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Department Happenings
— from the Chair, Daniel J. Gauthier

This has been a very active year here in Duke Physics and at Duke in general, with many exciting developments and several challenges. Our research activities continue to grow and have garnered international recognition. I am particularly impressed by the way that faculty have undertaken collaborative research that crosses sub-disciplinary boundaries within the department or disciplinary boundaries within the university. External funding for research continues to be a challenge, although most groups have been able to maintain or even expand their funding base. The graduate and undergraduate programs continue to remain strong and the department continues to expand its outreach activities in the Triangle area.

Campus-wide, the events of this spring related to the Duke men’s lacrosse team has generated many discussions - sometimes through formal meetings, but often through informal hallway conversation. While the situation continues to unfold, I anticipate that the university will use this event as an opportunity to change the way we think of campus life and the role of faculty in informal mentoring of students, especially outside the classroom.

In this note, I’ll touch on general issues that affect the department. I hope you will enjoy reading the rest of this newsletter to learn more about developments in our teaching programs, our undergraduate and graduate students’ accomplishments, and several exciting research topics currently being pursued here at Duke. I am especially pleased that this issue includes a profile of Maxine Stern, who has been a truly important contributor to the department for many years now.

Strategic Plan

Duke is in the final stages of developing a new strategic plan that will guide the administration’s efforts to support our research and teaching activities over the coming years. The Provost recently announced the overall goals, which include new initiatives to attract top faculty, involve students in the arts, and promote scholarship on real world issues.
The College of Arts & Sciences has identified three primary goals for its part of the plan:

Goal 1: Develop Duke’s Distinctiveness as a Nationally Recognized Leader in Emerging Fields and Disciplines; Goal 2: Enhance Duke’s Distinctiveness as a Leader in Inquiry-Based, Interdisciplinary Education; Goal 3: Provide an Appropriate Infrastructure to Support the Development of Arts and Sciences.

Related to our research mission, the plan proposes that we make differential investment in a limited number of thematic areas: Arts in Context; Brain, Mind, and Behavior; Global Health and Human Welfare; Individual and Collective Ethical Behavior Integration across Scale in the Sciences; Transcultural Studies; and Visual Culture. I anticipate that Duke Physics will be most able to support the initiatives in Brain, Mind, and Behavior (with a sub-focus in Imaging) and Integration across Scales in the Sciences. The plan also emphasizes the enhancement of cross-department and cross-school collaborations. (See http://www.aas.duke.edu/plan/plan.pdf.)

Bricks and Mortar

Construction continues on the French Family Science Center. The building will be partially occupied this fall, with full occupancy slated for January 1, 2007.

The renovations of the Advanced Laboratory and upper-level teaching laboratories in the sub-basement are moving along rapidly. This renovated space will create new learning opportunities for our majors, and faculty are developing new experiments to populate the labs.

The Staff Shop has been upgraded to a better training facility and workplace for students and others. This improvement in infrastructure is important for bringing our teaching and research mission to the next level. (See Staff News also.)

As many of you know, maintenance of the Physics Building has been deferred for years. The university is making a push to upgrade the space; this year, Prof. Behringer’s laboratories are getting a long-awaited face lift. It was also realized that the room numbering scheme no longer met with campus safety regulations, so all the room numbers have changed.

Faculty News

At a ceremony in the National Academies building on February 13, Prof. Arlie Petters was inducted into the National Academy of Sciences Portrait Gallery of Distinguished African-American Scientists. A much larger version of the portrait shown here is now on permanent display at the National Academies Keck Center in Washington, DC. It is wonderful to see Prof. Petters honored this way.

Prof. Haiyan Gao was the recipient of the 2005 Overseas Outstanding Young Scholar Collaborative Award bestowed by the China National Science Foundation. Congratulations to Prof. Gao!

Dr. Mary Creason was elected to the Executive Board of the APS Forum on Education as the APS/AAPT member at large. The Forum on Education (FoE) to involve APS members in activities related to physics education at all educational stages, from elementary to graduate school. APS members can join the FoE at http://www.aps.org/units/fed.

Research Scientist Dr. Mohammad Ahmed (TUNL) has been named Assistant Research Professor of Physics in the Department, beginning October 1, 2005.

Assistant Research Prof. Dipangkar Dutta will become a tenure-track Assistant Professor in the Department of Physics and Astronomy at Mississippi State University in August, 2006. He plans to continue his work involving collaborations at Jefferson Lab, Oak Ridge, and Duke.

I am sorry to report that Prof. Henry Everitt has left Duke Physics and the U.S. Army Research Office. Dr. Everitt will take the lead scientific position at Redstone Arsenal in Huntsville, Alabama. His Ultrafast Semiconductor Spectroscopy Laboratory has moved to Huntsville, but he will continue to collaborate with Duke faculty in Physics and Engineering. We will miss his many contributions to the Department and wish him all the best in his future research and life in Huntsville.

It is with regret that I report that Mrs. Mary Lewis died suddenly near the end of February. Mary was the widow of Harold Lewis, a former Duke Physics faculty member who died in 2000. Harold was also Dean, Vice Provost, and Chair of Physics through the 1960’s-1980’s. Both he and Mary were well known around the university.
Department Happenings

Staff News

I am happy to report that Ms. Chrystal Stefani has joined the departmental front-office staff as Assistant to the Director of Undergraduate Studies and that Ms. Donna Ruger has changed her role to be the Assistant to the Director of Graduate Studies. Both Ms. Ruger and Ms. Stefani will also provide administrative support to a number of faculty members and the department in general.

Jimmy Dorff is our new Senior Systems Programmer, having moved from Nortel Networks in the Research Triangle Park. He is looking forward to continuing Linux support and working on end user education. He has taken the place of Seth Vidal, who is now a Senior Systems Administrator in the Duke Office of Information Technology. We thank Seth for his many contributions to the Department and wish him the very best.

Richard Nappi has joined the Department as a Lecturing Fellow. Mr. Nappi is in charge of the Staff Shop and will create courses to train community members in safe machining methods as well as in the craft of fine machining. He joins us from the Duke Eye Center. He has already graduated his first class of student-machinists.

Leadership Changes

The Department now has a new Associate Chair for Teaching (ACT) and a new Director of Undergraduate Studies! Prof. Ronen Plesser stepped down on June 30 after a three-year term as ACT. He has made numerous improvements to the management of teaching in the Department while helping to oversee the quality and vitality of our programs. The new ACT is Prof. Haiyan Gao.

