% of our incoming freshmen complete a physics degree. They also show that the freshmen who do not complete a physics degree are replaced by roughly equal numbers of internal and external transfer students. For example, of the 36 freshmen who entered the program in 2009, 18 did not complete a physics degree. That same year, there were 7 external and 23 internal transfer students who would go on to complete a physics degree. (Of course, the students who entered in 2009 and completed a physics degree did not all graduate at the same time.)

We do not have a clear explanation for the low graduation rates, but suspect that the following situation is a contributing factor: Many technical/mathematical minded students find our program attractive, due to its relatively small size compared to engineering. They like the personal attention we are able to provide, and the comradery with their peers. Students are reluctant to leave the program, even when they are struggling in the physics majors' classes. Many of these students wait too long, until their junior or senior year, to recognize that they might not be able to complete a physics degree. It can be too late for them to change majors, for several reasons. First, a late change of majors can mean the student will require an extra semester or year to graduate; this is not economically realistic for many of our students. Second, these students have an established track-record of weak grades, at least in their physics courses, and other departments on campus refuse to allow them to transfer. This is part of a campus-wide problem at NC State. Students are in good standing with the university as long as their overall GPA is 2.0 or above. Yet, most departments on campus will refuse to accept an internal transfer student into one of their programs unless the student has a GPA closer to 3.0.

Relative to our peers, we award a moderate number of bachelor degrees in physics. If all students taking our mechanics course (PY 411) went on to get a bachelor degree in physics we would be near the top of our peers in degrees awarded.



Average # of Bachelor degrees in physics for past three years as reported by AIP.

Need/Placement

Central North Carolina has a dense population of high tech companies that provide many employment opportunities for physics degree recipients. The AIP list of nearby companies that have hired physics bachelors recipients include Cisco, Cree, IBM, Lord Corp. and others. Unfortunately, we have no systematic way of knowing where most of our graduates find employment. For those students who don't go on to graduate school, most wait until after graduation to begin a serious job search. Some recent graduates have found employment at a variety of companies, working in engineering, software development, and other STEM disciplines: Sumitomo, Farragut Systems, Sensus, Red

Hat, WebAssign. From the little information we have, employers seem quite happy with our graduates. For example, Farragut (a software development company) hired one of our graduates several years ago. They recently contacted the department to tell us how pleased they have been with their new employee. They asked us to encourage our future graduates to consider working for Farragut.

Over the past two years the physics department has worked closely with the University's Career Development Center. Each semester we organize a workshop for physics majors where we invite a member of the Career Development Center to discuss employment opportunities, job search strategies, etc. We encourage our students to work with the counselors at the Career Development Center and to attend both the College of Sciences and College of Engineering Career Fairs.

Curriculum/Instruction

Degree Requirements

Students working toward the **Physics BS** degree begin with four introductory physics courses:

- PY201, University Physics I (mechanics, with lab)
- PY202, University Physics II (electricity and magnetism, with lab)
- PY203, University Physics III (modern physics, with lab)
- PY252, Instrumental and Data Analysis (basic laboratory skills)

Note that these courses are separate from the service courses (e.g., calculus-based physics for engineers). This allows us to cover more material, and at a deeper level, in the introductory level physics majors' courses. After this sequence, students progress to higher level physics courses:

- PY411/412, Mechanics I/Mechanics II
- PY414/415, Electrodynamics I/Electrodynamics II
- PY401/402, Quantum Physics I/Quantum Physics II
- PY413, Thermal Physics
- PY452, Advanced Physics Laboratory

The required physics courses total 38 semester credit hours. The math courses required for the Physics BS degree consist of

- Calculus I, Calculus II, Calculus III
- Differential Equations I, Differential Equations II
- Linear Algebra

for a total of 21 credit hours. Physics BS students have two computing requirements:

- Introduction to Programming
- Computing and Numerical Methods

that can be fulfilled with a variety of courses. The remaining requirements for the Physics BS include:

- Chemistry with laboratory
- One basic science elective
- Three technical electives
- Statistics

along with 37 credit hours of English, humanities, social sciences, physical education, and free electives. The complete degree plan requires 120 credit hours.

The **Physics BA** degree differs from the BS degree in that the students are not required to take PY412 (Mechanics II), PY415 (Electrodynamics II), PY402 (Quantum Physics II), and Differential Equations II. In place of these requirements, the students must take 6 more credit hours of social sciences and humanities, 3 more hours of technical electives, and 3 more hours of free electives.

When a student is admitted into physics by the University Admissions office, either as an incoming freshmen or as an external transfer student, he/she is always placed into the BS degree plan. Students are free to change from the BS to the BA at any time after admission. Internal transfer students are accepted into physics at the discretion of the Director of Undergraduate programs, and can be placed in either the BS or BA degree plans. Most students prefer the BS degree plan, and it is the recommended degree plan for students who hope to attend graduate school in physics. The BA plan is intended for students who seek a background and training in a core science discipline, but do not plan to pursue a scientific career. (For example, students who plan to go to Law school or Medical school.) Most of our BA graduates are students who have changed from the BS plan to the BA plan because the upper level physics courses have become too challenging. They need a degree plan with fewer high level technical courses.

Experimental Physics Classes

The BS and BA curricula require two stand-alone classes in experimental physics in addition to the labs that accompany the three introductory level physics courses. The first of these courses, PY252 (Instrumental and Data Analysis) introduces students to basic laboratory skills and helps prepare them for independent research and for the Advanced Physics Lab. Most students take PY252 in their sophomore year. The second stand-alone experimental class is PY452 (Advanced Physics Laboratory), taken in the senior year. Students in PY452 complete several open-ended projects over the course of the semester, supervised by one or more physics faculty members. This course gives students valuable experience with written and oral communication.

Many of the higher—level courses that traditionally focus on theory, including Thermal Physics, Mechanics, and Electrodynamics, incorporate experimental exercises as part of the coursework. This is done through the Education and Research Laboratory (EaRL). EaRL is a 1600 square foot facility shared between classroom education and research. It contains two clean room spaces, four chemical hoods, and several pieces of cutting-edge research-grade equipment including a high quality atomic force microscope, absorption and emission spectroscopy, and fluorescence microscopy. So far, EaRL has been used to add an experimental, hands-on experience in the following upper-level physics courses:

- PY413 (Thermal Physics). Students measure the output of two different light-emitting diodes and model this behavior with a Boltzmann distribution. Students also investigate the tensile properties of rubber.
- PY411 (Mechanics I). Students measure the resonance frequency of several atomic force microscope tips (thin strip cantilevers driven at one end) with different stiffness using the Asylum AFM. They then modeled this effect.
- PY301 (Introduction to Quantum Mechanics). Students use absorption spectroscopy of dyes in solution to show that energy levels become more closely spaced as the molecule size increases. This is modeled as a particle in a box.
- PY415 (Electrodynamics II). Students study the frequency dependence of the dielectric constant. Students also work with the scanning tunneling microscope to visualize copper atoms.
- PY506 (Nuclear and Subatomic Physics). Students use a germanium detector to carbon date Brazil nuts.
- Experiments are under development for PY552 (Introduction to the Structure of Solids) and PY519 (Biological Physics)

Computational Physics Classes

The physics curricula require two courses in computational science. The “Introduction to Programming” requirement is satisfied by any one of several courses taught in the computer science and mathematics departments, including Java and Fortran. This requirement is also satisfied by our own python-based course PY251 (Introduction to Scientific Computation). The emphasis in PY251 is less on the details of the programming language, and more on the techniques used to solve scientific problems with computers. We feel that PY251 is a much better choice for physics majors, and encourage them to fulfill the “Introduction to Programming” requirement by taking PY251. However, due to the large number of our students who double major with engineering and mathematics, we do not require PY251 and allow other computer science and math courses to fulfill the “Introduction to Programming” requirement.

The higher level computational requirement is “Computing and Numerical Methods”. It can be fulfilled by one of several courses taught in the mathematics department, or by the physics department's beginning graduate level course PY525 (Computational Physics).

Knowing that students have had some exposure to computational methods, instructors for the upper-level physics courses, such as PY411/412 (Mechanics) and PY414/415 (Electrodynamics), often assign homework problems and/or projects that require numerical programming.

Elective Classes

The physics department offers on a regular basis a number of courses that are not required for physics majors, but are often taken by physics majors. These include:

- PY301 – Introduction to Quantum Mechanics
- PY328 – Stellar and Galactic Astrophysics
- PY341 – Relativity, Gravitation and Cosmology
- PY506 – Nuclear and Subatomic Physics
- PY507 – Elementary Particle Physics
- PY509 – General Relativity
- PY516 – Physical Optics
- PY519 – Biological Physics
- PY525 – Computational Physics
- PY543 – Astrophysics
- PY552 – Solid State

PY301 (Introduction to Quantum Mechanics) is intended to form a “bridge” between the modern physics course PY203 and the Quantum Physics sequence PY401/402. For many of our students, PY203 along with the differential equations courses provide adequate preparation for PY401/402. For others, it does not. In the past we have found that too many of our majors struggle with PY401/402. PY301 was created relatively recently to provide the extra preparation that these students need to succeed in PY401/402. Students who opt to take PY301 can use this course as a free or technical elective.

Outside the classroom

Society of Physics Students

Our chapter of SPS has a long history of engaging physics majors outside of the classroom. They host regular (usually bi-weekly) meetings that include topics like “how to get into grad school” and “how to get into research” as well as more social activities like game nights, bad physics movie nights and making liquid nitrogen ice cream. They host regular events like lunch with a professor, picnics, and an occasional star-gazing camping trip. Annual SPS events include college welcome week activities, a research speed-dating event, and an alumni dinner where alumni (usually from industry) come back to campus to talk to the students about life after a physics degree. Some unique SPS activities have included participating in the 24-hour grand opening of the Nature Research Center in downtown Raleigh, and a recent tour of Goddard Space Flight Center at the invitation of John Mather.

Undergraduate Research

The NC State Department of Physics has a long tradition of involving undergraduate students in meaningful research. Approximately 3/4 of our graduating seniors have had some independent research experience. Most of these experiences are with professors in the physics department; some are with professors in other departments such as mathematics, nuclear engineering, mechanical engineering, etc; some are external to the university. The department values undergraduate research and many of the faculty make it a priority to include undergraduates in their research efforts.

In the past, the students have had no systematic way of connecting with a faculty member for research. We would encourage students to become familiar with the department's research by viewing the faculty research web sites, and talking to fellow students. They were then welcomed to talk to professors about their work and available projects. This informal approach has the advantage of encouraging students to be proactive, and to interact and communicate with the faculty. The disadvantage is that the less outgoing students might miss the opportunity for research during their undergraduate careers.

We have recently created a web-based form that allows students to express their interest in research. We quickly received 30 responses from students who were interested in research. Some of these had already been involved in research, but many had not. We will circulate the results of this survey among the faculty with the hope of connecting more students with a research mentor.

Our coordinator for undergraduate research, Prof. Karen Daniels, has recently developed a First Year Physics Internship program for incoming freshmen. This program provides freshmen from physics and related disciplines with a real research experience, working with a physics faculty member. The goal is to provide early inspiration and motivation for students. The program seeks to attract students who have a strong science aptitude but are undecided in their major. It also seeks to attract women and minority students who might benefit from a broader exposure, beyond the classroom, to the people and activities in the physics department.

The quality of research by our undergraduates is high. We have had one Apker award winner, three Apker award finalists and at least 6 Goldwater Scholars. On average, about 15 out of 120 of the University's Undergraduate Research Awards go to physics students each year. Peer-reviewed publications co-authored by undergraduate physics majors in recent years include:

- Topographic measurement of buried thin-film interfaces using a grazing resonance soft x-ray scattering technique (2014) *Physical Review B*
- Pion momentum distributions in the nucleon in chiral effective field theory (2013) *Physical Review D*
- X-ray emission from strongly asymmetric circumstellar material in the remnant of Kepler's supernova (2013) *Astrophysical Journal*
- Chromatin modification mapping in nanochannels (2013) *Biomicrofluidics*
- Electrochemical detection of DNA at nanoelectrodes in nanochannels (2013) *Nano Life*
- Unifying the zoo of jet-driven stellar explosions (2012) *Astrophysical Journal*
- Fluctuation modes of nanoconfined DNA (2012) *Journal of Applied Physics*
- Blending with non-responsive polymers to incorporate nanoparticles into shape memory materials (2012) *Macromolecular Chemistry and Physics*
- Thermal fluctuations and nanoscale effects in the nucleation of carbonaceous dust grains (2011) *Monthly Notices of the Royal Astronomical Society*

- X-ray flares from propagation instabilitites in long gamma-ray burst jets (2011) *Monthly Notices of the Royal Astronomical Society*
- Embedded metal nanoparticles as localized heat sources (2011) *Polymer*
- Molecular Miscibility of Polymer-Fullerene Blends (2010) *J. Physical Chemistry Let*
- Revisiting the flip-flop instability of Hoyle-Lyttleton accretion (2010) *Astrophysical Journal*
- Mixing and segregation rates in sheared granular materials (2009) *Physical Review E*

Outreach

Our Society of Physics Students has a tradition of working with local public schools to help promote science awareness and literacy. For example, each year the SPS coordinates with Washington Elementary School in Raleigh to create "Family Math and Science Night". Our students borrow lecture demonstrations and telescopes from the department and spend the evening giving elementary school students a fun, hands-on experience with physics. They do outreach activities at other Wake County Schools, but this often depends on the class schedules of a few dedicated students (the WES event is in the evening and always draws a crowd of SPS students). SPS is also called upon to help with the department's Astronomy Open House, Astronomy Night, Astronomy Days at the NC Museum of Natural History, and many other one-time and annual events.

Program Assessment

In accordance with University policy, the physics department carries out assessment activities each year. The goal is to determine how well our programs meet our program objectives and outcomes, and to identify changes or modifications to the curriculum that can help us meet the objectives and outcomes. These formal assessments have led to several significant changes to the undergraduate curriculum. Other changes have grown from informal assessment processes, such as graduating senior exit interviews and faculty discussions. Each semester, the undergraduate advisors and the physics majors' instructors meet to discuss students' progress and improvements to the curriculum.

2008 – 2011

Traditionally, many of our students have struggled with the Quantum Physics sequence PY401/402. One of the root causes of this difficulty was a lack of skill in linear algebra; this subject was not required for physics majors prior to 2009. We were able to identify this deficiency by comparing PY401 grades between students who had and had not taken linear algebra, using PY411 (Mechanics I) as a control. The results supported our expectation that a formal course in linear algebra is significantly helpful for quantum mechanics. We added linear algebra as a degree requirement (for both the BS and BA degrees) in 2009.

The abstract character of quantum mechanics presents a barrier that is difficult for some students to overcome. In 2010 we created a “quantum pretest,” given to all PY majors who planned to take PY401 in the following year. The pretest was designed to check the students' readiness for PY401 with basic quantum problems like the square well potential. The problems were taken from the PY203 curriculum, and the students were given example problems well in advance of the pretest. Most of our students did well, but some did not. The at-risk students were channeled into a new course, PY301 (Introduction to Quantum Mechanics). This course was designed to form a bridge between PY203 and PY401, to help strengthen the preparation of the at-risk students. Using PY203 scores as a control, our assessments showed that the at-risk students who took PY301 were more successful in PY401 than those who did not take PY301. We continued the practice of giving the quantum pretest for several years, through 2012. We currently use advisors' recommendations and self-identification to channel students into PY301.

In the past, many of our students would do reasonably well in the mechanics sequence PY411/412 and the electrodynamics sequence PY414/415, then struggle to pass quantum physics PY401. This was particularly distressing because our students would not hit this barrier until Fall of their senior year. By that time, they felt it was too late to change majors. To help alleviate this problem we moved the PY401/PY402 sequence up one semester. Now, instead of waiting until their senior year to take PY401, the students typically take PY401 in the Spring of their junior year. This is followed by PY402 in the Fall of their senior year. This change, giving students earlier exposure to quantum mechanics, also helps those students who take the GRE physics exam in the Fall of their senior year.

