BAYLOR UNIVERSITY 1845

Ursa Baylor

Department of Physics, Baylor University

Annual Issue
Fall 2012

The Annual Newsletter of the Department of Physics

Baylor University PHYSICS

Outstanding!

Baylor University had quite a year! No less so was the year we had in the Physics Department! Three members of the department were recognized for their outstanding contributions to the University.

Above: President Ken Starr presented Dr. Jay R. Dittmann & Dr. Jeffrey S. Olafsen (left to right) with Outstanding Faculty Awards for Scholarship and Teaching, respectively, during the May Commencement.

Left: Provost Elizabeth Davis presented our own Chava Baker with an Outstanding Staff Award earlier in the spring of 2012.

Inside this issue:

From the Chair…

October 2012

Dear Friends,

Greetings from the Baylor Physics Department! The fall semester is well underway, and autumn is in the air with several 'cold' fronts having already passed through Waco. It was a pretty typical summer this year, with not nearly as many 100+ degree days as in our record 2011 summer. We held our annual Physics Department Picnic on Aug. 24th, at the end of our first week of class—and a good time was had by all! We thank the second-year graduate students for making the picnic a big success!

We welcome one new part-time lecturer this fall, Dr. Karen Bland. Karen is no stranger to us—having recently completed her Ph.D. in particle physics under the direction of Dr. Jay Dittmann. And speaking of Dr. Dittmann, we are pleased to have him back after his spring semester research leave, much of it spent in Geneva near the Large Hadron Collider at CERN. Our very active retiree Ed Schaub has also returned for another year of part-time duty as a Lecturer. And we are delighted to welcome eighteen new undergraduate majors and eight new graduate students into the physics fold!

Two of our faculty members were recognized during commencement ceremonies in May. Dr. Jeff Olafsen was recognized for his outstanding record in teaching, while Dr. Jay Dittmann was recognized for his outstanding contributions in scholarship. Also in the spring semester, our office manager, Chava Baker, received and Outstanding Staff award. Although we already knew we had outstanding faculty and staff members, it's nice to see them recognized as such!

Summer commencement was very special for the department. We graduated two B.S. students (Brandon Doyle and Alex Sabey), two M.S. students (Jonathan Perry and Tara Scarborough), and four Ph.D.s. (Drs. Karen Bland, Angela Douglass, Nan-Hsin 'Nancy' Yu, and Zhuanhao 'Victor' Zhang). It was quite an impressive showing—even Judge Starr said so!

Did you get up early on July 4th to listen to the Higgs Boson announcement from CERN? The discovery of a new boson was announced by both the CMS and Atlas experimental collaborations. The Baylor High Energy Physics Group figured prominently in the search for the Higgs, under the direction of Drs. Jay Dittmann and Kenichi Hatakeyama. Both faculty members were interviewed for articles in the Waco Tribune-Herald and Baylor Lariat, as well as a news release featured by the Baylor.

On August 15th, the department gathered for our Fall Faculty Retreat/Workshop at Baylor's Eastland Lakes facility. We have been conducting these sessions the past four years to briefly review the progress made in the previous year, and then to make plans for the upcoming year. Some of the items marked for emphasis this year are: developing a program of study leading to teacher certification in physics, beginning discussions toward developing an engineering physics option, making more use of the Meyer Observatory near Clifton, involving our Society of Physics Students in planning a public physics event in the spring, and developing a departmental wish list of items that would benefit our teaching and research missions.

One of the best ways to support the work of the department is through giving to the Physics Excellence Fund (032 MAUN). We use these funds in a variety of ways, including the purchase of research instrumentation to fully equip our laboratories. Thus year, a generous gift supported the stipend and accommodation for an undergraduate student pursuing summer-long research. If you are interested in assisting with these or other projects, or perhaps have a vision for something truly extraordinary, please let us know!