Prof. Calvin Howell is stepping down from the DUS position and stepping up to be the Director of TUNL. Prof. Howell has done an excellent job engaging our majors in a rigorous program, especially in the area of independent study and senior dissertation projects. He will be turning over the undergraduate program to Prof. Seog Oh.

I would like to thank Profs. Plesser and Howell for their dedicated service to the teaching mission of the department and I look forward to the new heights to which I believe Profs. Gao and Oh will elevate our educational programs. In assuming the directorship of TUNL, Prof. Howell will succeed Prof. Werner Tornow. I thank both of them for their dedication and hard work on behalf of the lab.

Teaching Program News

by Associate Chair Ronen Plesser

The ongoing review of the teaching program continued this year with the implementation of changes planned last year as well as a few new developments:

Our first Graduate Teaching Fellows, Ribhu Kaul and T. Brian Bunton, did an outstanding job as instructors. Students found that Ribhu’s course on computational physics gave them the confidence to tackle computational tasks in their research. Brian’s students found his skill and dedication an asset in their PHY53 experience. In the second year of the program, Hans Norrell has been selected as a Graduate Teaching Fellow, and he will be teaching a recitation section of PHY53 this fall.

The off-semester sequence of PHY53 was very successful. Interest was high and enrollment limited by capacity. We will continue to offer this class. For the first time, PHY54 has been added to the summer offerings at the Duke Marine Lab in Beaufort.

An online survey tool was used for administering the departmental Climate Survey, affording students the opportunity to fill out the survey at a time and place of their choosing. This is expected to provide more insightful comments. We will expand use of this tool to provide ongoing feedback.

The graduate core curriculum is being critically evaluated by a committee of faculty and students. We hope to present a proposed revision to the faculty early in the fall.

Physics Study Nights have been quite successful. Every Sunday or Thursday evening graduate and undergraduate students meet for informal discussion of homework sets, research, or other topics of interest to the students. Prof. Richard Palmer organized the schedule and a number of faculty members took a turn at hosting the event.

It has been a challenging and exciting three years for me as Associate Chair, but I am looking forward to more time for research and teaching. I owe more people thanks for help and wisdom than I can list here.
In the May 2006 Duke Graduation Ceremonies, eleven Physics students received Ph.D.s:

**Heejeong Jeong**, for “Direct Observation of Optical Precursors in a Region of Anomalous Dispersion,” with Dan Gauthier;

**Ribhu Kaul**, for “Interacting Electrons and Quenched Randomness: Mesoscopic Kondo Problem to the Kondo Lattice,” with Harold Baranger;

**Joe Kinast**, for “Thermodynamics and Superfluidity of a Strongly Interacting Fermi Gas,” with John Thomas;

**Chang-Won Lee**, for “Energy Transfer and Relaxation Dynamics of Europium-doped GaN,” with Henry Everitt;

**Meng-Ru Li**, for “Propagation of Bursts through Noisy Heterogenous Synfire Chains: A Theoretical Study with Application to the Songbird Nucleus HVC,” with Henry Greenside;

**Alex Makarovski**, for “Nanoscale Transport In Single-Walled Carbon Nanotubes with Doubly Degenerate Orbitals,” with Gleb Finkelstein;

**Matthew Prior**, for “Low Temperature Scanning Probe Microscopy of Single Walled Carbon Nanotubes,” with Gleb Finkelstein;

**Sven Rinke**, for “Worldsheet Approach to Strings and D-Branes,” with Ronen Plessner;

**Samadrita Roychowdhury**, for “High Brightness Electron and Photon Beams,” with Vladimir Litvinenko;

**Amanda Sabourov**, for “Understanding 7Li(d,n)8Be Reaction at Astrophysically Relevant Energies,” with Henry Weller;


A September 2005 Ph.D. was earned by **Oleg Tretiakov** for “Theory of Decay of Metastable States in Resonant Tunneling Structures,” with Konstantin Matveev.

Preliminary Exams were passed this year by **James Esterline**, Ken McKenzie, Zheng Gao, James Joseph, Arya Roy, Phillip Wu, and Xing Zong. Each is now a candidate for the PhD degree. A MS degree was obtained by **Josh Tuttle** and a MA degree by **Hyun-Kyung Ko**. In January 2006, five more graduate students completed their qualifying requirements. Congratulations to them.

A number of our graduate students have been recognized for their excellent work this year. **Andrew Dawes** won the Gordy Fellowship; **Ribhu Kaul** won the Fritz-London Fellowship; **Hana Dobrovolny** was elected Member-at-Large to the American Physical Society’s Forum on Graduate Student Affairs; **Alan Dunn** won a National Science Foundation Fellowship; and **Xin Qian** won the SURA/Jefferson Lab Graduate Fellowship.

We have the following information on the employment of the May 2006 Ph.D. recipients: **Heejeong Jeong** is a postdoc at Dartmouth; **Ribhu Kaul** is a postdoc at Harvard; **Joe Kinast** is a postdoc in Duke Physics; **Chang-Won Lee** is a scientist at Samsung Advanced Institute of Technology; **Matthew Prior** is the Principal Physicist at GlaxoSmithKline; **Amanda Sabourov** is at the Idaho National Laboratory; and **Rob Saunders** is a postdoc at Duke in Radiology.

We thank the Graduate Student Organization for their excellent work and advocacy for the Physics graduate students this past year. **Carolyn Berger** and **Joe Kinast** proved important resources as the GSO ombudspersons for the Physics graduate students. **Hana Dobrovolny** is stepping down from her position as GSO mentor coordinator. We thank her for the excellent work she did in building and maintaining a strong mentor program for our incoming graduate students.

We also thank the GSO for their enthusiasm and effort in welcoming graduate school applicants at our Open House 2006. As usual, faculty, staff, and students were generous with their time, help, and labs to make Open House 2006 a success. Our visitors speak very highly of this event. Special thanks go to the GSO recruiting committee: **Mary Kidd**, Brian Tighe, and Phillip Wu. We appreciate all of the graduate...
students who give of their time both at the Open House and when prospective graduate students drop by throughout the year to investigate Duke Physics. Thank you to Donna Ruger for handling the logistics of housing and reimbursement, and helping to manage the visits.

In addition to the Open House, our other major annual recruiting activity is to host visitors from Historically Black Colleges and Universities (HBCUs) in Atlanta. We hope to eventually expand this activity to include further HBCUs. This year eleven physics majors and two Physics faculty members visited from Morehouse College, Spelman College, and Clark Atlanta University. Thank you to graduate student volunteers Rufus Phillips, Samadrita Roychowdhury, and Xing Zong. Thanks also to Calvin Howell for providing a tour of the TUNL/HIγS facility, to Bill McNairy for his creative demonstrations, and to Donna Ruger for her organizational help.