Another difficult hurdle for many students is the jump from the 200 level, introductory physics courses to the 400 level advanced courses. We formerly scheduled PY411 (Mechanics I) and PY414 (Electrodynamics I) for Fall of the junior year, which was very difficult combination for some students. We have now shifted the Mechanics sequence up one semester, placing PY411 in the Spring of the sophomore year. This spreads out the transition from the 200 to the 400 level courses; we feel this is helpful for many students. The schedule change has another benefit: Students who lack the aptitude or drive to succeed in the advanced--level courses will find out earlier that physics is not for them. With early identification, these students have an easier time changing majors and completing a degree in another discipline.

2011 – 2012

To address the objective "graduates will have learned to communicate in the style of physics, on homework sets and laboratory reports," we instituted a uniform "homework communication rubric" across all physics majors' classes. This rubric emphasizes the importance of effective communication in technical subjects. It provides practical advise for creating homework solutions with a complete and clear chain of reasoning, such that a fellow student could easily follow. Each homework set is given a communication grade, separate from the content grade. We have found the rubric to be effective in helping the students create homework sets that are clear and well organized. Our assessment during 2011-2012 showed:

- PY202 (University Physics II): The communication grades were uniformly high. In part, this might have been due to the grader not fully understanding of the rubric. Inspection of some homework sets showed that, for the most part, students were following the rubric.
- PY411 (Mechanics I): The communication score for the first assignment was 88%, but the remainder averaged 93%. The initial lower grade might have been an adjustment to a new grader.
- PY413 (Thermal Physics): Communication grades averaged over 90%. The professor reviewed some of the graded homework and felt comfortable with the grading scale.
- PY414 (Electrodynamics I): The overall average was 81%.
- PY401/402 (Quantum Physics): The average communication score was 80% in PY401, and rose to 99% in PY402. While some improvement is expected, the very high grades in PY402 might have been a reflection of the grader as much as the students.

Overall, we feel that the homework rubric is working well, and continue to use it in all physics majors' courses. In addition to the quantitative evidence above, we have anecdotal evidence from graduating senior exit interviews that the homework rubric has had a positive impact. We feel that one of the strengths of the communication rubric is that it is universal, applied across all physics classes for all four years. This consistency gives strong reinforcement to the importance of communication quality, and emphasizes the unity of physics across individual courses.

To address the objective “Physics graduates will have gained a familiarity with fundamental laboratory procedures in physics, and with basic statistical principles of data analysis, such that they could successfully begin work at a commercial, government or university laboratory,” we expanded the experimental coursework required of majors. For many years our senior course PY452 (Advanced Physics Laboratory) provided the students' only formal exposure to experimental physics beyond the labs associated with the introductory sequence (PY201/202/203). Department members uniformly felt that students would benefit from earlier exposure to the techniques and principles of experimental physics. The sophomore level course PY252 (Instrumental and Data Analysis) was created as a required course for both BS and BA degrees. This course provides exposure to standard laboratory equipment and basic data analysis. These introductory skills no longer need to be taught in PY452, allowing the students to jump right in to meaningful and challenging experiments in PY452. PY252 has another important benefit: it helps prepare students for independent research in an experimental physics lab.

PY252 is typically taken in the sophomore year, often the first semester, while PY452 is typically taken in the senior year, often in the last semester. Students experience a long gap between exposure to experimental physics while they focus on the theoretical treatments of classical mechanics, electrodynamics, thermal physics, and quantum mechanics. We have taken steps to correct this imbalance by creating experimental projects and assignments to accompany many of the upper—level physics courses. Most of these assignments take place in the Education and Research Laboratory (EaRL). EaRL is a 1600 square foot facility shared between classroom education and research. It contains two clean room spaces, four chemical hoods, and several pieces of cutting-edge research-grade equipment including a high quality atomic force microscope, absorption and emission spectroscopy, and fluorescence microscopy. So far, EaRL has been used to add an experimental, hands-on experience in PY301 (Introduction to Quantum Mechanics), PY411 (Mechanics I), PY413 (Thermal Physics), PY415 (Electrodynamics II) and PY506 (Nuclear and Subatomic Physics). Experiments are under development for PY552 (Introduction to the Structure of Solids) and PY519 (Biological Physics)

The objective “Physics graduates will have learned to adequately program computers to address numerical physics problems” is covered, in part, by the “Introduction to Programming” degree requirement. Until recently, this requirement could only be met by one of several courses in the computer science department (java, C++, FORTRAN), or a matlab--based course from the mathematics department. Our informal discussions with students, as well as more formal graduating senior exit interviews, showed that these courses were not providing our students with the computer skills that were most valued in physics. In response, we have created our own course PY251 (Introduction to Scientific Computing) that satisfies the "Introduction to Programming" requirement. PY251 uses python as its official language, but its emphasis is on the methods and algorithms used in scientific computing.

In many of our advanced physics courses, such as PY411/412 (Mechanics) and PY414/415 (Electrodynamics), students are assigned homework problems or projects that require computational skills. Traditionally, our students have struggled with these assignments. In a future assessment, we will look for correlations between students who have had PY251 and success with computing assignments in the upper level courses. This should help us identify possible deficiencies in our current lessons and choices of topics for PY251.

PY251 also addresses the objective "Physics graduates will have gained a familiarity with the formats and procedures of communication in science, such that they can effectively report their technical work to fellow scientists, coworkers and employers." The first lesson in PY251 is an introduction to LaTeX. Throughout the semester, the students are expected to use LaTeX for their homework assignments. This requirement is counted as part of the homework communication grade.

2012 – 2013

Seniors in this academic year were the last cohort to take PY452 (Advanced Physics Laboratory) without having taken PY252 (Instrumental and Data Analysis). To judge the impact of PY252, we modified our normal assessment of PY452 to include specific attention to the laboratory skills outlined in the objective "Physics graduates will have gained a familiarity with fundamental laboratory procedures in physics, and with basic statistical principles of data analysis, such that they could successfully begin work at a commercial, government or university laboratory." Our assessment of this year's class serves as a baseline for future assessments of the PY252/PY452 sequence. The assessment for this year consisted of two components. First, the judgment and perception of the instructor, Dr. Dan Dougherty, of the students' progress and skills. Second, students in teams of two present a description of their final projects in a symposium at the end of the semester which is regularly attended by several faculty not associated with the course. Those faculty filled out a survey for each pair of students, including questions specifically targeted for the program objectives.

It was Dr. Dougherty's judgment that this year's students were all competent in the basic use of test and measurement equipment. He felt that they had gained enough experience to feel comfortable with future lab work. Dr. Dougherty felt that this class was highly motivated and, with only one exception, assigned final grades of A- or better. He also felt that the final presentations went well; this opinion was echoed by the other faculty in attendance. On the critical survey questions “The student presents evidence that she/he can employ fundamental lab procedures”, and “The student presents evidence that she/he can employ basic statistical principles of data analysis”, the average responses ranged from 3.0 to 4.4 on a scale from 1 (strongly disagree) to 5 (strongly agree). Finally, the yes/no question “In your opinion, does the performance on this presentation suggest that the student could successfully begin work in a commercial, government, or university laboratory?” yielded very positive results, with only 2 out of 45 “no” responses.

This group of students did well in PY452, in spite of the fact that they had not taken PY252. Dr. Dougherty has been a significant factor in these students' success. His course is well organized with clear expectations. The students feel supported. What we hope to see in future assessments is that our students, who will have had PY252 before taking PY452, can achieve this same high level of success without spending significant course time on basic lab skills. We expect these future PY452 students to be ready to dive into more advanced projects, to complete more elaborate experiments, and to develop more detailed analyses.

2013 – 2014

During this academic year we focused on the outcome “physics graduates will have learned to: Solve problems in a wide range of areas of physics, including invoking general principles, applying specific mathematical techniques, making approximations, and judging validity of the results.” We examined individual scores on final exam problems throughout the PY major: Freshmen courses PY201 (Introductory Physics I) and PY202 (Introductory Physics II), sophomore courses PY411 (Mechanics I) and PY413 (Thermal Physics), and junior/senior courses PY415 (Electrodynamics II) and PY401 (Quantum Physics I). We placed each problem into one or more broad categories: (1) simple recall; (2) basic understanding of principles; (3) application of standard algorithms; and (4) application of principles to novel situations. We found that the averages for problems within these categories were 86%, 76%, 69%, and 66%, respectively. These results support our expectation that the categories represent increasing difficulty. It is too early to draw any overarching conclusions from this assessment. We plan to repeat the assessment each year, and expect our definition of “problem categories” to evolve. We are considering adding a fifth category for mathematically demanding problems.

The discussions that have taken place have already resulted in the instructors' becoming more conscious of the character of the problems we ask our students to solve. This greater awareness is helping us to better align our exam problems with our curriculum objectives, and has already influenced our choice of exam problems for the 2014 – 2015 academic year.

Summary and Vision

We have long felt that our undergraduate program is strong and vibrant. We have made many incremental improvements to the program over the recent years, and we hope to continue to move in a positive direction.

The main difficulty that we face is helping our freshmen and external transfer students position themselves to be successful at NC State. These are the students sent to us by the Admissions Office. Too many of these students find that physics is not a suitable major, but have difficulty finding an alternative. Many of these students are quite bright, among the best prospects in the university. Some avoid leaving physics because we provide a welcoming and nurturing environment. Some are unable to leave physics because a change would postpone their graduation too much. Consequently, they don't graduate at all. Some are unable to leave physics because departments around campus routinely set the criteria very high for internal transfer. Currently, our 6-year graduation rate (the percentage of incoming physics freshmen who graduate from the University within 6 years in any major) is low, in spite of the fact that our incoming freshmen have some of the best high school credentials in the university.

Physics is not a subject with a built-in job market for BS and BA graduates. Most of our students have little knowledge of the career opportunities that lie ahead. It is an important goal for the department to help educate our students about careers in physics. We are currently working with the Career Development Center to provide career advice to our students through workshops, counseling and career fairs. We hope to improve in this area by building closer ties to nearby alumni in industry. We would like to establish a series of regular informal talks, aimed at undergraduates, from physicists working in industry.

One of the common complaints from the instructors of the advanced (400-level) physics courses is that many of the students do not maintain the math skills that they learn from calculus and differential equations courses. We have discussed the possibility of creating a “mathematical physics” course to help reinforce the key math skills that physicists need. An alternative is to create sets of review modules that can be used at the beginning of a physics course, to help bring students back up to speed with their math skills. For example, students whose linear algebra skills have slipped could work through a targeted lesson on that subject at the beginning of PY401 (Quantum Physics I). We have discussed the possibility of developing such lessons in collaboration with the math department.

Diversity is an issue in our department, as it is in physics departments across the nation. Our current undergraduate population is about 15% female, less than the national average of about 20%. In recent years as few as 10% of our undergraduates have been female. We do not believe this is a retention problem; rather, the low numbers appear from the beginning, with few female applicants, few female admits, and few female enrollees. Nevertheless, we know from anecdotal evidence that some of our female students feel intimidated by their male peers. In particular, the undergraduate student lounge is sometimes a “male centric” environment that can be unwelcoming to female students. During the past year we have remodeled the student lounge, created a set of “house rules” of behavior, and created a separate, quiet study area for undergraduates. We have also discussed these issues with the student SPS leaders. The environment appears to have improved; however this will be an ongoing issue as students flow though the program. We will need to be especially vigilant if our female population remains low.

There are only 10 black students in our department, 5% of the total population. Including mixed-race students who identify black as one component, the number is 12 (6%). The number of Hispanics is 2 (1%), or 8 (4%) including mixed-race students. As with females, we have no evidence that there is a particular retention problem. Nevertheless we are committed to helping all minority students feel welcome and supported. A very positive recent experience was sending two black undergraduate students to the annual meeting of the National Society of Black Physicists. They served as great ambassadors of our program, but also benefitted from the many networking opportunities provided by the meeting.

Overall we are proud of our undergraduate program. We have many students who are outstanding by any measure. Our more “average” students are talented and well-deserving of a physics degree; they go on to be successful, productive members of society, often working in STEM fields. Our continued success, of course, depends on continued support from the college and university.

Physics Department Strategic Plan

The physics department embraces the University's priority to build the College of Science into a world-class, high visibility institution. Over the next decade, this goal can be accomplished by creating a balanced research portfolio containing fundamental and application-oriented programs that will attract the attention of top faculty and top students. By aggressively embracing the need for *basic* science, as emphasized by the Chancellor, the newly formed College of Sciences at NCSU will be poised to tackle the most exciting emerging problems of the 21st century.

A top-rated physics department is a prerequisite to a world-class College of Sciences. Over the next ten years, we plan to greatly increase the visibility and leadership of the department in the broad fields of 1) ***Quantum Science***; 2) ***Physics of the Universe; 3) Biophysics;*** 4) ***Complex Materials and Mesoscale Physics;*** 5) ***Physics Education Research***.

The physics department is well-poised to assume leadership roles in these exciting fields by an injection of new cutting-edge tenure-track faculty, who will be attracted to the well-known research programs that are already in place. However, a key problem will soon arise: The physics department faculty currently is top-heavy, so that failing to implement a substantial junior faculty recruitment program over the next five years will have dire consequences for the reputation and long-term survival of the department.

In order to propel the department into the upper ranks of physics departments world-wide, we have therefore constructed our strategic plan around the premise that the department will require a two-fold faster tenure-track faculty growth rate than the specified goals for a university wide increase of 350 new tenure-track faculty by 2020, which would give the physics department just 10 new faculty in the next 5 years. In addition to this growth target, further faculty recruiting will be required to counterbalance the loss of retiring senior faculty and the loss of several key mid-career faculty members in recent years to head-hunting by other institutions. In total, over 10 years this plan requires the hiring of approximately 10 tenure-track faculty members *just to maintain* the steady state levels in the physics department. An *additional* 20 new tenure-track faculty members will be required to achieve tenure track faculty *growth* described by the upper administration as needed to establish the new College of Sciences as a world-class academic institution. Such a plan will propel the physics department research reputation to a position of high visibility compared to its peers. This strategy suggests an ambitious plan of 25-30 total faculty hires over the next decade. A large investment in the physics department will enable the research reputation and visibility to expand to the level expected for a first rate College of Science, which will stand as an essential pillar next to a nationally leading Engineering College.

To enhance the impact of the research accomplishments and current activity in the physics department, we plan a strategic focus on hiring tenure track faculty members who reinforce and broaden the existing strengths, as described in the following sections. Further, we plan to promote visibility, productivity, and growth in the next decade by expanding the department infrastructure to enhance all of the research programs.

The strategic plan is organized as follows:

- Description of each of the five broad focus areas.
- Ten-year hiring plan.
- Prioritized hiring plan for the next five years.
- Visibility plan.
- Graduate program enhancement plan.
- Plan for improving infrastructure.
- Space plan for housing new research programs.
- Undergraduate teaching plan.

I. Focus Areas for Physics Research

1) Quantum Science

Quantum physics connects diverse fields of fundamental science and is the microscopic cornerstone for our understanding of nature at all length and energy scales. Currently, "*Quantum Science,*" which connects fundamental quantum physics with technology, is a central concept receiving wide attention within funding agencies, such as ARO and DOE. DOE has nicely summarized a broad perspective in several *Grand Challenges*:

"*Design, discover, and synthesize new materials and molecular assemblies through atomic scale control; probe and control photon, phonon, electron, and ion interactions with matter; perform multi-scale modeling that bridges the multiple length and time scales; and use the collective efforts of condensed matter and materials physicists, chemists, biologists, molecular engineers, and those skilled in applied mathematics and computer science.*"

A well-balanced program in *Quantum Science* must include both purely fundamental research and applied research that connects fundamental physics and technology. Very high visibility is achieved by fundamental advances in single- investigator desk-top experiments, where ground-breaking new concepts are frequently published in *Science* and *Nature Magazines*. Major advances are often the result of strong ties between experiment and computational/analytic theory.

The field of atomic, molecular, and optical (AMO) physics has been especially successful, where eleven Nobel prizes have been awarded since 1997. This field has generated the concepts of quantum information processing and quantum simulation, ultrahigh resolution spectroscopy to test fundamental symmetries, measurement and control of nano-mechanical systems, and ultra-cold atomic gases as models of exotic condensed matter and nuclear matter systems.

Similarly, the field of condensed matter physics has established numerous bridges from fundamental Quantum Science principles governing the properties of matter to world-changing technological innovation. New electronic, optoelectronic, and spin- tronic devices will be founded on basic discoveries in polymer and organic materials, 2D layered materials, and organic-inorganic hybrid structures. These discoveries will be pioneered by NC State physicists working within the Quantum Science theme to create, characterize, model, and predict new quantum properties of condensed matter systems.