We again thank you for your interest and support. Please continue to pray with us that we honor God in all of our work, and that we accomplish goals that are pleasing to Him. We hope to see you at Baylor Homecoming on November 2nd - 3rd. We will hold our Homecoming Colloquium featuring Dr. Marlan Scully at 3 p.m. on Nov. 2nd, immediately followed by the Physics Homecoming Reception from 4 - 6 p.m. in BSB room E.301.

With warmest best wishes,

Greg Benesh

Professor & Chairman

The Department by the Numbers

Number of Full-time Faculty: **18**

Tenured or Tenure-Track Faculty: **15**

Lecturers: **3**

Undergraduate Physics, Astronomy & Astrophysics Majors: **45**

Physics Graduate Students: **29**

Postdoctoral Fellows: **4**

2011 - 2012 Enrollments

Number of Students Enrolled in Physics Classes: **2617**

Summer 2011: **112** Fall 2011: **1230** Spring 2012: **1275**

Number of Students Enrolled in Undergraduate Laboratories & Tutorials: **2985**

Summer 2011: **140** Fall 2011: **1393** Spring 2012: **1452**

Number of Undergraduate Laboratory & Tutorial Sections: **144**

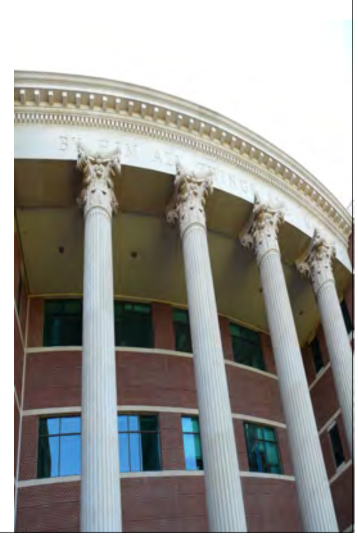
Summer 2011: **13** Fall 2011: **62** Spring 2012: **69**

In 2011 - 2012:

Number of Funded Grants: **15**

Scholarly Publications (including Conference Proceedings): **171**

Conferences attended by Department Members: **28**



US News & World Report's average ranking of the national universities from which our tenured and tenure-track faculty received their PhD degrees: **25**

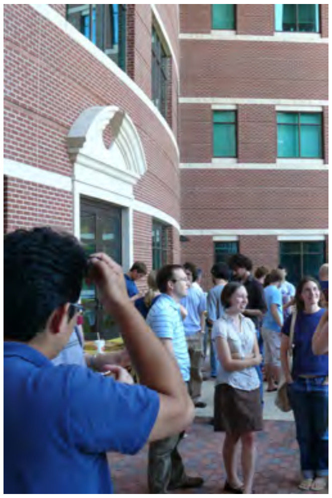
US News & World Report's Department Ranking: **113**

Academic Analytics Department Ranking: **103**

National Research Council Department Rankings: **R-Rank range: 96 - 147**

S-Rank range: 118 - 149

Graduate Program News



Fall Department Picnic

Dear Physics friends,

Our graduate program has had a good year. Our faculty are productive and active and our students are hard working and industrious. We have had a number of important achievements and advances in the graduate program over the past year. Please allow me to list some of the highlights here.

In the area of recruitment we have had a number of improvements. In 2011 we had 58 applications total applications; this year we had 91, a 57% increase. The applications are also increasing in quality, as evidenced by GRE outcomes. Eight new TAs were recruited for 2012-2013. Seven of the eight students received an enhancement in their stipend from the Graduate School. We also continued our recruitment efforts through the Physics recruitment "Open House" held on Feb. 10-12 as well as the successful Speaker Outreach Program. The latter helps communicate the excitement and interest we have in our research fields to prospective graduate students at nearby colleges and universities.

Our departmental proposal for stipend support garnered an additional annual $27,000 increase, enough for one new position and a modest 1.5% increase in base stipends.