Last year Duke Physics needed an updated Duke Physics Poster to advertise our graduate program. We held a contest open to graduate students and their colleagues. Our winners were Brad Marts and Eric Monson. You can see their winning design on this page and at undergraduate Physics departments throughout the country. We thank them for creating an attractive and compelling illustration of what Duke Physics has to offer.

The DGS has created a list of deadlines and responsibilities/suggestions that will be relevant to each graduate student during his/her time here at Duke (see http://www.phy.duke.edu/~rps/grad/checklist.html). This will hopefully help clarify what each student needs to do and when it needs to be done, along with providing links to both Physics and Graduate School policy pages. We welcome suggestions on what we can do to further clarify procedures and expectations in Duke Physics.

We are pleased to welcome an incoming graduate class of sixteen students for Fall 2006. The new students hail from China, Taiwan, Eritrea, and the United States. Their interests and experience include gravitational lensing, nanophysics, string theory, condensed matter theory and experiment, nuclear and particle theory, biophysics, nonlinear dynamics, cold atoms, and high energy experiment. This is an extremely strong class, with three James B. Duke Scholars, one University Scholar, and one Homeland Security Fellow. We will also have one exchange student from Germany. Some of the students will be arriving in the Summer of 2006 to begin research at Duke. All students will join us for our orientation events and welcoming Physics picnic before classes begin August 28, 2006.

The job of DGS would not be possible without the help of the DGS-Assistant and the Associate Chair for Teaching (ACT). Special thanks go to Donna Ruger, DGS-Assistant, for her enthusiasm and support all year long and to Ronen Plesser, ACT, for being such a great resource.
The Class of 2006

This year 19 students graduated in May with bachelor’s degrees in physics of which 12 were first majors. The first majors are shown in the photograph along with one second major (Grant Degler), one student who will graduate in December (Alexandria Owen) and the Director of Undergraduate Studies, Calvin Howell. The graduating second majors who are not shown in the photo are: Daniel Fritchman, William Hwang, Charles Lin, Stephen Relyea, Eric Tong and Thomas Williams. This class continues the tradition of academic excellence by our majors. Nine of our majors graduated with university honors and six graduated with physics department distinction. Our graduates continue to be accepted into the top graduate programs in the nation. Students from this class will attend graduate programs in physics or related fields at Cornell University, Duke University, Harvard University, Massachusetts Institute of Technology, Michigan State University, Oxford University and Rutgers University.

This class will follow impressively diverse career paths. Seven of our graduates will start graduate school this fall in physics or related fields, and one will attend law school. Others plan to attend graduate or professional school in engineering, bioinformatics, medicine and business after working for a few years. An important goal of the undergraduate physics program is to produce scientists who are capable of and interested in teaching physics to a broad audience. We are pleased that one of our graduates, Allen Lee, has expressed an interest in teaching high-school physics. We make special note of our graduates who serve our country in the military. This year we have one student who will start active duty after graduation. Thomas Williams will attend the Navy Nuclear Power School as a commissioned officer.

Providing students with opportunities to participate in frontier research is important to our success in attracting some of the brightest students at Duke as physics majors. Six of our majors in the graduating class of 2006 completed honors theses projects in physics and graduated with department distinction. They were: John Barton, “Leg-pole Factor Transformations in Two Dimensional String Theory,” supervised by Ronen Pless; Kate Bell, “Laser-Driven Polarized Light-Nuclei Gas Targets,” supervised by Haiyan Gao; Thomas Corona, “Simulation Tools for the 2KM detector at the T2K Experiment,” supervised by Chris Walter; Edward Daverman, “Search for Excited Muon Production Using the Dimuon + Photon Signature at CDF in Run II,” supervised by Ashutosh Kotwal; Ingrid Kaldre, “A Compact, Air-cooled Zeeman Slower as a Cold Atom Source,” supervised by John E. Thomas; and Abhijit Mehta, “Order of the Chiral Phase Transition in the Absence of the Anomaly,” supervised by Shailesh Chandrasekharan.

SPS and Sigma-Pi-Sigma News

At the conclusion of the annual department poster session for graduate and undergraduate research, which was held on April 14, six students were inducted into the Duke chapter of Sigma-Pi-Sigma, the national physics honor society. William McNairy, the faculty advisor for the Duke chapter, presided over the induction ceremony. The new members are: Morgan Brown (class of 2007), Joyce Coppock (class of 2006), Julia Goyer (class of 2007), Roarke Horstmeyer (class of 2007), Richard Wall (class of 2007), Katie West (class of 2007) and James Zou (class of 2007).

The officers of the Society of Physics Students (SPS) for this academic year (2004-05) were: Peter Blair (president), Alvaro Chavarria (vice president), Abhijit Mehta (treasurer), Jon Adkins and Allen Lee (social chairs) and Nigel Barrella (community service chair). Under their direction the SPS hosted activities that highlighted research at Duke and encouraged undergraduate students to become engaged in research. We congratulate the SPS for a very successful year, and we thank the SPS officers for their service and all who worked with the SPS this year. New officers for SPS were elected in the spring 2006.
The new officers for the 2006-07 academic years are: Alvaro Chavarria (president), Nigel Barrella (vice president), Anthony Aikens (treasurer), Richard Wall (secretary), Barry Wright (social chairs) and Forrest Sheldon (community service chair).

Student Scholarships

In this section we recognize physics majors who were awarded national scholarships and awards during the 2005-06 academic year.

William (Billy) Hwang (class of 2006) is one of the three Duke students this year who received a Rhodes Scholarship. This scholarship will cover all expenses for graduate studies at Oxford University for up to three years. In addition, Billy was awarded an NIH/Oxford Biomedical Research Scholarship which will cover the cost of up to five years of graduate and medical school for students pursuing dual Ph.D.-MD degrees.

Peter Blair (class of 2006) was awarded a Bell Graduate Research Labs Fellowship. This fellowship will provide stipend support for up to four years of graduate study. Peter will also receive a Harvard Purcell Fellowship and Graduate Prize to support his first year of graduate school at Harvard University.

Abhijit Mehta (class of 2006) was awarded a University Scholars Program Fellowship at Duke University. This fellowship provides tuition and a stipend for the first year of graduate school at Duke University. In addition, Abhijit is a recipient of a James B. Duke Fellowship which will provide a stipend supplement for up to four years of graduate study.