A priority for the physics department at NCSU should be to build a strong presence in the broad field of *Quantum Science*. The department is currently well-poised to attract top researchers in this broad field, by building on the atom-cooling group, the computational physics groups, the condensed matter experimental groups, and the nanofabrication capabilities that are already in place at the university.

Hires in the following areas will create a strong *Quantum Science* program by connecting current high visibility research within the Physics department:

- *Organic quantum electronics:* structure, electron spin and charge transport in organic materials.
- *Atomic, molecular and optical physics:* connections from ultracold atoms to condensed matter and nuclear matter systems, opto-mechanical quantum systems, quantum information processing, fundamental symmetries.
- *Computational physics:* High performance calculations of structure and physical properties in condensed matter and modeling of many-body cold atom systems.

2) Physics of the Universe

The study of the *Physics of the Universe*, from quarks to quasars, using experiment, observation and theory, continues to be an endeavor strongly associated with the physics department at NC State. In this broad field, present senior faculty members are leaders in their respective fields and the junior faculty show similar potential. The physics department at NC State is well positioned to exploit the new opportunities presented by the general reorienting of this field in recent years and further strengthen the association of NC State with the Physics of the Universe, by unifying well-known groups in nuclear and astrophysics theory with current strength in experimental nuclear physics. The *Physics of the Universe* has been the subject of considerable attention in recent years. There is much excitement in looking for physics beyond the Standard Model such as neutrino mass, dark matter and dark energy, exploiting new messenger particles such as neutrinos and gravitational waves, searching for the first stars and galaxies, and for pushing deep into the realm of unstable nuclei. Several national advisory committees have included topics such as these as high priorities in their respective fields. For example: the Nuclear Science Advisory Committee's most recent long-range plan identified the three frontiers for the subject to be:

i. Quantum Chromo Dynamics (QCD) and its implications and predictions,

ii. Structure of atomic nuclei and nuclear astrophysics;

iii. Developing a New Standard Model of nature's fundamental interactions.

In addition, the American Astronomical Society's Decadal Survey of 2011 also identified two of its goals to be:

i. Searching for the first stars, galaxies, and black holes; and

ii. Advancing understanding of the fundamental physics of the universe.

Currently, the high-energy physics community is going through a long-range planning discussion and, again, three frontiers have been identified known as the "Energy Frontier", the "Intensity Frontier" and the "Cosmic Frontier." Priorities will certainly include several experiments looking for Dark Matter and neutrinos. Funding agencies are making resources available to follow these plans: for example there is the Jefferson Lab upgrade, the Facility for Rare Isotopes Beams (FRIB), the Long Baseline Neutrino Experiment (LBNE), the Department of Energy's Topical Collaborations theory project, the James Webb Space Telescope, fundamental neutron physics at the Spallation Neutron Source (SNS), the Large Synoptic Survey Telescope (LSST), and much more. The Physics department at NC State has already begun capitalizing upon these opportunities. Both the nuclear theory and nuclear experimental groups have made recent hires to enhance NC State's efforts at these frontiers. Another experimental hire should be considered as an important step in moving NC State's expertise into this area and in order to further strengthen the Triangle Universities Nuclear Laboratory (TUNL) as a Department of Energy Center of Excellence.

The most urgent area needing attention is the astrophysics group, which has lost significant strength recently. The astrophysics theory group needs two or more new members urgently, if it is not to suffer long-lasting effects of these losses. The group has a diversity of interests circled around its strong reputation in computational astrophysics and space-based observation, which would likely attract good candidates.

Further expansion in both theoretical and experimental groups should be considered in the long term, including via bridge positions or joint appointments with Oak Ridge National Laboratory, Jefferson Laboratory, or Brookhaven National Laboratory. Finally, there is also important overlap with the *Quantum Science* focus area of the department, where important features of exotic, strongly correlated quantum fluids in nuclear matter, such as the quark-gluon plasma that comprised the universe just after the Big Bang, are modeled by ultra-cold quantum gases.

3) Biophysics

Biophysics and other quantitative biosciences are growing enterprises in the international research community. The emphasis on quantitative measurements and modeling in studies of biological phenomena is expected to enable accelerating progress in efforts to enhance human health, and thus will be supported with funding. Precise, quantitative research approaches are typical strengths of physicists, providing a robust future for biophysics as an important research area. The NCSU physics department has recently built an active research presence in biophysics. Computational and experimental strengths are both represented with 6 full time faculty members and several other faculty members with partial focus on these research problems. The current expertise in the department centers on molecular level interactions among biological assemblies. To increase the research efforts to even more health relevant topics, we see as priorities adding researchers who bridge studies of nanoscale biological processes to mesoscale biological effects.

- Computational biophysics – Our highest priority is to add expertise to linking nanoscale to mesoscale science. This will address important biological systems composed of multi-molecular complexes of large biological molecules. We seek an expert who can link current excellence in computational simulation of nanoscale systems to biologically significant effects in macromolecular assemblies.

- Our second priority will be to add an expertise in the experimental studies of systems biophysics at the level of living cells. This type of investigation will leverage our current expertise in molecular function to enable studies of the impact on living cells.

4) Complex Materials and Mesoscale Physics

The natural world is full of hierarchical materials with emergent properties: The flexibility and rigidity of living tissues arise from collective properties of organized cells, both plants and animals transport materials and information over networks with multiple length scales, and patterns self-assemble during phase separation and crystal growth. Physicists at NC State seek to discover, quantify, and apply the fundamental physical principles governing emergent phenomena in these complex systems.

Research efforts in this theme span a vast range of materials with applications from biological and geological processes to electronic device fabrication. Current projects in the Physics Department include the study of energy transfer in nanoparticle/polymer composites, packing and dynamics in granular materials, origins of frictional forces, blend morphology in polymer films, bio-inspired materials, and thin film growth dynamics. These many-constituent systems are often far from equilibrium and involve emergent "mesoscopic" length scales intermediate between the atomic and macroscopic. Therefore, these properties push the boundaries of state-of-the-art statistical mechanics.

The traditional approaches of creating new materials from uniform blends of chemicals and fabricating ever-smaller devices, is reaching its limit of productivity. In recognition of this, several high-profile funding programs, such as the White House Materials Genome Initiative and the 2012 DOE Basic Energy Sciences report "From Quanta to the Continuum: Opportunities in Mesoscale Science," are spurring intensive activity to open new avenues. The vision is to create hierarchical (multi-scale) materials that are self-assembled from discrete elements such as composite nanofibers within a matrix. The choice of these elements, their shapes, the chemical/electrical/mechanical interactions between them, and their geometric configurations will contribute to creating a bulk behavior tuned to optimize a particular application, such as biocompatible tissue scaffolds, optical or vibrational energy harvesting, or ultralight composites for energy-efficient vehicles. Further advances will come from understanding how to design smart materials, which, like biological tissues, change their properties in response to their environment.

The fundamental physics problem in both hierarchical and mesoscale materials is to understand how constitutive elements, such as cells, nanofibers, and colloids, cooperate to generate the behavior of the larger-scale material. Advances in understanding feedback between the constituent elements, their configuration and organization at various length scales, and the bulk response will require that we develop new theoretical tools for scaling up knowledge from the element scale to the continuum scale. In many cases, continuum models are not yet able to predict such systems' response to perturbations, but notions of percolation, networks, fragility, and jamming are likely to lead to new insights, ultimately allowing us to exploit multi-scale structures rather than homogenizing over them.

To aggressively establish the Physics Department as a key player in this field, we should add establish programs in the following areas:

- Experimental Bio-inspired Materials: This research area exploits analogs of biological processes, such as self-assembly, to develop new materials. It is synergistic with but distinguished from our existing strengths in biophysics, where the object is to understand biological function.
- Theoretical Statistical Mechanics of Hierarchical Materials. This research is distinct from, but will connect to existing strengths in computational materials modeling, including CHIPS.
- Experimental Hierarchical Materials, such biocompatible tissue scaffolds, optical, vibrational energy harvesting, or ultralight composites. These are will have strong connections with the engineering departments.

5) Physics education research:

The physics department has a world-renowned program in physics education research, which cannot maintain its high impact without expanded faculty. Currently, hundreds of departments world-wide are using the SCALE-UP approach pioneered here. Physics research education therefore provides significant visibility for the department and positively impacts our national and international reputation. Innovations developed through PER efforts benefit our department’s mission to educate the next generation of scientists. Physics education research activity enhances the quality of the instruction delivered to undergraduates at the introductory level. The experience of large numbers of students in many departments including engineering and life sciences majors benefit from PER research improving pedagogy, curriculum and technologies for delivery. A particularly intriguing, nascent direction for PER studies is seeking revolutionary approaches to experimental lab education and assessment at all levels, where the focus can range from introductory service courses to "capstone" and "advanced laboratory" experiences that primarily involve our large physics majors program. Our PER graduates are highly sought-after as faculty.

- Senior hires will invigorate the department's effort in this area. Our experience is that an extended time may be required to recruit the best candidates at this level in this field, so that identifying exceptional candidates is not guaranteed within any given year.
- Subsequent junior hires will benefit from the mentoring of the senior faculty.

A. Ten Year Hiring Plan

To achieve the goal of moving the Physics Department to the level of prominence expected for a top-flight College of Science, we propose an aggressive hiring plan over the next decade. Including more experimentalists than theorists in the plan will help to expand the graduate student enrollment, as the experimental groups generally support a large number of students. The breakdown of the proposed new faculty hires is as follows:

1) Quantum Science (12)

- 3 Condensed matter experimentalists
- 1 Condensed matter analytical theory
- 3 Organic electronics experimentalists
- 2 Atomic, molecular, and optical physics experimentalists
- 3 Computational condensed matter theorists

2) Physics of the Universe (6)

- 3 Astronomy/Astrophysics
- 2 Nuclear physics experimentalists
- 1 Nuclear theorist

3) Biophysics (3)

- 1 Computational theorist
- 2 Systems biophysics experimentalist

4) Complex Matter/Mesoscale Physics (6)

- 3 Multi-scale materials experimentalists
- 2 Bio-inspired materials experimentalist
- 1 Statistical mechanics theorist

5) Physics Education Research (3)

- 2 Senior faculty
- 1 Junior faculty

B. Prioritized Five-Year Search Plan

The initial steps in the ten-year plan require 10-15 new faculty members to be hired in the next five years. This will be accomplished by implementing the *Search Plan* that is tabulated below. Five-year search plans will be revised annually in response to the progress of the searches.

The Guiding Principle for this plan is to organize the concurrent searches for each year into groups of *Three Areas*, each with its own *Advertisement.* The goal is to hire the BEST candidates who emerge, in a manner that is, within reason, independent of the area. This broad search approach will help to enhance the diversity of the department. An added benefit of maintaining three hiring advertisements every year is a greatly increased *visibility* for the Department and the University.

In each of the five years, there also will be an *ongoing search* in *Physics Education Research*, with the initial goal of identifying one talented new senior faculty member as a target of opportunity.

Some of these searches may naturally fit into a *cluster hire,* for example, the area of Biophysics, some areas of Condensed Matter Physics, and some areas of Atomic, Molecular, and Optical physics, naturally cross interdepartmental boundaries. Other searches will not fit cluster hires and must remain focused within the Physics Department.

Year	AREA	AREA	AREA	AREA
2015-2016	Astronomy/ Astrophysics	Organic Electronics	Comp Theory Bio/CM	PER
2016-2017	AMO/QO Fund. Spectroscopy	Bio-inspired Multi-scale	Astronomy/ Astrophysics	PER
2017-2018	AMO QO/Fund-Spectroscopy	Nuclear Expt.	Stat-Mech Theory	PER
2018-2019	Comp Theory Bio/CM	Cond-Matt Expt.	Systems-Bio Expt.	PER
2019-2020	Bio-inspired Multi-scale	Nuclear Theory	Cond-Matt Expt.	PER

II. Visibility Plan

The physics department at NCSU is not as visible as it should be for a department that already has many extremely active, very well-known faculty members. We plan to take several steps to increase the visibility of the department:

We will exploit our weekly colloquiums as a platform for advertisement. We plan to appoint a two-member colloquium committee to coordinate the schedule and to rearrange our colloquium schedule to contain 6 slots for department heads and directors of graduate and undergraduate studies at other schools, which will help to make our program better known. Further, we will encourage senior faculty to make suggestions and take responsibility for inviting well-known high profile speakers, who can help to get the word out that our department is vibrant.

We will update our individual and department websites to be sure that they are current, and to convey the high quality of the research in the Physics department. This will be accomplished simply by hiring an adept undergraduate or graduate student to visit faculty members individually, to obtain the information needed to incorporate the latest results and research descriptions.

We will aggressively nominate faculty for external achievement awards. This will be accomplished by a small committee charged with compiling a list of possible awards in each field and relaying this information to the appropriate nominee and potential nominating faculty members.

We will host workshops and conferences, such as the APS Conference for the Division of Nuclear Physics, which will be hosted at NCSU in 2017.

We will encourage press releases for high-visibility publications.

We will employ very visible faculty search processes. As described for the five- year search plan, we plan to advertise for faculty positions simultaneously in several areas, which will increase both the visibility of the search and the diversity of the applicants. In addition to publishing in physics magazines, our ads will be directly disseminated by e-mail to friends and colleagues in physics departments at other universities.

We will encourage the formation of Centers, initially for collaborations that already exist within the department. Branding the Centers by publishing papers with an associated byline will increase the visibility of the research. Associated with each Center will be an invited colloquium presentation by an outside colleague.

We plan to implement a semi-annual department Newsletter, highlighting current activity and accomplishments of students and faculty.

III. Graduate Program Enhancement Plan

Raising the number and stature of the research programs in the College of Sciences will require recruiting an increasing number of high quality graduate students. In addition to increasing the visibility of the department in general, as outline above, additional efforts are required to generate a greater number of applications, to make the graduate program as attractive as possible, to identify and to enroll the best students. This effort must be department-wide and year-long. A number of possible strategies to generate a greater number of applications have been proposed.

We will encourage all faculty members to write to colleagues at other institutions, asking them to encourage their students to apply.

The Graduate Student Brochure will be sent to SPS and academic advisors at other institutions and appended, when appropriate, when replying to enquiries to the graduate studies program.

A recruitment PowerPoint presentation will be made available to all physics department faculty giving seminars and colloquia at other institutions. The presentation can be used to give talks to undergraduates interested in graduate school encouraging the application to NC State.

Rising seniors applying to physics department REU programs will be identified and sent an email encouraging them to apply for graduate school.

We will annually fund a Recruitment Table at the APS March and April meetings and elsewhere. All meeting attendees from NC State will be asked to assist in the recruitment effort.

We shall continue the Ambassador Program which sends out parties of physics department graduate students to other institutions to make presentations to undergraduates.

We shall survey the applicants to our graduate program in order to determine which recruitment tools are the most effective.

We plan to improve the application information on the department website to make clear that we look at the whole application, not just GRE scores, which are sometimes not indicative of a student’s ability.

Graduate Fellowships, to the extent that they are available, will be used as enticements for particularly strong applicants.

To assist the director of graduate studies during the recruitment period, we plan to appoint both an admissions chair and a recruiting chair. This will enable an increased effort to target graduate students who have strong applications with interests that overlap with those of the department.

Once enrolled at NC State, a well-constructed study and research program is required in order to produce graduates who can go on to further success. Although the Ph. D. program is our primary goal, we plan to examine the needs of students pursuing Masters degrees and undergraduate students who do not go on to Ph. D. programs. A number of possible enhancements to the graduate program have been identified:

We plan to create a graduate course curriculum and course structure that is optimized to provide a strong background in theory and methods for pursuing aggressive research problems. This will be accomplished in part by streamlining the core course curriculum, to provide time for more specialized courses, focused for example, on cluster hire areas. A curriculum task force will be appointed to investigate the course structure.

To increase the range of advanced theory courses, we plan to introduce *mini- courses.* These will be five-week, two-credit courses that can be taught enthusiastically, on a volunteer basis, by interested faculty as an add-on to their regular teaching load, without an undue overload.

We plan to develop a set of practical research-skill courses, which will be an integral part of student training. These will include such topics as electronics, machine shop practices, and mathematical methods, including computational methods. A web-based list of these courses will be created so that students know when they are available.