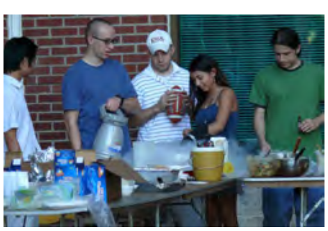
“We continue to lead the university in publications with our students.”

An important graduate course improvement last year was the reactivation and teaching of PHY 6372, Elementary Particle Physics, taught by Kenichi Hatakeyama. This course is standard at most physics graduate programs but had not been taught here for many years.

We continue to lead the university in publications with our students. The last university report had us collaborating on 146 papers with our students, or an average of 4.6 papers per graduate student.

The Department's participation in the LHC search for the Higgs particle has been widely recognized and appreciated both within the university and the community. This was one of the most significant particle physics findings since the Standard Model was formulated. We salute Jay Dittmann and Kenichi Hatakeyama and their students for their efforts.

Although it is easily the least enjoyable part of my job as GPD, the SACS Assessment Reports are important milestone markers for the department. The reports this year were improved and extended to include new aspects such as student graduation time and new analyses of the Exit interviews.



Liquid Nitrogen Ice Cream

Of course, the most significant highlight of all are the graduates from our program. This year we graduated 5 new PhDs and 2 new MSs. We are proud of them and we are grateful for the opportunity to teach and work creatively at Baylor.

May the good Lord keep us on His path for the upcoming year.

Walter Wilcox

Professor and Graduate Program Director

Undergraduate Program News

Dear Alumni and Friends of the Department of Physics,

Society of Physics Students

The 2012-13 academic year is off to a great start! The Department of Physics continues to be blessed by growth in many areas.

The Spring 2012 graduation ceremony was a time of celebration. Five students graduated from our department with B.S. degrees. Kyle Brown and Amir Ali completed the B.S. in Physics degree with a Pre-Health Care Concentration. Kimberly Orr finished a B.S. in Astronomy, and Kristen Deline and Janie Hoormann carried off B.S. degrees in Astrophysics. These three women were the first to complete degrees in our new astronomy and astrophysics degree programs! In addition, Brandon Doyle and Alex Sabey graduated with B.S. Physics degrees in Summer 2012. Alex was the first of our students to complete the Computational Physics Concentration. We celebrate together with these terrific students and wish them the best in their future endeavors.

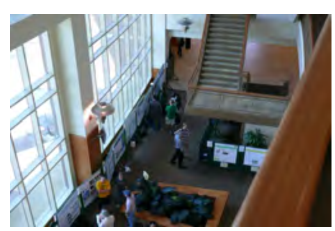
This fall, once again, the department welcomes a large group of new first-time freshman students – 18 in all! This freshman class is truly a talented group of individuals and we look forward to seeing what they can achieve at Baylor.

"We celebrate together with these terrific students and wish them the best in their future endeavors."

During the past year, one exciting addition to our degree programs is the availability of new secondary majors in physics, astrophysics, and astronomy. Students who are majoring in other degree programs can pursue one of these secondary majors, which opens many new possibilities for interdisciplinary studies. This concept is different from a double major, which restricts students to two majors in the same degree (for example, B.S.). Now, for example, a computer science major (seeking a B.S.C.S. degree) can obtain a secondary major in physics without taking all of the general education requirements required for the B.S. degree. We are excited about this new avenue for students.

This fall, one of the main goals of the Department is the development of a new Physics Education concentration associated with the physics major. We continue to receive inquiries as to whether one can obtain a degree in physics and also obtain the certification needed to teach high school physics. This initiative would make that possible!

And now, a special message to our alumni. We would love to hear your experiences with regard to careers in physics, and the role of your Baylor education in your life. Please stay in touch! We are also always grateful for your contributions in support of our programs and students.