Aaron Pollack (class of 2009) was awarded an American Physical Society Scholarship for Minority Undergraduate Physics Majors. This scholarship provides an annual stipend for up to two years of undergraduate study in physics.
Demonstration Facility Renovated and Expanded

by Bill McNairy

Big changes have been made to the Demo Room of the Physics department during the past seven years. In 1999, the demonstration collection was housed in room 104I, located behind the large lecture rooms. Approximately 150 demonstrations collected during the 20th century were scattered about the room on shelves that also held stored items for the Math and Physics departments. At the rear of the room was a storage area for TUNL equipment. In 1999 the Department decided to restore and expand the collection and hired Dr. William McNairy to do this. While he split time between the demonstration collection and teaching Introductory Physics, Dr. McNairy sorted through the existing demonstrations and planned the renovation of the facility. During the summer of 2000 the room was stripped to the walls (and roof!) and stored materials moved to other locations. The facility was completely renovated with the addition of an office for the Demonstration coordinator, expanded shelving, work tables, and fume hood. If you left Duke before 2000, you will be excused for not believing that the picture on this page was taken in the Physics Building!

In the years since, demonstrations have been categorized by conceptual content using the PIRA Demonstration Classification Scheme (http://www.wfu.edu/physics/pira/dcs/PIRADCS.html ). The original collection has been expanded to include over 900 items: approximately 600 are commercially available demos with the remainder being 'home-built'. Some are as simple as plastic straws that are cut to make very popular examples of a resonance reed while some demos are quite sophisticated, such as the awe-inspiring cloud chamber in which tracks from cosmic rays can be briefly seen.

Due in part to recent research on physics pedagogy, but also to the availability of demonstrations and Dr. McNairy’s support, the usage of the department’s collection has risen dramatically in recent years. Initially, expectations were that a few courses, primarily the introductory courses, would use a few dozen demonstrations during the course of a semester. The number has now reached several hundred per semester, including expanded use of demonstrations in the upper-level courses for majors.

Dr. McNairy’s top demos

Top 5 Golden Oldies
1) Charge to Mass Ratio of the electron using a e/m tube with Helmholtz coils
2) Theatrical dimmer circuit showing LR and LRC circuits
3) Frankenstein Lab Spark Machine, a.k.a. Jacob’s Ladder
4) Whimshurst electrostatic generator
5) “Shoot Gumby” projectile apparatus

Top 5 New Acquisitions
1) Lecture Hall Cloud Chamber
2) Double Belt Van de Graaff Generator
3) Elihu Thompson Ring Flinger
4) Low–T Stirling Engine
5) Matched Tuning Forks and Resonators
Demo Outreach: Teaching and Learning in the Extended Community

by Bill McNairy

In the darkened room eager eyes watch a cone of light passing through a beaker of water. Slowly over the next few minutes the water turns cloudy, scattering blue light, then the mid-range wavelengths of color. The transmitted light cast on a screen turns yellow-orange, then a deep red. Finally, the beaker is filled with milky-white light scattered multiple times by a growing precipitate from the dilute sodium thiosulfate and sulfuric acid solution stirred in minutes ago by the instructor. Thus the audience has seen both why the sky is blue and why sunsets are red. Is this a classroom in Introductory physics at Duke? Or a third grade class at CK Poe Elementary School in Durham? Or a public lecture at the Chapel Hill Public Library?

Actually, the answer to each of these questions is "Very likely"! Since the renovation of the Demonstration Facility in 2000, the Department of Physics has not only seen an increase in the use of demonstrations for courses, but also an explosive growth in their use by faculty and students in outreach efforts to the community at large. During the 2005-06 academic year, over 400 demonstrations have been used for more than 80 programs outside the Physics Building. Dr. Henry Greenside has given several talks on fusion and modern physics in schools and libraries, Dr. Ronen Plesser has visited many local schools as well as several around the state to talk about Astronomy, Dr. William McNairy has visited schools and science fairs to present varied Demonstration Shows. Dozens of engineering students, funded by NSF grants secured by Dr. Gary Ybarra of the Pratt School’s Department of Electrical and Computer Engineering, use physics demonstrations to enhance their work as science and math specialists in public elementary and middle schools around Durham. Many of the faculty and students in Physics have visited schools and community organizations to present programs for old and young alike. The desire to see and understand physics phenomena draws in crowds who have never had a course in Physics, and the Physics Department is thrilled to support the teaching of physics beyond the boundaries of Duke’s campus.

Top Ten Outreach Demonstrations

1) Seat of Nails
2) Sunset Demonstration
3) Large Concave and Convex Mirrors
4) Interference Patterns in Large Soap Bubbles
5) Fire Extinguisher / Rocket Cart
6) Rotating Stool with Masses
7) Archimedes Diver
8) Van der Graaff generator
9) Standing Waves on a String with Strobe Light
10) Methanol Bottle Explosion

Making liquid nitrogen cooled ice cream in a jiffy.
Maxine Springer Stern grew up with two brothers in Woodmere, a small town on Long Island, not far from New York City. After completing a BA in History at the University of Rochester, she earned a PhD in Sociology from the University of North Carolina at Chapel Hill and worked for 10 years as a researcher. While working towards her doctorate, she married Alan Stern, a friend from high school who is now a psychoanalyst working in Chapel Hill, N.C. They have 2 children: a son, Samuel Stern, who lives in Massachusetts; and a daughter, Rebecca Stern, who lives in New York City.

While working as Director of Research and Evaluation at a mental health center, Dr. Stern realized that to evaluate programs, one needs to understand their costs, not just their content. She took an accounting course at the business school at UNC and liked it so much she decided to become a CPA. After she completed CPA training and worked for several years as an Accounting and Financial Planner for a research company, friends suggested that she apply for a position at Duke because of the college tuition benefit. She was soon hired as Assistant Director in the Office of Research Support at Duke University. (The tuition benefit did turn out to be important later in sending Becca to Swarthmore College and Sam to Brown University.)

When Hurley Mulkey announced his retirement, former chair Larry Evans conducted a thorough search for his replacement. Dr. Evans recalls that “the job was made quite attractive because the Dean had agreed to upgrade the position. Of our three main candidates the only one known to many of our faculty was Maxine, because she worked in the Office of Research Support, which processes proposals to granting agencies. When she agreed to accept our offer we were delighted, but some of my friends in the other sciences were not at all happy that we had taken away the most competent person at ORS — some said the only competent person. It is worth noting that ORS replaced her with three people.”