The Graduate Student Orientation program for new students will be improved to provide more guidance.

We plan to implement a new “buddy” system for incoming students, with new students being introduced to a more senior student, who will act as a student mentor. New students will be encouraged to attend the group meetings of the student mentor, which will expose them to research early in the graduate program. The corresponding group leader will act as a faculty mentor. Such an approach will give each incoming student an immediate “home” base and broad source of information. Further, it will encourage students to become involved in research as early as possible.

IV. Infrastructure

Growth in the key focus areas will require a parallel investment in infrastructure to maximize research productivity. This investment must include support staff to help with large enrollment courses and a greatly increased graduate research program, and technical staff to support research.

Permanent staff members are needed to coordinate large enrollment courses to assure consistently high quality. We plan to accomplish this goal by hiring Teaching Assistant Professors, who will help to reduce the course load on research-active faculty and who will provide long-term memory for efficiently implementing the large courses.

Information technology staff members are required to address the increasing need for data management, which is becoming mandatory for work funded by government agencies. Further support is needed for the Education and Research Laboratory, which ideally will be linked to a student electronics shop, where students can learn and practice circuit design and construction. A mechanism for training students in safe and effective machine shop practice also is needed. In addition, support is needed for the administration of grant proposals and contract management.

V. Space Plan

Key to the success of the proposed expansion of the graduate research program at NSCU is a substantial increase in the available office and laboratory space, which is currently a bottleneck for all future growth.

We plan to create a major presence in the fields of experimental and theoretical condensed matter physics, by consolidating our condensed matter program on Centennial Campus. This is an ideal location for a condensed matter physics program, which has substantial overlap with the Materials Science and Engineering programs at NCSU and will foster *collaborative* interactions.

The merging of several condensed matter groups will be accomplished in part by the move of two experimental groups from the Riddick Physics Building to Partners III.

However, our ten-year hiring program requires laboratory space for approximately 15 new experimental groups. With the move of two experimental groups from Riddick and one additional laboratory in Partners III, we have, at present, laboratory space for only 3 new experimental groups.

On a ten-year time scale, we also need new high quality office space for increasing the faculty size by at least 20. This space should include offices for students and post-doctoral associates, and common meeting rooms.

A partial remedy would be to move the Animal Science program out of Riddick, which would free substantial space for new faculty. We will try to identify a small amount of under-utilized space, which can be given back to make room for new research groups. We will also investigate shared space or rented space.

The ideal long-term solution to the space bottleneck is to renovate the Mann building, which neighbors Riddick. This solution would provide nearly contiguous space for Physics and would permanently end the space problem that is currently the bottleneck for substantial long-term growth.

VI. Teaching Plan

The Physics Department is currently very successful in accomplishing our teaching mission at all levels, including service courses, undergraduate major courses and graduate courses. We plan to continue with innovations in our undergraduate majors program. However, in light of the strategic emphasis on enhancement of the research mission, which necessarily requires expansion of the graduate program, we foresee required innovation in teaching focusing mostly on enhancing the graduate level program, as described above. Our undergraduate teaching plan will be based on the following Guiding Principles.

We will continue to maintain high quality undergraduate instruction, which benefits from connections to our Physics Education Research program.

We will enhance research productivity by developing optimized teaching practices.

We will make Physics courses accessible to Engineering students at all levels, to enhance connections between technology, industry, and fundamental physics.

We will maintain high quality undergraduate instruction laboratories. Our implementation of the undergraduate laboratories can be improved in several ways. We plan to hire a Teaching Assistant Professor, who will coordinate the laboratories and who will supervise and train the TA graduate students who run the laboratories. This will provide a consistent long-term approach. By implementing PER studies, we plan to find new approaches to experimental lab education and assessment at all levels.

Harald Ade
Distinguished Professor

Education
State University of New York, Stony Brook, Ph.D. in Physics, 1990
University of Tübingen, Vordiplom in Physics, 1983

Professional Experience

2014-	Distinguished Professor, Dept. of Physics, North Carolina State University
2001-2014	Professor, Dept. of Physics, North Carolina State University
2013	Visiting Professor, Georgia Institute of Technology
1997-2001	Associate Professor, Dept. of Physics, North Carolina State University
1992-1997	Assistant Professor, Dept. of Physics, North Carolina State University

Honors and Awards
2013 Shirley Award for Outstanding Science at the Advanced Light Source
2013 NCSU Alumni Outstanding Research Award
2011 Fellow of the American Association for the Advancement of Science
2010 Fellow of the American Physical Society
2002 Halbach Award for Innovative Instrumentation, ALS
2000 K. F. J. Heinrich Award, Microbeam Analysis Society
1995 Sigma Xi Research Award, NCSU
1994 NSF Young Investigator Award

Select Publications
Aggregation and morphology control enables multiple cases of high-efficiency polymer solar cells Nature Communication (2014) 5, 5292. Y. Liu, J. Zhao, Z. Li, C. Mu, W. Ma, H. Hu, K. Jiang, H. Lin, H. Ade, and H. Yan

The influence of molecular orientation on organic bulk heterojunction solar cells Nature Photonics (2014) 8, 385. J. R. Tumbleston, B. A. Collins, L. Yang, A. C. Stuart, E. Gann, W. Ma, W. You, and H. Ade

The Importance of Fullerene Percolation in the Mixed Regions of Polymer–Fullerene Bulk Heterojunction Solar Cells Adv. Energy Materials (2013) 3, 364. J. A. Bartelt et al.

Absolute measurement of domain composition and nanoscale size distribution explains performance in PTB7:PC71BM solar cells Adv. Energy Materials (2013) 3, 65. B. A. Collins, Z. Li, J. R. Tumbleston, E. Gann, C. R. McNeill, and H. Ade

Fluorine Substituents Reduce Charge Recombination and Drive Structure and Morphology Development in Polymer Solar Cells J. American Chemical Society (2013) 135, 1806. A. C. Stuart, J. R. Tumbleston, H. Zhou, W. Li, S. Liu, H. Ade, and W. You

David Aspnes

Distinguished University Professor
Alumni Distinguished Graduate Professor

Education

University of Wisconsin, B.S. in Electrical Engineering, 1960
University of Wisconsin, M.S. in Electrical Engineering, 1961
University of Illinois Urbana/Champaign, Ph.D. in Physics, 1965

Professional Experience

1998- Distinguished University Professor of Physics, NC State University
2009-2013 Visiting Professor, Department of Physics, Kyung Hee Univ., Seoul, Korea
1992-1998 Professor of Physics, NC State University
1984-1992 Head, Interface Physics and Optical Physics Departments, Bellcore
1967-1984 Member of Technical Staff, AT&T Bell Laboratories
1966-1967 Postdoctoral Researcher, Brown University
1965-1966 Postdoctoral Researcher, University of Illinois

Honors and Awards

2013 Fellow, National Academy of Inventors
2011 Mentor Award, Society of Vacuum Coaters
2009-13 Global Eminent Scholar, Korean World Class University Project
2005 Alumni Distinguished Graduate Professor, NC State University
2002 Fellow, American Association for the Advancement of Science
1999 Distinguished University Professor of Physics, NC State University
1998 Medard W. Welch Award, American Vacuum Society
1998 National Academy of Sciences, US, elected

Select Publications

Optical Properties of Thin Films, Thin Solid Films **89**, 249 (1982), D. E. Aspnes.

Dielectric functions and optical parameters of Si, Ge, GaP, GaAs, GaSb, InP, InAs, and InSb from 1.5 to 6.0 eV, Phys. Rev. **B27**, 985 (1983), D. E. Aspnes and A. A. Studna.

Growth of $Al_xGa_{1-x}As$ parabolic quantum wells by real-time feedback control of composition, Appl. Phys. Lett., **60**, 1244 (1992), D. E. Aspnes, W. E. Quinn, M. C. Tamargo, M. A. A. Pudensi, S. A. Schwarz, M. J. S. P. Brasil, R. E. Nahory, and S. Gregory.

Integrated rotating-compensator polarimeter for real-time measurements and analysis of organometallic chemical vapor deposition, Thin Solid Films **455-456**, 639-644 (2004), K. Flock, S.-J. Kim, M. Asar, and D. E. Aspnes.

Relative bulk and interface contributions to optical second-harmonic generation in silicon, Phys. Rev. **B72**, 205203 (2005), H. J. Peng, E. J. Adles, J.-F. T. Wang, and D. E. Aspnes.

Robert Beichner

Alumni Distinguished Undergraduate Professor
Director, STEM Education Initiative

Education

SUNY Buffalo, Ph.D. in Science Education, 1989
University of Illinois, M.S. in Physics, 1979
Pennsylvania State University, B.S. in Physics, Math (w/ highest distinction), 1977

Professional Experience

2007-	Director, STEM Education Initiative, North Carolina State University
2005-	Editor, Physical Review Special Topics: Physics Education Research
2003-	Alumni Distinguished Professor, Department of Physics, NC State University
1992-2003	Assistant, then Associate Professor, Dept. of Physics, NC State University
1989-1992	Visiting Assistant Professor, SUNY Buffalo

Honors and Awards

2014 Inaugural Fellow of the American Association of Physics Teachers
2011 McGraw Prize in Education
2011 Fellow of the American Association for the Advancement of Science
2010 UNC Board of Governors Award for Teaching Excellence
2010 National Undergraduate Science Teacher of the Year
2010 Fellow of the American Council of Education
2003 Fellow of the American Physical Society

Select Publications

Do they see it coming? Using expectancy violation to gauge the success of pedagogical reforms. Phys Rev ST-Phys. Ed. Res. 6, 010102, Gaffney, J., Housley Gaffney, A., and Beichner, R. (2010).

New Physics Teaching and Assessment: Laboratory and Technology Enhanced Active Learning. Handbook of College Science Teaching, Washington DC: National Science Teachers Association. Beichner, R., Dori, Y., and Belcher, J. (2006).

Introduction to the SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) Project. Invention and Impact: Building Excellence in Undergraduate Science, Technology, Engineering and Mathematics (STEM) Education, Am. Assoc. for the Advancement of Science, Washington DC, Beichner, R., and Saul, J. (2005).

Essentials of Elementary Science (3rd Ed.). Boston: Allyn & Bacon. Dobey, D., & Beichner, R. (2004).

Jerzy Bernholc

Drexel Professor
Director, Center for High Performance Simulation

Education

University of Lund, Sweden, Ph.D. in Physics, 1977
University of Lund, Sweden, B.S. in Physics & Math, 1973

Professional Experience

2000-	Drexel Professor of Physics, North Carolina State University
2002-	Visiting Distinguished Scientist, Oak Ridge National Laboratory
1990-2000	Professor, Department of Physics, NC State University
1986-1990	Associate Professor, Department of Physics, NC State University
1980-1986	Senior Physicist, Corporate Research Science Laboratories, Exxon Research

Honors and Awards

2011 Fellow of the American Association for the Advancement of Science
2011 Fellow of the Materials Research Society
2003 Jesse Beams Award for Outstanding Research, American Physical Society
1992 Alumni Outstanding Research Award, North Carolina State University
1991 Fellow of the American Physical Society

Select Publications

Enzymatic Mechanism of Copper-Containing Nitrite Reductase, Y Li, M Hodak, J Bernholc - Biochemistry, (2015)

Electric Field Induced Phase Transitions in Polymers: a Novel Mechanism for High Speed Energy Storage, V. Ranjan, M. Buongiorno Nardelli and J. Bernholc, Phys. Rev. Lett. 108, 087802 (2012)

Theory of Nitrogen Doping of Carbon Nanoribbons: Edge Effects, J. Jiang, J. Turnbull, W. Lu, P. Boguslawski, and J. Bernholc, J. Chem. Phys. 136, 014702 (2012)

Mechanism of copper(II)-induced misfolding of Parkinson's disease protein, F. Rose, M. Hodak, and J. Bernholc, Nature Scientific Reports 1, 11 (2011)

Quantum-Interference-Controlled Three-Terminal Molecular Transistors Based on a Single Ring-Shaped Molecule Connected to Graphene Nanoribbon Electrodes K. K. Saha, B. K. Nikolic, V. Meunier, W. Lu, and J. Bernholc, Phys. Rev. Lett. 105, 236803 (2010)

*Functional implications of multistage copper binding to the prion protein,*M. Hodak, R. Chisnell, W. Lu, and J. Bernholc, Proc. Nat. Acad. Sci. 106, 11576 (2009)

John M. Blondin

Alumni Distinguished Undergraduate Professor
Department Head

Education

University of Chicago, Ph.D. in Astronomy & Astrophysics, 1987
University of Chicago, M.S. in Astronomy & Astrophysics, 1984
University of Wisconsin, B.A. in Physics, 1982

Professional Experience

2012-	Head, Dept. of Physics, North Carolina State University
2002-	Professor, Dept. of Physics, North Carolina State University
1997-2002	Associate Professor, Dept. of Physics, North Carolina State University
1993-1997	Assistant Professor, Dept. of Physics, North Carolina State University
1991-1992	Postdoc, Dept. of Physics & Astronomy, University of North Carolina - CH
1989-1991	Postdoc, Dept. of Astronomy, University of Virginia
1987-1989	NAS Research Associate, NASA/GSFC

Honors and Awards

2011 Sigma Xi Service Award, NCSU Chapter
2010 NCSU Alumni Distinguished Undergraduate Professor
2009 Fellow of the American Physical Society
2000 NCSU Alumni Outstanding Teacher Award
1997 CAREER Award (National Science Foundation)
1996 Cottrell Scholar (Research Corporation)

Select Publications

Axisymmetric Ab Initio Core-Collapse Supernova Simulations of 12-25 Solar-Mass Stars Astrophysical Journal Letters, 2013, 767L, 6. Bruenn, S. W. et al.

Accretion Disks in Two-Dimensional Hoyle-Lyttleton Flow Astrophysical Journal, 2013, 767, 135. Blondin, J. M.

Three-Dimensional Numerical Investigations of the Morphology of Type Ia SNRs Monthly Notices of the Royal Astronomical Society, 2013, 429, 3099. Warren, D. C., & Blondin, J. M.

Hoyle-Lyttleton Accretion in Three Dimensions Astrophysical Journal, 2012, 752, 30. Blondin, J. M., & Raymer, E.

Generating Pulsar Spin in Supernovae Nature, 2007, 445, 58, Blondin, J. M. & Mezzacappa, A.

Pulsar Wind Nebulae in Evolved Supernova Remnants Astrophysical Journal, 2001, 563, 806, Blondin, J. M., Chevalier, R. A. & Frierson, D. M.