URSA Scholars Week in BSB

With warm regards,

Jay R. Dittmann

Associate Professor and Director of Undergraduate Studies

Faculty Research Profiles

Wickramasinghe Ariyasinghe (Ari)

Associate Professor

Research Interests:

Atomic & molecular physics

Auger electron spectroscopy

Electron scattering

Dr. W. Ariyasinghe engages in atomic and molecular physics experiments. The department has several electron beam facilities (20 eV to 10 KeV energy) for studying interactions of low energy and intermediate energy electrons with atoms and molecules. He utilizes these facilities to measure the total electron scattering cross sections, the most reliable experimental scattering cross section, of atoms and molecules at low and intermediate energies. Accurate measurement in this region of energies requires extremely good energy and angular resolution to avoid effects due to forward-scattered electrons. With this in mind, he has developed an experimental station to measure the total cross section accurately. Recently, he has been studying the total electron scattering cross section of hydrocarbons and fluorocarbons, research of great importance to astrophysics, atmospheric physics, chemical physics, plasma physics, bio-medical physics, and semiconductor physics. His goal with this research is to provide an accurate pool of total electron scattering cross sections for the users in the above fields and industry.

The past research involves the use of Auger electrons produced by heavy ion bombardment (protons and He^+ ions) of small organic molecules to study the effect of chemical bonding on normal and satellite lines produced by the impinging ions. The study of heavy ion induced Auger spectroscopy continued to produce the K-shell and L-shell ionizations cross sections (an essential tool in understanding the interaction mechanism between energetic ions with atoms or molecules) of all second and third raw elements in the periodic table. In addition, Dr. Ariyasinghe conducted experiments to investigate the isotropic/anisotropic nature of heavy ion induced Auger emission.

For several years, Dr. W. Ariyasinghe and collaborators have been involved with the slowing of He^+ ions in thin films of vapor-deposited elemental matter and in gases to study the degenerate electron gas model of Jens Lindhard (a student of Niels Bohr in Copenhagen) in three areas: (i) stopping power, (ii) calculation of mean ionization potentials, and (iii) energy straggling. The model is excellent for predicting qualitative features of various parameters, although certain quantitative limitations are clearly revealed.

Publications:

An empirical expression for total scattering cross sections of normal hydrocarbons, and experimental cross sections of C_3H_4 and C_4H_6, W. M. Ariyasinghe and G. Vilela, *Nucl. Inst. and Meth. Phys. Res. B* **268,** 2217 – 2220 (2010) .

Electron scattering from alkenes in the energy range 200 – 4500 eV, P. Wickramachchi, P. Palihawadana, G. Villela and W. M. Ariyasinghe, *Nucl. Inst. and Meth. Phys. Res. B* **267** (2009).

Total Electron Scattering Cross Sections of alkanes at intermediate energies, W. M. Ariyasinghe, P. Wickramarachchi, and P. Palihwadana, *Nucl. Inst. and Meth. Phys. Res. B* **259**, 841 - 846 (2007) .

Total electron scattering cross sections of Kr ans Xe in the energy range 250 - 4500 eV with C. Goains, *Phys. Rev. A* **70**, 1050294 (2005).

Electron scattering cross sections of He, Ne and Ar at intermediate electron energies with C. Goains, D. Powers, T. Wijerathna and P. Phalihawadana, *Nucl. Inst. and Meth. Phys. Res. B* **225**, 191 - 197(2004).

Total electron scattering cross sections of CH4 and NH3 molecules in the energy range 400 - 4000 eV with T. Wijerathna and P. Palihawadana, *Nucl. Inst. and Meth. Phys. Res. B* **217**, 389 - 395 (2004).

Total electron scattering cross sections of PH3 and SiH4 molecules in the energy range 90 – 3500 eV with T. Wijerathne and D. Powers. *Phys. Rev. A* **68**, 032708 (2003).

Total electron scattering cross sections of CF_4 and C_2F_6 in the energy range 100 – 1500 eV *Journal of Rad. Phys. Chem.* **68**, 79 (2003).

Total electron scattering cross seections of CH_4, C_2H_2, C_2H_4 and C_2H_6 in the energy range 200-1400 eV with D. Powers, *Phys. Rev. A* **66**, 052723 (2002).