Maxine’s first major challenge after joining the Physics Department was to work with the university administration to
set up the financial structures governing the building and maintenance of the Duke Free Electron Laser Lab. Former chair Harold Baranger notes that for the past 15 years, the DFELL budget has dominated the department's discretionary budget and “has to be managed very, very carefully, which Maxine does extremely well.” Her handling of projections and cost allocations has been greatly appreciated by everyone involved. As former chair Berndt Muller puts it: “During [the mid-’90s] the Department went through a difficult period as the leadership of the DFELL changed. It was a great relief to be able work with someone as competent and diligent as Maxine, who had everything related with budgets and administrative issues under firm control. I recall thinking many times that it was her stewardship of the Department which allowed all of us to focus on our own work and to sleep well at night.”

In addition to her CPA training, Maxine's general managerial and personal skills are much appreciated by her colleagues. Former chair Bob Behringer notes that “In some sense, she is the administrative glue that holds the department together. Her depth of experience, and knowledge of how the university operates are an exceptional benefit to the department. Adding to that a her real sense of dedication, and her openness and friendliness, makes for an a fantastic person in the front office.” Donna Ruger, Staff Assistant to the DGS, who has worked with Maxine for 16 years, also speaks highly of her personal qualities: “Maxine treats everyone fairly and is there for us. She is a compassionate, kind and energetic person, and because of this, there is a real comradery among the staff. She is eager to work with her co-workers/staff to help them achieve their full potential.” Donna Elliott, Administrative Secretary, agrees, adding that “Maxine’s door is always open if you have a problem and need help.” And Larry Evans recalls that “During my tenure as chairman three successive managers of the instrument shop retired and had to be replaced — the final replacement being Robert Timberlake, whom we were lucky to be able to keep. The shop and its staff present a set of people and issues quite different from the academic parts of the department, and fortunately we had Maxine, who was able to deal effectively with all of the managers despite their very different personalities.”

When not busy with departmental business, Maxine enjoys the beauty of the Duke campus, and Duke Gardens in particular. She is especially interested in North Carolina wildflowers. Alan and Maxine have also enjoyed traveling both to cities and to remote locations. She reports that the highlight of their travels was a safari to Kenya and Tanzania. Closer to home, Maxine enjoys spending time with family members and at monthly dinners with a group of long-standing women friends.

Maxine is also active in the Jewish community in Durham. She uses her professional skills in chairing the Jewish Community Foundation and serving on the finance committee at Beth El Synagogue. She also enjoys studying with a group from her synagogue — eight very wise and insightful women ranging in age from 40 to 80. In the future, Maxine would like to participate in the North Carolina CPA Association’s financial literacy community education program.

Administration of the Physics Department requires oversight of a great variety of facilities, auxiliary enterprises and support personnel. The department's payroll has more people on it than several schools at Duke, while the faculty members charged with administrative tasks have very little formal training in finance or personnel management. Maxine Stern's dedicated efforts on behalf of the department have been, and will continue to be, greatly appreciated.
Graduate Student Organization Activities

Graduate Student Life
by Bryon Neufeld

DukeChina

Physics graduate students come to Duke University primarily to work in the Physics Department; however, some students have taken initiative to become involved in University-wide activities. One platform where this is abundantly apparent is in the Duke Chinese Students and Scholars Association, or DCSSA. As the name suggests, the DCSSA is a campus-wide organization geared toward Duke's Chinese community. Its purpose is to provide support to Chinese students, many of whom are in the midst of adjusting to American life and culture, and also to promote the reputation of Duke in China.

Several physics graduate students are actively involved in the DCSSA, none more so than Xing Zong and Wei Chen. Xing is a 4th year student, and Wei a 3rd year student, both working in experimental nuclear physics under the advisement of Prof. Haiyan Gao. Xing recently served as President of DCSSA and under his leadership it launched their website, www.dukechina.org. The website was born out of a desire to provide a medium between Duke University and the Chinese people. It is primarily written in Chinese, although it includes some English, too. The website features updates on every aspect of Duke: academics, athletics, administration, and student life. And the effort of the DCSSA has not been in vain. In an article titled 'Introduce Blue Devils to Red Dragon', Xing writes, “According to the statistics, the DukeChina website has accumulated in total 100,000 hits within 9 months, averaging 11,000 hits per month.”

The technical side of the website is managed by Wei Chen, who serves as Webmaster of DCSSA, and wrote the html code for www.dukechina.org. Wei says the philosophy of the design is to “provide very easy access to information and not be too fancy.” The website has also caught the attention of Duke’s student newspaper, the Chronicle, which recently ran a lengthy article featuring Xing and Wei and their role in www.dukechina.org.

GPSC

The physics department is well represented in Duke’s Graduate and Professional School Council (GPSC) by 3rd-year graduate student Nathan Kundtz, who was recently elected Vice-President. During the past year, GPSC’s lobbying resulted in a significant improvement in health benefits; this year PhD students will have health insurance covered either by grants or the Graduate School and premiums will be lower than before for the vast majority. The GPSC Vice-President focuses on administration of the organization and chairs the general assembly. Nathan is particularly interested in running the GPSC leadership retreat this year, where 70 students will meet to work on graduate student community development and promote student leadership on campus. Nathan is pursuing his PhD in experimental nano-physics under the direction of Prof. Albert Chang.
Graduate Student Seminar

The weekly graduate student seminar continues to be a staple of graduate student interaction throughout the department. Each Friday at noon, graduate students gather in the faculty lounge to listen to one of their peers give a talk on his/her research while enjoying lunch generously provided for by the department. The lunch is usually pizza or Chinese food.

Graduate Student Travel

One of the great advantages of collaborating with physicists around the world is the opportunity to travel. Many of Duke’s graduate physics students have traveled recently to present their research or to collaborate with colleagues. Two of these are Matthew Blackston and Leah Broussard. Matthew is a 4th year student working with Prof. Henry Weller. He recently traveled to Germany on a DAAD fellowship. Leah is a 3rd year student working with Prof. Albert Young, she went to Los Alamos this spring and will return this fall.

Basketball

You don’t have to be a nuclear physicist to know that basketball is big on Duke’s campus. The Cameron Crazies are known as the best fans in college basketball and recently Sports Illustrated ranked Cameron Indoor Stadium as the best home court advantage in college basketball. Every fall you can feel the excitement on campus as the Duke community looks forward to another basketball season. It is this excitement that drove a core group of Physics graduate students to participate in the annual GPSC basketball camp-out this past September.