J. David Brown

Professor and Director of Undergraduate Programs

Education

Oklahoma State University, Physics and Mathematics, B.S. 1979
The University of Texas at Austin, Physics, Ph.D. 1985

Professional Experience

2002-	Professor, Dept. of Physics, North Carolina State University
1997-2002	Associate Professor, Dept. of Physics, North Carolina State University
1993-1997	Assistant Professor, Dept. of Physics, North Carolina State University

Honors and Awards

2010 Fellow of the American Physical Society

Select Publications

Numerical Simulations with a First Order BSSN Formulation of Einstein's Field Equations, J.D. Brown, P. Diener, S.E. Field, J.S. Hesthaven, F. Herrmann, A. Mroue, E. Schnetter, M. Tiglio, and M. Wagman, Phys. Rev. D 85 (2012) 084004 (arXiv:1202.1038 [gr-qc])

Generalized Harmonic Equations in 3+1 Form, J.D. Brown, Phys. Rev. D 84 (2011) 124012 (arXiv:1109.1707 [gr-qc])

Oppenheimer-Snyder Collapse in Moving-Puncture Coordinates, A.N. Staley, T.W. Baumgarte, J.D. Brown, B. Farris, and S.L. Shapiro, Class. Quant. Grav. 29 (2012) 015003 (arXiv:1109.0546 [gr-qc])

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Action Principle for the Generalized Harmonic Formulation of General Relativity,J.D. Brown, Phys. Rev. D 84 (2011) 084014. (arXiv:1008.3177 [gr-qc])

Probing the puncture for black hole simulations, J.D. Brown, Phys. Rev. D 80 (2009) 84042. (arXiv:0908.3814 [gr-qc])

Quasilocal energy and conserved charges derived from the gravitational action, J.D. Brown and J.W. York, Phys. Rev. D 47 (1993) 1407{1419. (gr-qc/9209012)

Kazimierz J. Borkowski
Research Professor

Education
University of Colorado, Ph.D. in Astrophysics, 1988
University of Wroclaw, Poland: M.S. in Astronomy, 1977

Professional Experience
1994-1995 NAS/NRC Senior Research Associate, NASA/Goddard Space Flight Center
1990-1994 Research Associate, Dept. of Astronomy, University of Maryland
1988-1990 Research Associate, Dept. of Astronomy, University of Virginia

Select Publications
Nonuniform Expansion of the Youngest Galactic Supernova Remnant G1.9+0.3. Borkowski, K. J., Reynolds, S. P., Green, D. A., Hwang, U., Petre, R., Krishnamurthy, K., & Willett, R. 2014, ApJ, 790, L18 (6pp)

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Supernova Ejecta in the Youngest Galactic Supernova Remnant G1.9+0.3. Borkowski, K. J., Reynolds, S. P., Hwang, U., Green, D. A., Petre, R., Krishnamurthy, K., & Willett, R. 2013, ApJ, 771, L9 (6pp)

Azimuthal Density Variations around the Rim of Tycho's Supernova Remnant. Williams, B. J., Borkowski, K. J., Ghavamian, P., Hewitt, J. W., Mao, S. A, Petre, R., Reynolds, S. P, & Blondin, J. M. 2013, ApJ, 770, 129 (11pp)

X-Ray Emission from Strongly Asymmetric Circumstellar Material in the Remnant of Kepler's Supernova. Burkey, M. T., Reynolds, S. P., Borkowski, K. J., & Blondin, J. M. 2013, ApJ, 764, 63 (6pp)

Dust in a Type Ia Supernova Progenitor: Spitzer Spectroscopy of Kepler's Supernova Remnant. Williams, B. J., Borkowski, K. J., Reynolds, S. P., Ghavamian, P., Blair, W. P., Long, K. S. & Sankrit, R. 2012, ApJ, 755:3 (8pp)

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Laura I. Clarke
Associate Professor

Education
University of Oregon, Physics, Ph.D., 1988
Montana State University, Physics, B.S., 1992

Professional Experience
2009-present Associate Professor, Physics, NC State University
2008-present Affiliate Faculty, Textile Engineering, NC State University
2003-2009 Assistant Professor, Physics, NC State University
2002-2003 Senior Research Associate, Physics, University of Colorado-Boulder
2000-2002 Research Associate, Physics, University of Colorado-Boulder
1999-2000 Postdoctoral Assistant, Physics, Dartmouth College

Select Publications
Spatial Temperature Mapping within Polymer Nanocomposites Undergoing Ultrafast Photothermal Heating via Gold Nanorods, S. Maity, Wei-Chen Wu, C. Xu, J. B. Tracy, K. Gundogdu, J. R. Bochinski, and L. I. Clarke, " Nanoscale 6, 15236 (2014).

Blending with Non-Responsive Polymers to Incorporate Nanoparticles into Shape Memory Materials and Enable Photothermal Heating: The Effects of Heterogeneous Temperature Distribution. D. Abbott, S. Maity, M. Burkey, R. E. Gorga, J. R. Bochinski, and L. I. Clarke, and R. E. Gorga, Macromolecular Chemistry and Physics (in press) (2014).

Thermal annealing of polymer nanocomposites via photothermal heating: effects on crystallinity and spherulite morphology. V. Viswanath, S. Maity, J. R. Bochinski, L. I. Clarke, and R. E. Gorga, Macromolecules 46, 8596 (2013).

Anisotropic Thermal Processing of Polymer Nanocomposites via the Photothermal Effect of Gold Nanorods, S. Maity, K. A. Kozek, Wei-Chen Wu, J. B. Tracy, J. R. Bochinski, and L. I. Clarke, Particle & Particle Systems Characterization 30, 193 (2013).

Karen Daniels
Associate Professor

Education
Cornell University, Ph.D. in Experimental Condensed Matter Physics, 2002
Dartmouth College, A.B. in Physics, 1990

Professional Experience
201-present	Associate Professor, Department of Physics, NC State University
2005-2011	Assistant Professor, Department of Physics, NC State University
2013	MPI for Dynamics and Self-Organization, Gottingen, Germany
2005	Newton Institute for Mathematical Sciences, Cambridge, UK
2002-2005	Postdoc, Dept. of Physics, Duke University
1994-1997	Instructor, Saint Ann's School, Brooklyn, NY

Honors and Awards
2007	NSF Faculty Early Career Development Program (CAREER) Award
2011	Alexander von Humboldt Fellowship for Experienced Researchers
2013	LeRoy and Elva Martin Award for Teaching Excellence
2013–2018	North Carolina State University Faculty Scholar

Select Publications
The Statistical Physics of Athermal Materials, Annual Reviews of Condensed Matter Physics (2015) arXiv:1404.1854Bi, D., Henkes, S., Daniels, K. and Chakraborty, B.

Elastocapillary deformations on partially- wetting substrates: rival contact-line models, Soft Matter. 10: 7361-7369, 2014. Joshua B. Bostwick, Michael Shearer, Karen E. Daniels.

Self-healing Dynamics of Surfactant Coatings on Thin Viscous Films, Physics of Fluids. 26: 042109, 2014. Stephen L. Strickland, Matthew Hin, M. Richard Sayanagi, Cameron Gaebler, Karen E. Daniels, Rachel Levy

Equilibrating temperaturelike variables in jammed granular subsystems, Physical Review Letters. 110: 058001, 2013. James G. Puckett and Karen E. Daniels

Acoustic measurement of a granular density of modes, Soft Matter, 9: 1214-1219, 2013. Eli T. Owens and Karen E. Daniels

Flow-Driven Formation of Solid-like Micro- sphere Heaps, Soft Matter, 9: 543-549, 2013. Carlos P. Ortiz, Robert Riehn, and Karen E. Daniels

Capillary fracture of soft gels, Physical Review E. 88: 042410, 2013. Joshua B. Bostwick and Karen E. Daniels

Abay G. Dinku
Research Associate Professor

Education
Linköping University, Sweden, Ph.D. in Applied Physics, 2006
Addis Ababa University, Ethiopia, M.S. in Physics, 2001
Addis Ababa University, Ethiopia, B.S. in Physics, 1996

Professional Experience
2014-	Research Assistant Professor, Dept. of Physics, North Carolina State University
2010-2014	Postdoc, Dept. of Chemistry, University of North Carolina at Chapel Hill
2007-2009	Postdoc, Hasselt University, Belgium

Honors and Awards
2002 International Science Program Fellowship

Select Publications
On the origin of the open-circuit voltage of polymer–fullerene solar cells. Nature Materials 8, 904 - 909 (2009). Koen Vandewal, Kristofer Tvingstedt, Abay Gadisa, Olle Inganäs & Jean V. Manca

Solution processed Al-doped ZnO nanoparticles/TiOx composite for highly efficient inverted organic solar cells. A. Gadisa, T. Hairfield, L. Alibabaei, C. L. Donley, E. T. Samulski, and R. Lopez, ACS Appl. Mater. Interfaces , 5, 8440 (2013).

Modifications in Morphology Resulting from Nanoimprinting Bulk Heterojunction Blends for Light Trapping Organic Solar Cell Designs. J. R. Tumbleston, A. Gadisa, Y. Liu, B. A. Collins, E. T. Samulski, R. Lopez, and H. Ade, ACS Appl. Mater. Interfaces , 5, 8225 (2013).

Effects of nano-patterned versus simple flat active layers in upright organic photovoltaic devices. Y. Liu, C. Kirsch, A. Gadisa, M. Aryal, S. Mitran, E. T. Samulski and R. Lopez, J. Phys. D: Appl. Phys. 46 (2013) 024008.

Role of thin n-type metal-oxide interlayers in inverted organic solar cells. A. Gadisa, Y. Liu, E. T. Samulski, ACS Appl. Mater. Inter. 4, 3846 (2012).

Minimizing interfacial losses in inverted organic solar cells comprising Al-doped ZnO A. Gadisa, Y. Liu, E. T. Samulski, and R. Lopez, Appl. Phys. Lett. 100, 253903 (2012).

Daniel Dougherty

Associate Professor

Education

University of Maryland at College Park, Ph.D. in Physics,
Texas A&M University, B.S. in Physics, 1999

Professional Experience

2014-	Associate Professor, Dept. of Physics, NC State University
2008-2014	Assistant Professor, Dept. of Physics, NC State University
2006-2008	Postdoc, National Institute of Standards and Technology
2005-2006	Postdoc, Dept. of Chemistry, University of Pittsburgh

Honors and Awards

2011 NSF Early Career Award
2013 DOE Early Career Award

Select Publications

Toward Single Crystal Hybrid-Carbon Electronics: Impact of Graphene Substrate Defect Density on Copper Phthalocyanine Film Growth T. McAfee, E. Gann, T. Guan, S.C. Stuart, J.E. Rowe, D.B. Dougherty, and H. Ade, Crystal Growth & Design **14**, 4394 (2014)

Coverage Dependent Surface Magnetism of Iron Phthalocyanine on an O-Fe(110) Surface D.B. Dougherty, A. Sandin, E. Vescovo, and J.E. Rowe, Phys. Rev. B **90**, 045406 (2014)

Coexisting Bi and Se Surface Terminations of Cleaved Bi2Se3 Single Crystals A.S. Hewitt, J. Wang, J. Boltersdorf, P.A. Maggard, and D.B. Dougherty J. Vac. Sci. Tech. B **32**, 040103 (2014)

Extrinsic Origins of Electronic Disorder in 2D Organic Crystals J. Wang and D.B. Dougherty, J. Vac. Sci. Tech. B **32**, 030601 (2014)

Molecular Doping Control at a Topological Insulator Surface J. Wang, A.S. Hewitt, R. Kumar, J. Boltersdorf, T. Guan, F. Hunte, P.A. Maggard, J. Brom, J.M. Redwing, and D.B. Dougherty, J.Phys. Chem. C **118**, 14860 (2014)

Carla Fröhlich
Assistant Professor

Education
University of Basel, Switzerland, Physics – PhD, 2007
University of Basel, Switzerland Theor. Physics -M.Sc., 2003

Professional Experience
2010-Present Assistant Professor, Department of Physics, North Carolina University
2007-2010 Astrophysics Enrico Fermi Fellow, University of Chicago

Honors and Awards
2014 Cottrell Scholar
2013 DOE Office of Science Early Career Award
2011 R.E. Powe Junior Faculty Enhancement Award
2007 PhD Prize, Swiss Physical Society

Select Publications
Influence of nuclear reaction rates on the nucleosynthesis in neutrino- driven winds. Proceedings to 15th International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics, in press. C. Fröhlich and D. Hatcher

Neutrinos and nucleosynthesis in core-collapse supernovae. AIP Conference Proceedings 1604, 178 (2014) C. Fröhlich, J. Casanova, M. Hempel, M. Liebendörfer, C.A. Melton, A. Perego

Supernovae, Neutrinos, and Nucleosynthesis. Journal of Physics G Focus Issue "Nucleosynthesis and the role of neutrinos". Eds. C. Volpe & B. Balantekin. J. Phys. G 41, 044003 (2014) C. Fröhlich

Origin of Elements. Treatise on Geochemistry (2nd Edition), Eds. H. Holland & K. Turekian, Elsevier (2014) A. Heger, C. Fröhlich, J.W. Truran

Constraining the astrophysical origin of the p-nuclei through nuclear physics and meteoritic data. Rep. Prog. Phys. 76, 06621 (2013) T. Rauscher, N. Dauphas, I. Dillmann, C. Fröhlich, Zs. Fülöp, Gz. Gyürky

Systemtic study of (p,g) reactions on Ni isotopes. Phys. Rev. C 87, 055802 (2013) Simon, A. Spyrou, T. Rauscher, C. Fröhlich, S.J. Quinn, A. Battaglia, A. Best, B.Bucher, M. Couder, P.A. deYoung, X. Fang, J. Goerres, Q. Li, L.-Y. Lin, A. Long, S. Lyons, A. Roberts, D. Robertson, K. Smith, E. Stech, B. Stefanek, W.P. Tan, X.D. Tang, M. Wiescher

Robert Golub
Professor

Education
Massachusetts Institute of Technology, Ph.D. in Physics, 1968
Massachusetts Institute of Technology, M.S. in Electrical Engineering, 1960
The City College of New York, B.S. in Electrical Engineering, 1959

Professional Experience
2008	Professor, Department of Physics, North Carolina State University
2004-2008	Research Professor, Department of Physics, North Carolina State University
1991-2003	Research Scientist, Hahn Meitner Institut, Berlin, Germany
1986-1991	Postdoctoral Fellow, Technical University Berlin, Berlin, Germany
1985-1986	Research Physicist, Max Planck Institut for Physics, Freimann, Germany
1980-1985	Postdoctoral Fellow, Technical University Munich, Munich, Germany
1968-1980	England Research Fellow, University of Sussex, Sussex

Honors and Awards
Fellow, American Physical Society
Fellow, Neutron Scattering Society of America

Select Publications
Calculation of geometric phases in electric dipole searches with trapped spin-1/2 particles based on direct solution of the Schrödinger equation. A Steyerl, C Kaufman, G Müller, SS Malik, AM Desai, R Golub Physical Re- view A 89 (5), 052129, 2014

Universality of spin-relaxation for spin 1/2 particles diffusing over magnetic field inhomogeneities. M Guigue, G Pignol, R Golub, AK Petukhov, Physical Reveiw A, July 2014

Correlation functions for restricted Brownian motion from the ballistic through to the diffusive regimes. CM Swank, AK Petukhov, R Golub, , CM Swank, AK Petukhov, R Golub Physics Letters A 376 (34), 2319-2324 2012

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Comment on “Limits on possible new nucleon monopole-dipole interactions from the spin relaxation rate of po- larized He 3 gas” Physical Review D 84 (5), 058501 2011. AK Petukhov, G Pignol, R Golub

Kenan Gundogdu
Assistant Professor

Education
University of Iowa, Ph.D. in Physics, 2004
Bogazici University, B.S. in Physics, 1999

Professional Experience
2009- Assistant Professor, Dept. of Physics, North Carolina State University
2006-2008 Postdoc, Dept. of Chemistry, MIT
2004-2006 Postdoc, Dept. of Chemistry, University of Iowa

Honors and Awards
2013 Office of Naval Research Young Investigator

Select Publications
A femtosecond study of the anomaly in electron injection for dye-sensitized solar cells: the influence of isomerization employing Ru(II) sensitizers with anthracene and phenanthrene ancillary ligands, Physical Chemistry Chemical Physics (2015) 17, 2750. Cheema, H., Younts, R., Ogbose, L., Gautam, B., Gundogdu, K. and El-Shafei, A.

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Many-Body Effects in Valleytronics: Direct Measurement of Valley Lifetimes in Single-Layer MoS2, Nano Letters (2014) 14, 202. Mai, C., Barrette, A., Yu, Y., Semenov, Y. G., Kim, K. W., Cao, L. and Gundogdu, K.

David G. Haase
Alumni Distinguished Undergraduate Professor

Education
Duke University, Ph.D. in Physics, 1975
Duke University, M.A. in Physics, 1972
Rice University, B.A. in Physics and Math, cum laude, 1970

Professional Experience
1987-	Professor of Physics, N. C. State University
2013-2014	Associate Head, Department of Physics
2006	Visiting Scientist, Los Alamos National Laboratory
1991-2007	Director, The Science House, NC State University
1988	Visiting Professor, Louisiana State University
1981-1987	Associate Professor, NC State University
1976-1981	Assistant Professor, NC State University
1975-1976	Visiting Assistant Professor, NC State University

Honors and Awards
2015	Board of Governors Award for Teaching Excellence
2001	Pegram Medal, Southeastern Section of the American Physical Society
2000	Fellow of the American Physical Society
1998	Alexander Holladay Medal for Excellence, NC State University
1999	Distinguished Service Award, NC Science Teachers Association
1990	NC Professor of the Year, Council for Advancement & Support of Education
1989	NC State Alumni Distinguished Undergraduate Professor

Select Publications
National Task Force on Physics Teacher Education in Physics Report Synopsis http://www.ptec.org/webdocs/TaskForce.cfm

Barriers to Physics Education, David Haase and Paul Cottle, Op-Ed piece in the Raleigh News and Observer, July 8, 2011. (This article was the subject of editorials in the Raleigh N&O and Charlotte Observer, July 21 and 22, 2011).

A Course to Prepare Physics Students for the Research Laboratory, David G. Haase, Hans Hallen, and David P. Kendellen, Spring 2012 Newsletter of the Forum on Education of the American Physical Society, p. 13.

Measurement and Modeling of Thermal Flow in an Enclosed Tube Containing Superuid Helium Film, D.P. Kendellen and D.G. Haase. Cryogenics 57 (2013)134-139

Hans Hallen
Professor

Education
Cornell University, Ph.D. in Applied Physics, 1991
Cornell University, M.S. in Applied Physics, 1986
Cornell University, B.S. (with Distinction) in Engineering Physics, 1984

Professional Experience

2007-	Professor of Physics North Carolina State University
2001-2007	Associate Professor of Physics, North Carolina State University
1995-2001	Assistant Professor of Physics, North Carolina State University
1993-1995	Visiting Assistant Professor of Physics, North Carolina State University
1991-1993	Postdoctoral Member of Tech. Staff, AT&T Bell Laboratories

Select Publications
Near-field enhanced ultraviolet resonance Raman spectroscopy using aluminum bow-tie nano-antenna Appl. Phys. Lett. **101** (11) 2012. Ling Li, Shuang Fang Lim, Alexander Puretzky, Robert Riehn, and Hans Hallen

Comparison of diffraction-enhanced computed tomography and monochromatic synchrotron radiation computed tomography of human trabecular bone, 21 Oct. 2009, v **54**, n 20, p 6123-33. D.M. Conner, H. D. Hallen, D. R. Sumner, Z. Zhong, D. S. Lalush Physics in Medicine and Biology,

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The electric field at the apex of a near-field probe: implications for nanoRaman spectroscopy, J. Raman Spectroscopy **34** (9): 655-62 (2003) H. D. Hallen and C.L. Jahncke, -- An invited paper.

Long Range Prediction of Fading Signals: Enabling Adaptive Transmission for Mobile Radio Channels, IEEE Signal Processing Magazine, Vol. 17, No. 3, pp. 62-75, May 2000. Alexandra Duel-Hallen, Shengquan Hu, Hans Hallen, -- An invited paper

Keith Heyward
Teaching Assistant Professor

Education
North Carolina State University, Ph.D. in Physics, 2008
Georgia Institute of Technology, B.S. in Electrical Engineering, 1983

Professional Experience

2011-present	Teaching Assistant Professor, North Carolina State University
2008 – 2011	Lecturer, North Carolina State University
1997 – 2000	Product manager, Siemens Power Transmission & Distribution
1985 – 1997	Project Manager, Siemens Energy & Automation, Inc.
1983 – 1985	Electrical Engineer, NASA, Reynolds, Cape Kennedy, FL

Miroslav Hodak
Research Assistant Professor

Education
University of Pennsylvania, Ph.D. in Materials Science, 2002
Comenius University, Slovakia, M.S. in Physics, 1998

Professional Experience
2008-	Research Assistant Professor, Dept. of Physics, North Carolina State University
2007-2008	Scientist, Department of Physics, North Carolina State University
2003-2007	Postdoc, Department of Physics, North Carolina State University

Select Publications
Enzymatic Mechanism of Copper-Containing Nitrite Reductase, Y. Li, M. Hodak, J. Bernholc, ACS Biochemistry **54**, 1233 (2015).

Scaling the RMG Quantum Mechanics Code, S. Moore, E. L. Briggs, M. Hodak, W. Lu, J. Bernholc, and C. W. Lee, Proceedings of the Extreme Scaling Workshop (2012).“Mechanism of copper(II)-induced misfolding of Parkinson's disease protein”, F. Rose, M. Hodak, J. Bernholc, Nature Scientific Reports, **1**, 11 (2011).

Functional implications of multistage copper binding to the prion protein, M. Hodak, R. Chisnell, W. Lu, and J. Bernholc, Proc. Natl. Acad. Sci. USA **106**, 11576 (2009).

Insights into prion protein function from atomistic simulations, invited perspective and cover, M. Hodak and J. Bernholc, Prion **4**, 13 (2010). “

Recent developments and applications of the real-space multigrid method, J. Bernholc, M. Hodak and W. Lu, J. Phys. Cond. Matt. **20**, 294205 (2008).

Hybrid ab initio Kohn-Sham DFT/frozen-density orbital-free DFT simulation method suitable for biological systems, M. Hodak, W. Lu, and J. Bernholc, J. Chem. Phys. **128**, 014101 (2008).

Implementation of ultrasoft pseudopotentials in large-scale grid-based electronic structure calculations, M. Hodak, S. Wang, W. Lu and J. Bernholc, Phys. Rev. B, **76**, 085108 (2007).

Paul Huffman
Professor
Associate Director of TUNL

Education
Duke University, Ph.D. in Physics, 1995
Duke University, M.S. in Physics, 1992
North Carolina State University, B.S. in Physics, 1990

Professional Experience

2008-	Professor, Department of Physics, North Carolina State University
2004-	Joint Faculty, Oak Ridge National Laboratory
2004-2008	Associate Professor, Department of Physics, North Carolina State University
2000-2004	Physicist, National Institute of Standards and Technology
1998-2000	NRC Postdoc, National Institute of Standards and Technology
1995-1998	Postdoc, Department of Physics, Harvard University

Select Publications
Overview of Magnetic Trapping Neutron Lifetime Experiments, P. R. Huffman, In Next Generation Experiments to Measure the Neutron Lifetime, Ed. Susan J. Seestrom, World Scientific, 15–24 (2014). DOI: 10.1142/9789814571678 0003

Measuring the Neutron Lifetime with Magnetically Trapped Ultracold Neutrons, H. P. Mumm et al. (including C. R. Huffer, P. R. Huffman, K. W. Schelhammer, and C. O'Shaughnessy), In Next Generation Experiments to Measure the Neutron Lifetime, Ed. Susan J. Seestrom, World Scientific, 121–134 (2014). DOI: 10.1142/9789814571678 0013

Parity Violation in Photonuclear Reactions at HIGS, M. W. Ahmed, A. E. Champagne, B. R. Holstein, C. R. Howell, P. Huffman, W. M. Snow, R. P. Springer, and Y. K. Wu, arXiv:1307.8178, Snowmass 2013: Intensity Frontier.

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Cryogenic Design and Performance of an Apparatus for Magnetically Trapping Ultracold Neutrons, P. R. Huffman, K. J. Coakley, J. M. Doyle, C. R. Huffer, H. P. Mumm, C. M. OShaugh- nessy, K.W. Schelhammer, P-N. Seo, L. Yang, Submitted to Cryogenics, (2014).

Fundamental Neutron Physics Beamline at the Spallation Neutron Source at ORNL, N. Fomin, G. L. Greene, R. Allen, V. Cianciolo, C. Crawford, T. Ito, P. R. Huffman, E. B. Iverson, R. Mahurin, and W. M. Snow, Submitted to Nuclear Inst. and Methods in Physics Research, A, (2014).

Chueng-Ryong Ji
Professor and Director of Graduate Programs

Education
Korea Advanced Institute of Science and Technology, Ph.D. in Particle Theory, 1982
Korea Advanced Institute of Science and Technology, M.S. in Particle Theory, 1978
Seoul National University, B.S. in Physics, 1976

Professional Experience
1997-	Professor, Department of Physics, NCSU
2013-	Director of Graduate Program, Department of Physics, NCSU
2005	Visting Professor, School of Physics, Seoul National University
1992-1997	Associate Professor, Department of Physics, NCSU
1993	Visting Professor, School of Physics, Seoul National University
1987-1992	Assistant Professor, Department of Physics, NCSU
1986-1987	Research Associate, Brooklyn College of the CUNY
1984-1986	Research Associate, Stanford University
1982-1984	Visiting Scholar, SLAC, Theory Group, Stanford University

Honors and Awards
2011 Fellow, American Physical Society
2008 Outstanding Referee, American Physical Society
1988 Dirac Scholarship Award, Intersections between Particle and Nuclear Physics.
1982 Fellowship, Korea Science and Engineering Foundation

Select Publications
Consistency of the Light-Front Quark Model with the Chiral Symmetry in the Pseudoscalar Meson Analysis, Phys. Rev. D,in press, arXiv:1412.2507 [hep-ph]. H. M. Choi and C.-R. Ji

Nuclear chromodynamics: Novel nuclear phenomena predicted by QCD, Prog. Part. Nucl. Phys. 74 (2014) 1. B. L. G. Bakker and C.-R. Ji

Anatomy of relativistic pion loop corrections to the electromagnetic nucleon coupling. Phys. Rev. D 88 no. 7, 076005 (2013) [arXiv:1306.6073 [hep-ph]]. C.-R. Ji, W. Melnitchouk and A. W. Thomas

Conceptual issues concerning generalized parton distributions, Int. J. Mod. Phys. E 22 no. 2, 1330002 (2013). C.-R. Ji and B. L. G. Bakker

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John Kelley
Research Associate Professor

Education
Michigan State University, Ph.D. in Physics, 1995
Greenville College, B.A. in Math and Physics, 1989

Professional Experience
2012-2014	Visiting Associate Professor, Duke University
2010-	Research Associate Professor, NC State University
2000-2009	Research Assistant Professor, NC State University
1996-1999	Research Associate, Duke University, Nuclear Physics
1995-1996	Res. Asoc. Institut de Physique Nuclaire, Orsay France

Select Publications
Energy levels of light nuclei A=11, Nucl.Phys. A880, 88 (2012) J.H.Kelley, E.Kwan, J.E.Purcell, C.G.Sheu, H.R.Weller

Dual-fission chamber and neutron beam characterization for fission product yield measurements using monoenergetic neutrons, Nucl. Instrum. and Meth. A 757, 7 (2014) C Bhatia, B Fallin, ME Gooden, CR Howell, JH Kelley, W Tornow, CW Arnold, EM Bond, TA Bredeweg, MM Fowler, WA Moody, RS Rundberg, G Rusev, DJ Vieira, JB Wilhelmy, JA Becker, R Macri, C Ryan, SA Sheets, MA Stoyer, AP Tonchev

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Cross-Section Measurements of the 86Kr(γ,n) Reaction to Probe the s-Process Branching at

5Kr, Phys. Rev. Lett. 111, 11250 (2013) R. Raut, A. P. Tonchev, G. Rusev, W. Tornow, C. Iliadis, M. Lugaro, J. Buntain, S. Goriely, J. H. Kelley, R. Schwengner, A. Banu & N. Tsoneva

James Kneller
Assistant Professor

Education

The Ohio State University, Ph.D. 2002

1990 – 1993 Undergraduate, The University of Manchester, Manchester, UK

Professional Experience

2010 – present	Assistant Professor, NC State University, Raleigh, NC
2008 - 2010	Chercheur, Institut de Physique Nucl´eaire, Orsay, France
2008 – 2008	Visiteur, Institut de Physique Nucl´eaire, Orsay, France
2005 – 2008	Postdoctoral, University of Minnesota, Minneapolis, MN
2002 – 2005	Postdoctoral, NC State University, Raleigh, NC
2001 – 2002	Postdoctoral, The Ohio State University, Columbus, OH

Honors and Awards

2011 Department of Energy Early Career Award

Select Publications

Stimulated neutrino transformation through turbulence, Phys. Rev. D, 89, 073022 (2014) K. Patton J. P. Kneller, and G. C. McLaughlin

Does The Finite Size of the Proto-Neutron Star Preclude Supernova Neutrino Flavor Scintillation Due to Turbulence?, Phys. Rev. D, 88, 045020 (2013) Kneller, J. P. & Mauney, A. W.

Consequences of large θ13 for the turbulence signatures in supernova neutrinos, Phys. Rev. D, 88, 025004 (2013) Kneller, J. P. & Mauney, A. W.

Combining collective, MSW, and turbulence effects in supernova neutrino flavor evo- lution' Phys. Rev. D, 88, 023008 (2013) , Lund, T. & Kneller, J. P.,

Stimulated neutrino transformation in supernovae, Journal of Physics G Nuclear Physics, 40, 055002 (2013) J. P. Kneller, G. C. McLaughlin and K. Patton

Jacqueline Krim

Distinguished University Professor
Associate Dean for Research

Education

University of Washington, Ph.D. in Physics, 1984
University of Washington, M.S. in Physics, 1980
University of Montana, B.A. in Physics, 1978

Professional Experience

2014-	Distinguished University Professor, North Carolina State University
2013-	Assoc. Dean for Research, College of Sciences, North Carolina State U.
2011-2013	Interim Assoc. Dean for Research, PAMS College NCSU
2009-2010	Visiting Professor of Physics, Duke University, Durham, NC (sabbatical)
1998-2014	Professor of Physics, North Carolina State University
1991-1992	Senior Research Fellow, Katholieke Univ. Leuven, Belgium (sabbatical)
1984-1998	Assistant, Associate (1992), Professor (1996) of Physics, Northeastern

Honors and Awards

2015 David Adler Lectureship, APS Division of Materials
2010 NSF DMR American Competitiveness and Innovation Fellow
2002 NC State Alumni Outstanding Researcher Award
2000 Fellow of the American Physical Society
1999 Fellow of the American Vacuum Society
1987 NSF Presidential Young Investigator Award

Select Publications

Friction and energy dissipation mechanisms in adsorbed molecules and molecularly thin films. Advances in Physics, 61 (3) 155-323, (2012), J. Krim

Impact of oxygen and argon plasma exposure on the roughness of gold film surfaces, D. Berman and J. Krim, Thin Solid Films 520, pp. 6201-6206 (2012)

Temperature dependence of single-asperity friction for a diamond on diamondlike carbon interface, Applied Phys. 107, #114903 (2010) C.G. Dunkle, I.B. Altfeder, A.A. Voevodin, J. Jones, J. Krim and P. Taborek, J.