The camp-out is held every fall for the purpose of distributing season tickets for men’s basketball, one of the most coveted tickets in all of sports. The format is a grueling 36 hour marathon of what are known as ‘check-ins’. The camp-out begins at 7:00 p.m. on Friday evening where the first check-in occurs (at a check in, you wait in a line to have your name checked off on a list, your name being verified by your student i.d. card). Then, subsequent check-ins are signaled by a loud whistle at random intervals for the next 36 hours, culminating in the final check-in at 7:00 a.m. on Sunday morning. Those who make all the check-ins have their names put in a drawing for season tickets.

This past fall 6 physics graduate students participated in the camp-out: Brad Marts, Kristine Callan, James Esterline, Bryon Neufeld, Nathan Kundtz, and Peng Li. They ended up with 3 season tickets which they split amongst themselves. When asked if the rigorous 36 hour camp-out was worth her effort, Kristine Callan said, “Yes. It was a good opportunity to bond with other graduate students outside of the classroom. Plus, it gave me an excuse to take a short, but much needed break from the first-year homework sets.”
Dr. Chiho Nonaka was a postdoctoral research associate in the QCD group working with Profs. Steffen Bass and Berndt Muller from September 2002 to August 2005. During her time at Duke she focused on developing a fully three dimensional relativistic hydrodynamic model for the description of collisions of ultra-relativistic heavy nuclei. Such nuclear collisions are currently being investigated at the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory with the goal of creating matter at a temperature and energy-density similar to conditions in the early universe, a couple of micro-seconds after the Big Bang. Recent discoveries at RHIC indicate that this matter, which is being referred to as the Quark-Gluon-Plasma (QGP), has the properties of an ideal fluid, therefore giving her work a high impact in the field.

In addition, Dr. Nonaka worked on the parton recombination model, which describes the formation of hadronic matter (such as protons and neutrons) from a decaying Quark-Gluon-Plasma. The development of the parton recombination model has been spearheaded by the Duke QCD group and has gained rapid acceptance by the community as the standard model for hadron formation from a QGP under particular kinematic conditions. For her work on this model, Dr. Nonaka was awarded the 2004 Publication Prize for Young Nuclear Theorists by the Nuclear Society of Japan. This award is offered to young researchers within 5 years of their Ph.D. She received the prize in recognition of her work on Parton Recombination: “Hadronization in Heavy-Ion Collisions: Recombination and Fragmentation of Partons” by R.J. Fries, B. Mueller, C. Nonaka and S.A. Bass, Physical Review Letters 90 (2003), 202303.

In September of 2005, Dr. Nonaka moved to the University of Minnesota to continue her research as a postdoctoral research associate with Prof. Josef Kapusta, funded by a JSPS fellowship. Shortly thereafter she accepted an offer for a tenured Assistant Professor position at Nagoya University in Nagoya, Japan. She joined the faculty of the Physics Department at Nagoya on April 1st of 2006.

— by Steffen Bass

Dr. Karen Daniels came to Duke in the summer of 2002, after having completed a Ph.D. at Cornell University on pattern formation and convection. A key focus of her work at Duke involved studies of granular shear flow, using a special apparatus that she developed. This device can simultaneously thermalize the granular material through vibration and also provide shear, and was developed to help understand the statistical and rheological properties of dense granular materials. Dr. Daniels then carried out a series of experiments with this apparatus. Perhaps the most striking development to date from this work is the discovery of a novel order-disorder transition. Contrary to expectation, vibration/thermalization acts to order the grains into a perfect 3D lattice; shearing acts to disorder the sample. The results of these experiments have appeared in Physical Review Letters and other journals. And, they have attracted considerable attention in the popular science press. Work using this apparatus, and other granular experiments that Dr. Daniels helped develop is ongoing; the key focus now is to help develop the novel idea of a granular temperature. In a very different direction, Dr. Daniels, in collaboration with Duke graduate student Shomeek Mukhopadhyay, has discovered a novel instability that occurs during spreading of liquid drops. These experiments are particularly novel because the substrate on which the drop spreads is a gel (similar in spirit to Jello). This type of substrate was chosen because it is intermediate between a rigid solid substrate, and a fluid. In the summer of 2005, Dr. Daniels joined the Physics faculty at North Carolina State University, where she is energetically establishing her own research lab.

— by Bob Behringer
Electrons at the Nanoscale

by Professor Harold Baranger

The broad focus of my group is the interplay of electron-electron interactions and quantum interference at the nanoscale. Fundamental interest in nanophysics — the physics of small, nanometer scale, bits of solid — stems from the ability to control and probe systems on length scales larger than atoms but small enough that the averaging inherent in bulk properties has not yet occurred. Using this ability, entirely unanticipated phenomena can be uncovered on the one hand, and the microscopic basis of bulk phenomena can be probed on the other. Additional interest comes from the many links between nanophysics and nanotechnology. Within this thematic area, our work ranges from projects trying to nail down realistic behavior in well-characterized systems, to more speculative projects reaching beyond regimes investigated experimentally to date.

I’ll highlight two of our theory projects here. For information about experimental nanophysics research, see the articles by Profs. Chang and Finkelstein in the 2004 and 2005 newsletters.

Correlations in Circular Quantum Dots

Properties of the “electron gas” — a key condensed matter model in which conduction electrons interact by means of Coulomb forces but ionic potentials are neglected — change dramatically depending on the balance between kinetic energy and Coulomb repulsion. The limits are well understood: for weak interactions (high density), the system behaves as a Fermi liquid, with delocalized electrons; in the strongly interacting limit (low density), the electrons localize and order in a triangular lattice called a Wigner crystal. The physics at intermediate densities is very rich and remains a subject of fundamental research.

We have studied the intermediate-density electron gas confined to a circular disk or quantum dot [1], where the density can be controlled. A quantum dot — a nanoscale island containing a puddle of electrons — provides a simple, tunable setting for studying the effects of Coulomb interactions. Level quantization and quantum interference can be controlled, and very low densities can be achieved. There are in addition natural parallels between quantum dots and other confined systems of interacting particles, such as cold atoms in traps.

Using accurate quantum Monte Carlo techniques, we show that the electron-electron correlation induced by an increase of the interaction smoothly causes rings and angular modulation. This is illustrated in Figure 1. Note, first, the dramatic change in density upon increasing interaction strength: For weak interactions (left panel), the density is rather homogeneous, with small orbital effects. In contrast, strong interaction (middle) induces the formation of sharp rings. Angular modulatio evident (right) when we consider the pair-density, the probability of finding an electron at location \( r \) when an electron is held fixed at \( r_0 \). The most prominent feature is a hole around the location of the fixed electron. In addition, there are clear oscillations along the angular direction near the fixed electron, a signal of “incipient” Wigner localization.