Magic-sized Diamond Nanocrystals Physical Review Letters 102, #136104 (2009). I. Altfeder, J. Hu, A. Voevodin and J. Krim

Bridging the gap between macro- and nanotribology: A quartz crystal microbalance study of tricresylphosphate uptake on metal and oxide surfaces, Physical Review Letters 92, #176101, (2004) M. Abdelmaksoud, J. W. Bender, and J. Krim

OTS adsorption: A dynamic QCM study, Colloids And Surfaces A-Physicochemical And Engineering Aspects 262, 81-86, (2005) Y. Hussain, J. Krim, and C. Grant

Dean Lee
Alumni Distinguished Undergraduate Professor

Education
Harvard University, Ph.D. in Theoretical particle physics, 1998
Harvard University, A.B. Summa cum laude in physics, 1992

Professional Experience
2012 - Professor, North Carolina State University
2007 – 2012 Associate Professor, North Carolina State University
2001 – 2007 Assistant Professor, North Carolina State University
1998 – 2001 Postdoctoral Researcher, University of Massachusetts

Honors and Awards
2014 Fellowship, American Physical Society
2013 Alumni Distinguished Undergraduate Professor, North Carolina State University
2007 Outstanding Teaching Award, North Carolina State University
1992 – 1997 Graduate Fellowship, Fannie and John Hertz Foundation
1996 Robbins Prize, Harvard University
1988 – 1992 Deturs Prize, Gross Scholar, Hoopes Prize, John Harvard Scholarship, Phi Beta Kappa, Harvard University
1991 Apker Award, national co-winner, American Physical Society

Select Publications
Ab initio calculation of the spectrum and structure of 16O, Phys. Rev. Lett. 112 102501 (2014), E. Epelbaum, H. Krebs, T. Lähde, D. Lee, U.-G. Meißner, G. Rupak
Lattice Effective Field Theory for Medium-Mass Nuclei, Phys. Lett. B732 110 (2014), E. Epelbaum, H. Krebs, T. Lähde, D. Lee, U.-G. Meißner, G. Rupak
Viability of carbon-based life as a function of light quark mass, Phys. Rev. Lett. 110 112502 (2013), E. Epelbaum, H. Krebs, T. Lähde, D. Lee, U.-G. Meißner
Structure and rotations of the Hoyle state, Phys. Rev. Lett. 109 252501 (2012), E. Epelbaum, H. Krebs, T. Lähde, D. Lee, U.-G. Meißner
Volume Dependence of Bound States with Angular Momentum, Phys. Rev. Lett. 107 192501 (2011), S. König, D. Lee, H.-W. Hammer
Ab initio calculation of the Hoyle state, Phys. Rev. Lett. 106 192501 (2011), E. Epelbaum, H. Krebs, D. Lee, U.-G. Meißner
Lattice effective field theory calculations for A=3,4,6,12 nuclei, Phys. Rev. Lett. 104 142501 (2010), E. Epelbaum, H. Krebs, D. Lee, U.-G. Meißner
Lattice simulations for few- and many-body systems, Prog. Part. Nucl. Phys. 63 117 (2009), D. Lee

Shuang Fang Lim
Assistant Professor

Education
University of Cambridge, UK, Ph.D. in Physics, 2004
National University of Singapore, M.S. in Physics, 1998
National University of Singapore, B.S. (honors) in Materials Science, 1996

Professional Experience
2012-	Assistant Professor, Dept. of Physics, NC State University
2010-2012	Research Assistant Professor, Dept. of Physics, NC State University
2008-2009	Postdoc, Dept. of Physics, NC State University
2004-2008	Postdoc, Depts. of Physics, Materials Science Eng., Princeton University
1998-2000	Research Officer, Institute of Materials Research, Singapore

Select Publications
Probing transient protein-mediated DNA linkages using nanoconfinement. Biomicrofluidics 8(3): 034113/1-15, 2014. M. Roushan, P. Kaur, A. Karpusenko, P. J. Countryman, C. P. Ortiz, S. F. Lim, H. Wang, R. Riehn

Chromatin modification mapping in nanochannels. Biomicrofluidics 7(6): 064105/1-8, NOV 2013. S. F. Lim, A. Karpusenko, D.E. Streng, R. Riehn

Fluctuation modes of nanoconfined DNA. Journal of Applied Physics 111(2): 024701-024708, JAN 2012. A. Karpusenko, J. H. Carpenter, C. , S. F. Lim, J. Pan, R. Riehn

Near-field enhanced ultraviolet resonance Raman spectroscopy using aluminum bow-tie nano-antenna Applied Physics Letters 101(11): 113116/1-4, SEP 2012. L. Li, S. F. Lim, A. A. Puretzky, R. Riehn, H. D. Hallen

DNA Methylation Profiling in Nanochannels. Biomicrofluidics 5(3): 034106-034114, JUL 2011. S. F. Lim, A. Karpusenko, J. J. Sakon, J. A. Hook, T. A. Lamar, R. Riehn

Density fluctuations dispersion relationship for a polymer confined to a nanotube. Applied Physics Letters 98(25): 253704-253706, JUN 2011 J. H. Carpenter, A. Karpusenko, J. Pan, S. F. Lim, R. Riehn

Epigenetic Analysis of Chromatin in Nanochannels. Biophysical Journal 98(3): 600A-600A, JAN 2010. D. E. Streng, S. F. Lim, R. Riehn

Particle size dependence of the dynamic photophysical properties of NaY4:Yb, Er nanocrystals. Optics Express 18(3): 2309-2316, FEB 2010. S. F. Lim, W. S. Ryu, R. H. Austin

Upconverting nanophosphors for bioimaging. Nanotechnology 20(40): 405701 SEP 2009. S. F. Lim, R. Riehn, C-K Tung, W. S. Ryu, R. Zhuo, J. Dalland, R. H. Austin

Richard Longland

Assistant Professor

Education

University of North Carolina, Chapel Hill, Ph.D. in Physics, 2010
University of North Carolina, Chapel Hill, M.S. in Physics, 2006
University of Surrey, UK, MPhys in Physics, 2004

Professional Experience

2014-	Assistant Professor, Department of Physics, NC State University
2013-2014	Postdoc, Department of Physics, University of North Carolina
2010-2013	Postdoc, Universitat Politècnica de Catalunya, Barcelona

Select Publications

Thermonuclear reaction rate of $^{18}Ne(\alpha,p)^{21}Na$ from Monte Carlo calculations, Phys. Rev. C **90** (2014) 065806. P. Mohr, R. Longland, and C. Iliadis

Nuclear astrophysics in the laboratory and in the universe, AIP Advances **4** (2014) 041006. A. E. Champagne, C. Iliadis, and R. Longland

Performance improvements for nuclear reaction network integration, A&A**563** (2014) A67. R. Longland, D. Martin, and J. José

Evidence for the existence of the astrophysically important 6.40-MeV state of ^{31}S, Phys. Rev. C **88** (2013) 055803. D. Irvine, A. A. Chen, A. Parikh, K. Setoodehnia, T. Faestermann, R. Hertenberger, H.-F. Wirth, V. Bildstein, S. Bishop, J. A. Clark, C. M. Deibel, J. Hendriks, C. Herlitzius, R. Krücken, W. N. Lennard, O. Lepyoshkina, R. Longland, G. Rugel, D. Seiler, K. Straub, and C. Wrede

Mean proton and α-particle reduced widths of the Porter-Thomas distribution and astrophysical applications, Phys. Rev. C **88** (2013) 015808. I. Pogrebnyak, C. Howard, C. Iliadis, R. Longland, and G. E. Mitchell,

Wengchang Lu

Research Associate Professor

Education

Fudan University, China, Ph.D. in Condensed Matter Physics, 1993
Henan Normal University, China, M.S. in Theoretical Physics, 1988
Tianjin University, China, B.S. in Applied Physics, 1984

Professional Experience

2007-	Research Associate Professor, Dept. of Physics, North Carolina State University
2001-2007	Research Assistant Professor, Dept. of Physics, North Carolina State University
1999-2001	Postdoc, Dept. of Physics, North Carolina State University
1997-1999	Postdoc, Muenster University
1994-1997	Postdoc, Max Planck Institut/FKF

Select Publications

Real Space multigrid (RMG) code release, https://sourceforge.net/projects/rmgdft.

First-principles methodology for quantum transport in multiterminal junctions, K. K. Saha, W. C. Lu, J. Bernholc, and V. Meunier, Journal of Chemical Physics **131**,164105 (2009).

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Recent developments and applications of the real-space multigrid method, J. Bernholc, M. Hodak, and W. C. Lu, Journal of Physics-Condensed Matter **20**, 294205 (2008).

Theory of nitrogen doping of carbon nanoribbons: Edge effects, J. Jiang, J. Turnbull, W. Lu, P. Boguslawski, and J. Bernholc, J. Chem. Phys., **136**, 014702 (2012).

Gail McLaughlin
Professor

Education
University of California – San Diego, Ph.D. in Physics, 1996
Princeton University, B.S. magna cum laude in Physics, 1991

Professional Experience
2009- Professor, Department of Physics, North Carolina State University
2005-2009 Associate Professor, Department of Physics, North Carolina State University
2000-2005 Assistant Professor, Department of Physics, North Carolina State University
1998-2000 Postdoc, TRIUMF, Vancouver, BC
1996-1998 Postdoc, INT, University of Washington

Honors and Awards
2010 Alumni Outstanding Research Award, North Carolina State University
2009 Fellow, American Physical Society

Select Publications
Stimulated neutrino transformation through turbulence Physical Review D (2014) 89, 7. Patton, K. M., Kneller, J. P., and McLaughlin, G. C.

The influence of neutrinos on the nucleosynthesis of accretion disc outflows, J. of Physics G (2014) 41: 044004. Caballero, O. L., Malkus, A. C., McLaughlin, G. C. et al

Production of Ni-56 in black hole-neutron star merger accretion disc outflows, J. of Physics G (2014) 41, 044006. Surman, R., Caballero, O. L., McLaughlin, G. C., et al.

Neutrino oscillations above black hole accretion disks: Disks with eletron-flavor emission, Physical Review D (2012) 86, 085015. Malkus, A., Kneller, J. P., McLaughlin, G. C. et al.

Influence of neutron capture rates in the rare earth region on the r-process abundance pattern, Physical Review C (2012) 86, 035803. Mumpower, Matthew R., McLaughlin, Gail C., and Surman, Rebecca

Lubos Mitas
Professor

Education
Institute of Physics, Slovak Academy of Sciences, Ph.D. in Theoretical Physics 1989
Slovak Technical University, Bratislava, Czechoslovakia, Solid State Physics, Dipl. Ing., 1983

Professional Experience
2006-	Professor, Department of Physics, North Carolina State University
2003-2006	Associate Professor, Department of Physics, North Carolina State University
2000-2003	Assistant Professor, Department of Physics, North Carolina State University
1996-2000	Research Scientist, NCSA, University of Illinois at Urbana-Champaign
1992-1996	NSF Postdoctoral Fellow, NCSA, University of Illinois at Urbana-Champaign
1990-1992	Postdoc, Dept. of Physics, University of Illinois at Urbana-Champaign
1988-1989	Research Fellow, Centro di Fisica, C.N.R., Trento (Italy)

Honors and Awards
2010 Fellow of the American Physical Society

Select Publications
Quantum Monte Carlo for Solids, Rev. Mod. Phys., 73, pp. 33-83 (2001), W. M. C. Foulkes, L. Mitas, R.J. Needs and G. Rajagopal

Spin multiplicity and symmetry breaking in vanadium- benzene complexes, Phys. Rev. Lett., 109, 053001(2012), L. Horvathova, M. Dubecky, L. Mitas and I . Stich

QWalk: Quantum Monte Carlo code for electronic structure, J. Comput. Phys., 228, 3390 (2009), L.K. Wagner, M. Bajdich, L. Mitas

Quantum Monte Carlo calculations of structural properties of FeO solid under pressure, Phys. Rev. Lett. 101, 185502 (2008), J. Kolorenc, L. Mitas

Pfaffian pairing and backflow wavefunctions for electronic structure quantum Monte Carlo methods, Phys. Rev. B **77**, 115112 (2008), M. Bajdich, L. Mitas, K.E. Schmidt

Structure of fermion nodes and nodal cells, Phys. Rev. Lett. **96**, 240402 (2006) L. Mitas

Stephen Reynolds

Alumni Distinguished Undergraduate Professor

Education

University of California, Berkeley, Ph.D. in Physics, 1980
University of California, Berkeley, M.A. in Physics, 1973
Harvard, B.A. (magna cum laude, Phi Beta Kappa) in Physics, 1971

Professional Experience

2003	NRC Senior Associate, NASA/Goddard Space Flight Center
2002	Visiting Astronomer, Harvard-Smithsonian Center for Astrophysics
1995 –	Professor, Department of Physics, North Carolina State University
1990-1995	Associate Professor, Department of Physics, North Carolina State University
1985-1990	Assistant Professor, Department of Physics, North Carolina State University
1982-1985	Research Associate, National Radio Astronomy Observatory
1979-1982	Visiting Assistant Professor, Astronomy Department, University of Virginia

Honors and Awards

2012	UNC System Board of Governors Teaching Award
2000	Fellow of the American Physical Society
2000	NCSU Alumni Distinguished Undergraduate Professor
1991	NCSU Alumni Outstanding Teacher Award

Select Publications

Asymmetries in core-collapse super- novae from maps of radioactive 44Ti in Cassiopeia A. 2014, Nature, 506, 339. Grefenstette, B.W., Harrison, F.A., Boggs, S.E., Reynolds, S.P., et al.

X-Ray Emission from Strongly Asymmetric Circumstellar Material in the Remnant of Kepler's Supernova. 2013, ApJ, 764:63. Burkey, M.T., Reynolds, S.P., Borkowski, K.J., & Blondin, J.M.

Dust in a Type Ia Supernova Progenitor: Spitzer Spectroscopy of Kepler's Supernova Remnant. 2012, ApJ, 755:3. Williams, B.J., Borkowski, K.J., Reynolds, S.P., Ghavamian, P., Blair, W.P., Long, K.S., & Sankrit, R.

Magnetic Fields in Supernova Remnants and Pulsar-Wind Nebulae." 2012, SpSciRev, 166, 231. Reynolds, S.P., Gaensler, B.M., & Bocchino, F.

RCW 86: A Type Ia Supernova in a Wind-blown Bubble. 2011, ApJ, 741:96 Williams, B.J., Blair,

W.P., Blondin, J.M., Borkowski, K.J., Ghavamian, P., Long, K.S., Raymond, J.C., Reynolds, S.P., Rho, J., & Winkler, P.F

Robert Riehn

Associate Professor

Education

University of Cambridge, UK, Ph.D. in Physics, 2003
University of Cape Town, South Africa, Physics, B.sc. (hons.), 1999
Technische Universität Clausthal, Germany, Physics, Vordiplom, 1998

Professional Experience

2012-	Associate Professor, Department of Physics, NC State University
2006-2012	Assistant Professor, Department of Physics, NC State University
2003-2006	Research Associate, Department of Physics, Princeton University

Select Publications

Local probing of photocurrent and photoluminescence in a phase-separated conjugated polymer blend by mean of near-field excitation. Robert Riehn, Richard Stevenson, David Richards, Daejoon Kang, Mark Blamire, Andrew Downes, Franco Cacialli, Advanced Functional Materials, 16(4), pp. 469-47 (2006)

Near-field optical lithography of a conjugated polymer, Riehn, R., Charas, A., Morgado, J., Cacialli, F., Applied Physics Letters 82, pp. 526 (2003)

Ultraviolet-visible near-field microscopy of phase-separated blends of polyfluorene-based conjugated polymers. Stevenson, R., Riehn, R., Milner, R.G., Richards, D., Moons, E., Kang, D.-J., Blamire, M., Morgado, J., Cacialli, F., Applied Physics Letters 79, pp. 833 (2001)

Near-Field Enhanced UV Resonance Raman Spectroscopy Using Aluminum Bow-tie Nano-antenna. Ling Li, Shuang Fang Lim, Alexander A. Puretzky, Robert Riehn, and H.D. Hallen, accepted for publication, Applied Physics Letters **101** (2012), art. no. 113116 ,doi: 10.1063/1.4752455

Fluctuation modes of nanoconfined DNA. Alena Karpusenko, Joshua H. Carpenter, Chunda Zhou, Shuang Fang Lim, Junhan Pan, Robert Riehn. Journal of Applied Physics, 111 (2012), art. no. 024701,doi:10.1063/1.3675207

Christopher Roland
Professor

Education
McGill University, Ph.D. in Physics, 1989
McGill University, M.S. in Physics, 1986
University of Western Ontario, B.S. in Applied Mathematics, 1983

Professional Experience
2014-	Advisor to the Dean on IT Affairs, COS NC State University
2002-	Professor of Physics, NC State University
1998-2002	Associate Professor of Physics, NC State University
1993-1998	Assistant Professor of Physics, NC State University
1990-1992	Postdoctoral, AT&T Bell Labs,
1989-1990	Postdoctoral, Physics, Univ. of Toronto
1987	Lecturer, Dawson College, Montreal PQ Canada

Honors and Awards
2012 Fellow of the American Physical Society
1995 NSF Career Award

Select Publications
Structural determinants of polyglutamine protofibrils and crystallites, ACS Chem. Neurosci., submitted 2014 V.H. Man, C. Roland and C. Sagui

Ion distributions around left- and right-handed DNA and RNA duplexes: a comparative study, Nucleic Acids Research, in press online 2014.F. Pan, C. Roland, and C. Sagui

Investigating rare events with nonequilibrium work measurements. II. Transition and reaction rates, J. Chem. Phys. 140, 034115 (2014). M. Moradi, C. Sagui, and C. Roland

Reaction path ensemble of the B-Z DNA transition: a comprehensive atomistic study, Nucleic Acids Research 41, 33 (2013). M. Moradi, V. Babin, C. Roland and C. Sagui

A statistical analysis of the PPII propensity of amino acid guests in proline-rich peptides, Biophysical Journal **100**, 10883 (2011).M. Moradi, V. Babin, C. Sagui, and C. Roland

Celeste Sagui

Professor

Education

University of Toronto, Ph.D. in Physics, 1995
National University of San Luis, Argentina, Licentiate, Physics, 1989

Professional Experience

2009-	Professor of Physics, NC State University
2005-2009	Associate Professor of Physics, NC State University
2000-2005	Assistant Professor of Physics, NC State University
2001-	Affiliate Faculty, Genomic Sciences, NC State University
1998-2000	SLOAN Postdoctoral Fellowship in Computational Biology
1995-1997	Postdoc, McGill University

Honors and Awards

2013	Fellow of the American Physical Society
2004	NSF CAREER Award
1998	POWRE: Professional Opportunities for Women in Research and Education NSF

Select Publications

Structural determinants of polyglutamine protofibrils and crystallites, V.H. Man, C. Roland, and C. Sagui, ACS Chem. Neuroscience, submitted 2014.