We conclude that inhomogeneities in a confined or disordered system, which exist because of quantum interference even without interactions, are significantly enhanced by correlations.

Conduction Through Single Molecules – Spintronics

The general area of electrical conduction through single molecules has taken off in the last few years [2], mainly because of remarkable experimental advances which allow the trapping and contacting of a single molecule in a nano-gap between two metal electrodes (see Figure 2). Two-terminal switches, rectifiers, and three-terminal transistors have all been experimentally studied. From a fundamental chemical physics point of view, electrical conduction provides a completely new and exquisitely sensitive probe of the properties of molecules and their connection to metals.
A quantitative understanding of non-equilibrium systems is fundamentally lacking. Such systems include plasmas, industrial chemical reactors, surface reactions, some atmospheric processes and living organisms. Each of these diverse examples falls into the class known as reaction-diffusion systems, in which the competition between transport and reaction gives rise to the complex dynamics which dominates them. Prof. Lin’s lab conducts experiments and numerical simulations to investigate fundamental open questions in non-equilibrium dynamics and statistical mechanics focused on pattern forming systems, – systems which spontaneously develop spatial and/or temporal structure.

Chemical Pattern Formation

Lin’s group has collected the first experimental demonstration of a transverse instability of a Bloch front near the NIB bifurcation leading to vortex-nucleation events. These events induce a transition to a disordered state. In collaboration with Ehud Meron (BGU) and Aric Hagberg (LANL) Lin’s group is investigating spiral-vortex nucleation in bistable systems. This phenomenon has been related to a front instability, the non-equilibrium Ising-Bloch (NIB) bifurcation, through indirect experimental evidence. Different aspects of these results were published in Physical Review Letters and Physica A. A review article on this topic is in preparation for Chaos.

In experimental investigations of spatial inhomogeneities on spiral vortex patterns and curvature-driven front dynamics in an oscillatory, bistable reaction-diffusion system, Lin’s group examined three qualitatively different patterns: large domains, localized structures, and labyrinths. The patterns form in an open chemical reactor as a control parameter is varied, providing insight into the asymptotic pattern formation resulting from the balance established between the competing mechanisms of curvature and front interactions. Similar curvature-driven front dynamics are observed in many places, including experiments of a coupled laser system and in the non-equilibrium Ising model, suggesting that the generalized mechanism may be broadly found in the physics of non-equilibrium systems. These results were published in Physical Review E.

Population Transitions in E. Coli Colonies

Lin’s group also conducts experiments to test the validity of the prediction of a critical system size required for colony growth. Any process captured by the general equation \( \frac{\partial c}{\partial t} = D \nabla^2 c + f(c) \) where \( c(x, t) \) is the concentration (of bacteria, e.g.) and \( f \) is some nonlinear function describing growth and saturation, has a critical system size, below which no growth can be sustained and the asymptotic state is extinction. We are investigating whether models of this general form are reasonable descriptions of bacterial colonies by testing for the existence of this critical system size using our experimental set-up. Preliminary results show a critical system size does exist for the bacterial colonies, and that the dynamics of the colony growth is more complex than is captured by simple models. Results from this project were published in the Biophysical Journal.

Signaling Patterns in Neural-Glia Networks

In living systems nerve cells are always found in the presence of glia cells. Until recently, glia were thought to play only the role of scaffolding and nutrient management for nerve networks. Now researchers have begun to find evidence that the glia, which supports traveling waves of calcium, plays a signaling role in the central nervous system. Understanding the mechanisms that give rise to brain functions, from the simplest to the most complex, will require an understanding of the excitation patterns that result from coupling between glia and nerves. The coupling of the two widely separated time scales of neuron and glia cell signaling...
Theoretical Particle Physics and QCD

by Assistant Professor Thomas Mehen

Prof. Mehen joined the physics department in January 2002, with an appointment in the Nuclear/Particle Theory group that is also a bridge position supported by the Thomas Jefferson National Laboratory (JLAB) in Newport News, VA. The primary goal of his research, which lies at the interface of nuclear and particle physics, is improving our quantitative understanding of Quantum Chromodynamics (QCD), the theory which describes the strong force between the quarks and gluons. These are the constituents of the proton and neutron, as well as other particles called hadrons that are observed in cosmic rays and created in high energy collider experiments.

The equations of QCD can be written on a single line of notebook paper, but quantizing the theory and deducing the properties of the bound states of quarks and gluons is a notoriously difficult problem. Over 30 years ago, D. Gross, D. Politzer and F. Wilczek (Nobel Prize, 2004), realized that QCD exhibits asymptotic freedom the coupling of the quarks and gluons gets smaller as the quarks and gluons are brought closer together. This implies that at sufficiently high energies, perturbation theory can be used to calculate the interaction between the quarks and gluons. As one separates a quark and antiquark, the coupling increases until at a distance of about 1 fm, roughly the size of a proton, the coupling diverges and perturbation theory is useless. The nonperturbative regime of QCD exhibits novel and poorly understood phenomena, the most important of which are confinement and chiral symmetry breaking.

Confinement is the permanent trapping of quarks and gluons into bound states. At large distances the force between a quark and antiquark is thought to be linear and attractive, therefore the quark and antiquark can never be separated. Though there is overwhelming experimental evidence as well as numerical simulations to support this picture, deriving it directly from QCD is so difficult that now the Clay Mathematics Institute is offering $1,000,000 to anyone who can supply a rigorous proof! (see http://www.claymath.org/millennium/) The equations of QCD exhibit an approximate symmetry called chiral symmetry which acts on the quark fields and implies an approximate degeneracy in spectrum of QCD that is not observed in nature. This happens because the ground state of QCD does not share the symmetry of the underlying equations, a situation called spontaneous symmetry breaking (SSB). General theorems show that SSB implies the existence of low mass particles (massless in the limit of exact symmetry) whose interactions with each other and other particles are tightly constrained. In QCD these particles are the pions, kaons, and etc. The pions are important in nuclear physics because the exchange of pions gives the long range part of the force between nucleons. In fact the form of the long range part of the nuclear force can be deduced almost entirely from chiral symmetry breaking considerations alone.

Experimental physicists around the world produce hadrons in a variety of experiments covering a wide range of energies that involve the collision of electrons and positrons, photons and protons, or protons and antiprotons, for example. They study how the particles interact, how they are produced and how they decay to test our understanding of QCD, to learn more about the weak force governing their decays and to look for signs of the physics that lies beyond the Standard Model of elementary particles. The questions that underlie Mehen’s research are: when we study a process that involves low energy QCD dynamics, how can we make predictions despite our incomplete understanding of QCD? When a process involves different energy scales, how do we can we organize our calculations so that we cleanly separate dynamics at perturbative scales from nonperturbative scales? The tool Mehen uses for solving these problems is effective field theory.

Effective field theories exploit the symmetries of QCD to make model independent predictions when the dynamics of these hadrons are too hard to solve explicitly. For example, the properties of a hadron containing a very heavy quark are insensitive to the orientation of the heavy quark spin. Mehen has continued on page 19
Prof. Henry Weller has supervised 23 PhD students and published over 200 journal papers since coming to Duke in 1978. Weller has been working at the Triangle Universities Nuclear Laboratory where he has used polarized beams to study few-body nuclear systems and radiative capture reactions relevant to nuclear astrophysics.

For the past several years Weller has been involved with developing a research program for the new High Intensity γ-Ray Source (HIγS) being developed by TUNL in collaboration with the Duke Free Electron Laser Laboratory. This new beam is produced by back scattering FEL photons from high energy (up to 1.2 GeV) electrons inside of the Duke storage ring. The resulting γ-ray beam has an intensity which is over 1000 times greater than any existing facility. It is also 100% polarized, and nearly monoenergetic. The beam energy can be varied from as low as 2 MeV up to 158 MeV, which is important since this exceeds the energy at which pions begin to be produced.

An upgrade of the facility is presently underway. The main component of this upgrade is the installation of a 1.2 GeV booster injector. This will allow the electrons in the storage ring to be continuously replaced at full energy and thereby provide for a continuous γ-ray beam. Prior to this upgrade, the collision of the photons and the electrons knocked the electrons out of the storage ring when γ-rays > 20 MeV were produced, resulting in a decreasing beam intensity. The upgrade is scheduled to be completed by the end of 2006.

The properties of the HIγS beams open up many new opportunities for research in nuclear physics and nuclear astrophysics. One experiment which is being developed will measure the rate of the ⁴He + ¹²C → ¹⁶O + γ reaction by using the γ-beam to measure the rate of the inverse reaction. This reaction plays a key role in the helium burning cycle and its rate determines whether a supernova ultimately becomes a black hole or a neutron star.

Another program being developed involves elastic scattering of γ-rays from nucleons, a process called Compton scattering. Weller has worked with Prof. Haiyan Gao and an International Collaboration to formulate a research program in this field. Their proposed program is summarized in some detail at www.tunl.duke.edu/~mep/higs/compton.pdf. There are two major goals for this program. The first goal is to measure the electric and magnetic polarizabilities of the proton and the neutron. These quantities tell us how difficult or easy it is to induce an electric or a magnetic dipole moment in the nucleon, respectively. Their values are determined by the details of the internal structure of the nucleons described in terms of quarks, gluons and a pion-cloud. The second goal is to measure the so-called spin polarizabilities of the nucleons. These quantities will provide deeper insight into the internal structure of the nucleons. The spin polarizabilities measure how stiff the spin, carried by the quarks and gluons, is—i.e. how difficult or easy it is to rotate the spin, held in place by its interaction with the pion cloud, by applying the electromagnetic fields of the γ-rays. They will be measured by scattering polarized γ-rays from polarized nucleons.
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Meanwhile, the spin degree of freedom of the electron has attracted increasing attention because of its nonvolatile, power-saving, and fast-responding nature. Traditional spintronic devices are based on spin polarization of the current passing through a ferromagnetic layer, but single molecules can also be used for spin generation and detection. In a metal-molecule-metal junction, the most straightforward route to spin dependence is through a molecular magnet in which the conduction channels of only one spin component aligns with the chemical potential, resulting in a spin polarized electric current.

We have investigated [3] spin-dependent transport through a molecule containing a simple well-studied functional group—cobaltocene, a cobalt atom sandwiched between two five-member carbon rings, which bears one free spin. This type of interdisciplinary work requires a team of physicists and chemists. In this case I have collaborated with student Rui Liu, post-doc San-Huang Ke, and Chemistry professor Weitao Yang.


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used this heavy quark spin symmetry to make predictions for the production and decay of heavy mesons and quarkonia at collider experiments. Mehen’s early work applied chiral symmetry and effective field theory to the analysis of low energy two and three-body nuclear systems, such as the deuteron and triton. While at Duke, Mehen and Prof. Roxanne Springer used a theory which synthesizes chiral and heavy quark symmetries to analyze the decays of recently discovered excited mesons that contain charm and strange quarks. This analysis improved our understanding of these hadrons by ruling out molecular interpretations of the particles. Currently, Mehen has been pursuing a novel application of this symmetry which relates mesons with a single heavy quark to baryons with two heavy quarks. This work is useful in analyzing data from Fermilab experiments which may have evidence for previously unseen doubly charmed baryons.

Mehen is also working on Soft-Collinear Effective Theory (SCET), a new tool for analyzing high energy QCD processes. SCET allows one to systematically derive factorization theorems which separate perturbative and nonperturbative scales. Renormalization group equations of SCET are used to perform all order resummations of large perturbative corrections. While at Duke, Mehen has made important contributions to the formal development of SCET as well as develop applications to the production of $J/\psi$ (charm-anticharm bound states) in various collider experiments. In particular, Mehen’s work has resolved apparent discrepancies between theory and experimental data on $J/\psi$ production in electron-positron and photon-proton colliders.

Almost all particle and nuclear physics experiments involve hadrons in some way. As a practical matter, understanding QCD quantitatively is essential for progress in this field. Prof. Mehen’s research is motivated by both the practical issues for medium- and high-energy experiments as well as an aesthetic appreciation of the many phenomena exhibited in hadronic physics.

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provides a much richer spectrum of signal encoding possibilities than does a single time scale. Lin and her group are applying the tools and perspective of quantitative pattern formation research to explore the signaling possibilities of the nervous system in large networks of nerves and glia. They have conducted preliminary investigations of the spatio-temporal signaling patterns in rat hippocampus and cortical cultures using calcium sensitive dyes in conjunction with fluorescence microscopy to measure simultaneously the reaction-diffusion waves of $Ca^{2+}$ propagating in the glia cells and the spiking of neurons. The voltage change of a firing neuron is accompanied by a corresponding rise in $Ca^{2+}$ concentration). We have implemented various data analysis tools such as local linear embedding to quantify the data.

Prof. Lin’s group collaborates with Mike Ehlers’ group (Duke Neurobiology) on experiments and with Craig Henriquez’s group (Duke BME) and Dave Schaeffer (Duke Math) on numerical and analytic models.