Ion distributions around left- and right-handed DNA and RNA duplexes: a comparative study, F. Pan, C. Roland, and C. Sagui, Nucl. Acids Res. 42, 13981-13996 (2014).

Classical electrostatics for biomolecular simulations, G.A. Cisneros, M. Karttunen, P. Ren and C. Sagui, Chem. Rev. 114, 779 (2014).

The gp41(659-671) HIV-1 antibody epitope: a structurally challenging small peptide, Y. Zhang and C. Sagui, J. Phys. Chem. B 118, 69 (2014).

Binding polymorphism in the DNA bound state of the Pdx1 homeodomain, V. Babin, D.L. Wang, R.B. Rose and C. Sagui, PLoS Comput. Biol. 9, e1003160 (2013).

Are long-range structural correlations behind the aggregation phenomena of polyglutamine diseases?, M. Moradi, V. Babin, C. Roland, and C. Sagui, PLoS Comput. Biol. 8, e1002501 (2012).

Conformations and free energy landscapes of polyproline peptides, M. Moradi, V. Babin, C. Roland, T. Darden and C. Sagui, Proc. Natl. Acad. Sci. USA 106, 20746 (2009).

Thomas Schäfer
Distinguished Professor

Education

Regensburg University, B.S., Physics, 1992
Giessen University, M.S. (Diplom), Physics, 1989

Professional Experience

2012 - present Distinguished Professor, North Carolina State University
2006 - present Professor, North Carolina State University
2003 - 2006 Associate Professor, North Carolina State University
2003 - 2004 Associate Professor, State University of New York at Stony Brook
2000 - 2002 Assistant Professor, State University of New York at Stony Brook
2000 - 2005 RIKEN BNL Research Center Fellow
1998 - 1999 Member, Institute for Advanced Study, Princeton
1995 - 1998 Research Associate, Institute for Nuclear Theory, Seattle
1992 - 1995 Feodor Lynen Fellow and Research Associate, SUNY Stony Brook

Honors and Awards

2006 Fellow, American Physical Society
2002 Outstanding Junior Investigator Award, US Department of Energy
1992 Feodor-Lynen Fellow, A.v.Humboldt Foundation, Germany

Select Publications

Medium effects and the shear viscosity of the dilute Fermi gas away from the conformal limit, Physical Review A (2014) 90, 063615. Bluhm, M. and Schaefer, T.
Bulk Viscosity and Conformal Symmetry Breaking in the Dilute Fermi Gas near Unitarity, Physical Review A (2013) 11, 120603. Dusling, K. and Schaefer, T.
Universal mechanism of (semi-classical) deconfinement and theta-dependence for all simple groups, J. of High Energy Physics (2013) 3, 087. Poppitz, E., Schaefer, T., Uensal, M.
Strongly correlated quantum fluids: ultracold quantum gases, quantum chromodynamic plasmas and holographic duality, New Journal of Physics (2012) 14, 115009. Adams, A., Carr, L. D., Schaefer, T., Steinberg, P., Thomas, J. E.
Bulk viscosity, particle spectra, and flow in heavy-ion collisions, Physical Review C (2012) 85, 044909. Dusling, K. and Schaefer, T.
Universal Quantum Viscosity in a Unitary Fermi Gas, Science (2011) 331, 58. Cao, C., Elliott, E., Joseph, J., Wu, H., Petricka, J., Schaefer, T., Thomas, J. E.

John Thomas

John S. Risley Distinguished Professor

Education

Massachusetts Institute of Technology, Ph.D. in Physics, 1979
Massachusetts Institute of Technology, B.S. in Physics, 1973

Professional Experience

2011-	Professor of Physics, North Carolina State University
1991-2011	Professor of Physics, Duke University
1986 -1991	Associate Professor of Physics, Duke University
1981-1986	Research Scientist, Physics Dept., MIT
1980-1981	Assistant Professor, Aeronautics and Astronautics, MIT
1979-1980	Postdoctoral Associate, Aeronautics and Astronautics, MIT
1979	Postdoctoral Associate, Physics, MIT

Honors and Awards

Phi Beta Kappa, Sigma Chi, Fellow of the American Physical Society
Hertz Foundation Predoctoral Fellow (1973-1978).
C. S. Draper Career Development Chair (1980-1981).
NIST Precision Measurements Grant (1990-1993).

Select Publications

Universal Quantum Viscosity in a Unitary Fermi Gas, Science (2011) 331, 58. Cao, C., Elliott, E., Joseph, J., Wu, H., Petricka, J., Schaefer, T., Thomas, J. E.

Observation of a strongly interacting degenerate Fermi gas of atoms, Science, K. M. O'Hara, S. L. Hemmer, M. E. Gehm, S. R. Granade, and J. E. Thomas, **298**, 2179 (2002).

Evidence for superfluidity in a resonantly interacting Fermi gas, J. Kinast, S. L. Hemmer, M. E. Gehm, A. Turlapov, and J. E. Thomas, Phys. Rev. Lett. **92**, 150402 (2004).

Heat capacity of a strongly-interacting Fermi gas, J. Kinast, A. Turlapov, and J. E. Thomas, *Science* **307**, 1296 (2005), with Q. Chen, J. Stajic, and K. Levin.

*All-optical production of a degenerate Fermi gas,*S. R. Granade, M. E. Gehm, K. M. O'Hara, and J. E. Thomas, Phys. Rev. Lett. **88**, 120405 (2002).

Laser-Noise-Induced Heating in Far-Off Resonance Optical Traps, T. A. Savard, K. M. O'Hara, and J. E. Thomas, Phys. Rev. A **59**, Rapid Comm., R1095 (1997).

Mithat Ünsal
Associate Professor

Education

University of Washington, Ph.D. in Physics, 2004
Bilkent University, Turkley, M.S. in Physics, 1999
Bilkent University, Turkley, B.S. in Physics, 1997

Professional Experience

2014-	Associate Professor, Department of Physics, North Carolina State University
2011-2013	Assistant Professor, Dept. of Physics and Astronomy, San Francisco State U
2006-2011	Postdoctoral, Stanford University
2004-2006	Postdoc, Boston University

Select Publications

QCD in magnetic field, Landau levels and double-life of unbroken center-symmetry. Anber, M. M. and Ünsal, M. (2014) J. of High-Energy Physics, 12, 107.

Uniform WKB, multi-instantons, and resurgent trans-series. Dunne, G. V. and Ünsal, M. (2014) Physical Review D, 89, 105009.

Generating nonperturbative physics from perturbation theory. Dunne, G. V. and Ünsal, M. (2014) Physical Review D, 89, 041701.

Resurgence theory, ghost-instantons, and analytic continuation of path integrals, Basar, G., Dunne, G. V., and Ünsal, M. (2013) J. of High-Energy Physics, 10, 041.

Theta dependence, sign problems, and topological interference. Ünsal, M. (2012). Physical Review D, 86, 105012.

Continuity, deconfinement, and (super) Yang-Mills theory, Poppitz, E., Schäfer, T., and Ünsal, M. (2012) J. of High-Energy Physics, 10, 115.

The semi-classical expansion and resurgence in gauge theories: new perturbative, instanton, bion, and renormalon effects, Argyres, P. C. and Ünsal, M. (2012) J. of High-Energy Physics, 8, 063.

Hong Wang
Assistant Professor

Education

University of North Carolina–Chapel Hill, Ph.D. in Applied and Materials Science, 2003
Zhejiang University, Zhejiang, P.R. China, B.S. in Materials Sciences, 1991

Professional Experience

2012 – Assistant Professor, Department of Physics, North Carolina State University
2008- 2011 Postdoctoral Fellow, University of Pittsburgh
2004-2008 Postdoctoral fellow, National Institute of Environmental Health Sciences

Select Publications

TRF1 and TRF2 use different mechanisms to find telomeric DNA but share a novel mechanism to search for protein partners at telomeres. Lin, J., Countryman, P., Buncher, N., Kaur, P., E, L., Zhang, Y., Gibson, G., You, C., Watkins, S.C., Piehler, Opresko, P., Kad N., Wang, H. (2014) Nucleic Acids Res, 42, 2493-2504.

Single-molecule analysis reveals human UV-damaged DNA-binding protein (UV-DDB) dimerizes on DNA via multiple kinetic intermediates. Ghodke, H., Wang, H., Hsieh, C.L., Woldemeskel, S., Watkins, S.C., Rapic-Otrin, V. and Van Houten, B. (2014) PNAS, 111, E1862-1871.

Probing transient protein-mediated DNA linkages using nanoconfinement, Roushan, M., Kaur, P., Karpusenko, A., Peston J. C., Ortiz, C. P. Lim, S. F., Wang, H. and Riehn, R. (2014) *Biomicrofluidics,* in press.

Collaborative dynamic DNA scanning by nucleotide excision repair proteins investigated by single-molecule fluorescence imaging of quantum dot labeled proteins. Kad, N., Wang, H., Kennedy, G.G., Warshaw, D.M., Van Houten, B. (2010). Molecular Cell Mar 12;37(5):702-13.

Keith R. Weninger
Associate Professor

Education
University of California, Los Angeles, Ph.D. in Physics, 1997
University of California, Los Angeles, M.S. in Physics, 1993
University of Wisconsin-Madison, B.S. in Mathematics, B.S. in Physics, 1992

Professional Experience
2009- Associate Professor, Dept. of Physics, North Carolina State University
2004- Associate Member, Dept. of Molecular and Structural Biochemistry, NCSU
2004-2009 Assistant Professor, Dept. of Physics, North Carolina State University
2000-2004 Postdoc, Department of Physics, Stanford University
1997-2000 Postdoc, Department of Physics, University of California, Los Angeles

Honors and Awards
2013 University Faculty Scholar, North Carolina State University
2010 Research Scholar Award, American Cancer Society
2015 Ralph E. Powe Junior Faculty Enhancement Award, Oak Ridge Associated Universities
2002 Career Award at the Scientific Interface, Burroughs Wellcome Fund

Select Publications
Single molecule studies of DNA mismatch repair, D. Erie and K. Weninger, *DNA repair*, accepted (11 pages) (2014).

Dynamics of MutS-mismatched DNA complexes are predictive of their repair phenotype, V. C. DeRocco, L.E. Sass, R. Qiu, K.R. Weninger, D.A. Erie, *Biochemistry*, **53**, 2043-2052 (2014).

The cancer/testes antigen PAGE4, a regulator of c-Jun transactivation, is phosphorylated by homeodomain-interacting protein kinase 1, a component of the stress-response pathway, S.M. Mooney, R. Qiu, J.J. Kim, E. Sacho, K. Rajagopalan, D. Johng, T. Shiraishi, P. Kulkarni, K.R. Weninger, *Biochemistry*, **53**, 1670-1679 (2014).

The stress-response protein prostate-associated gene 4, interacts with c-Jun and potentiates its transactivation, K. Rajagopalan, R. Qiu, S.M. Mooney, S. Rao, T. Shiraishi, E. Sacho, H. Huang, E. Shapiro, K.R. Weninger, P. Kulkarni, *Biochim Biophys Acta.*, **1842**, 154 (2014).

Large conformational changes in MutS during DNA scanning, mismatch recognition and repair signaling, R. Qiu, V.C. DeRocco, C. Harris, A. Sharma, M. Hingorani, D.A. Erie, K.R. Weninger, The EMBO Journal 31, 2528-2540 (2012).

A. **Honors or awards *received in 2014***, from University or Professional Societies

B. **Publications**
   a. In peer-reviewed journals (with impact factor > 1), published in 2014
   b. Conference proceedings, books/chapters, software, published in 2014
   c. Other publications (including items submitted but not yet published)

C. **Research grants in effect** title, agency, investigators, amount, period of grant
   For RADAR report, log in to https://www3.acs.ncsu.edu/sor/search.php and select 'Advanced Project Query'; select the Investigator, fill in 01/01/2014 through 12/31/2014 for 'Awards Active…'and hit 'Run Query.' You do not need to use the RADAR format.

D. **Proposals submitted**
   For RADAR report, log in to https://www3.acs.ncsu.edu/sor/search.php and select 'Generate Date-limited Report'; fill in 01/01/2014 through 12/31/2014 and select the PI; highlight 'Detailed Proposal Report' and submit. This may not include everything, e.g., renewal proposals.

E. **Research Mentoring**
   a. Undergraduate research students (name, source of funding, outcomes)
   b. Graduate research students (name, brief status, source of funding)
   c. Students receiving graduate degrees in 2014 (name, current employment)
   d. Other graduate student committees
   e. Postdoctoral researchers

F. **Invited talks, seminars, colloquia**

G. **Contributed talks and posters at professional meetings**

H. **Other research activities and achievements** not included above, e.g., research collaborations, meetings attended, facilities development, press releases, etc.

I. **Classroom Instruction**
   a. Courses taught
   b. Documented peer evaluation of instruction
   c. Course/Curricular development
   d. Teaching Scholarship and Development; list activities associated with improvement of teaching

J. **Service to the Department, College or University**
   a. Service roles (academic advising, course coordinator, etc.)
   b. Committees; identify those chaired by you
   c. Graduate and undergraduate recruiting activities
   d. Other department/college/university service (faculty mentoring, departmental reports, proposals, panels, etc.)

K. **Service in Professional Organizations** elected offices, boards, panels, workshop and conference committees

L. **Outreach and extension** presentations to public agencies, public schools, government agencies, public events or collaborations with external education or public agencies

M. **Other activities and achievements** not included above

N. **Professional development,** describe briefly your plans for next year

		Committees chaired last 5 yrs			
		Master's		PhD	
Name	Rank	Comp	Current	Comp	Current
Ade,Harald	Distinguished Professor	19	1	3	4
Aspnes,David E	Distinguished University Prof	1		5	
Beichner,Robert J	Professor			4	5
Bernholc,Jerzy	Drexel Professor		1	4	4
Blondin,John M	Professor			1	
Bochinski,Jason	Lecturer			1	
Borkowski,Kazimierz	Research Professor	1		1	
Brown,John D	Professor			2	
Buongiorno-Nardelli, M	Adjunct Professor			5	
Chabay,Ruth W.	Emeritus Professor	2		5	
Clarke,Laura I	Associate Professor	4		4	
Daniels,Karen E	Associate Professor	1	1	3	2
Dougherty,Daniel B.	Associate Professor	2	1	4	5
Ellison,Donald C	Emeritus Professor				1
Golub,Robert	Professor			1	1
Gould,Christopher R.	Professor	1			
Gundogdu,Kenan	Assistant Professor	1		1	3
Haase,David G.	Professor			1	
Hallen,Hans D	Professor			3	3
Huffman,Paul R	Professor	1		5	3
Ji,Chueng Ryong	Professor	8	2	2	2
Kneller,James P	Assistant Professor				1
Krim,Jacqueline	Distinguished University Prof	1		5	3
Lazzati,Davide	Adjunct Assoc Professor		1	1	
Lee,Dean J.	Professor			3	1
Lim,Shuang Fang	Associate Professor		1		1
Lucovsky,Gerald	Distinguished University Prof			3	1
McLaughlin,Gail C.	Professor			2	1
Mitas,Lubos	Professor			7	1
Mitchell,Gary E.	Emeritus Professor			6	
Paesler,Michael	Professor			1	2
Pearl,Thomas P.	Adjunct Asst Professor			2	
Reynolds,Stephen P.	Professor	1		1	
Riehn,Robert	Associate Professor			4	2
Roland,Christopher M	Professor	1		2	1
Rowe,John E	Research Professor	1		1	

Sagui,Maria C	Professor	2		3	1
Schaefer,Thomas M	Distinguished Professor			2	
Sherwood,Bruce A.	Research Professor			1	
Thomas,John E	Risley Professor				3
Wang,Hong	Assistant Professor				1
Weninger,Keith R.	Associate Professor			3	1
Young,Albert R.	Professor		1	3	5

Note: The adjunct professors listed above were originally in T/TT positions.