Absolute K-shell ionization cross-section measurements of B produced by 0.4 - 2.0 MeV H+ and He+ ions and by .6 - 1.2 MeV H2+ ions with D. Powers, *Phys. Rev. A* **59**, 1291 (1999).

K-shell ionization of B,O, and F by 0.4-2.0 MeV He+ ions, with A. Ghebremedhin and D. Powers. *Phys. Rev. A* **53**, 1537 (1996).

Faculty Research Profiles

Gregory A. Benesh

Professor & Chair

Department of Physics

Research Interests:

Surface Electronic Structure

Embedding Problems

Gravitational Collapse

Professor Greg Benesh's research deals primarily with embedding problems. In metal surfaces the redistribution of charge upon adsorption of atoms or molecules determines the nature of the surface chemical bond. Charge redistribution also causes changes in surface work functions and affects the core-level binding energies of atoms near the adsorption site. Many metal surfaces, such as those of platinum, tungsten, silver, and gold, display spontaneous phase transitions from the bulk crystal structure to a new structure once the surface is created. The role that electrons play in such transitions is under investigation. Metal surfaces also serve as catalysts for important chemical reactions. The rate at which interactions progress can often be enhanced by introducing different metal catalysts or by exposing a different crystal face of the same metal. Current research focuses on the face-dependent catalytic activity of various metal surfaces, and the nature of inter-atomic forces on surface atoms.

One of the drawbacks of many surface calculations is the problem of interacting surface states across a thin slab; another is the neglect of bulk electron states which affect the energies of surface states and surface resonances. The analysis of a surface system can be formulated more generally as an embedding problem: how to find the properties of an interacting system of particles that is subject to boundary conditions imposed by an underlying medium. Examples of embedding problems include local magnetic moments arising from transition metal impurities in paramagnetic crystals, vacancies, chemisorbed molecules on surfaces, and surfaces themselves—which are merely two-dimensional impurities in a three-dimensional crystal. Professor Benesh and collaborators have developed a computational technique in which the surface atomic layers of a crystal are embedded onto the semi-infinite bulk substrate by means of an embedding potential derived from the bulk Green function. The embedding potential is an additional term in the surface region's Hamiltonian, which causes the wave function solutions to match in amplitude and derivative to solutions in the substrate across an embedding surface. The Surface Embedded Green function (SEGF) method has proved to be extremely accurate for determining work functions and the energetics of surface states and resonances. Further refinements and extensions of the method, including time-dependent embedding, are under development.

Currently, Dr. Benesh is focusing attention on several surfaces of rhodium and silver. The Rh(111) surface is particularly interesting since the surface and subsurface shifts are in opposite directions! Obviously, contributions other than from charge transfer play an important role, because no charge transfer is expected between neighboring rhodium atoms. In fact, it is believed that the environmental effect (caused by the reduced coordination of surface atoms) is at least as important as charge transfer. There is also a relaxation (final-state) contribution that is caused by the different screening properties of surface and bulk atoms.

Dr. Benesh has recently been collaborating with Prof. Roger Haydock of the University of Oregon on a project that employs the maximum breaking of time-reversal symmetry (MBTS) boundary condition to embed systems of interest. Prof. Haydock and Dr. C. M. M. Nex have previously derived the MBTS condition for single bands in discrete systems. The current project focuses on a boundary condition for continuous wavefunctions when a finite system is being embedded into an infinite one. The conditions for one- and two-band continuous systems have now been derived, and we are presently applying the condition to different model potentials.

On the lighter side, Dr. Benesh is also interested in the physics of everyday phenomena—including the positioning of a gazebo to mark the summer solstice, the death of Spider-Man's original girlfriend Gwen Stacy, the drowning of Charlie in the underwater (Looking Glass) station on the television series LOST, and the results of various MYTHBUSTERS tests. Dr. Benesh has recently submitted a paper with Dr. Jeffrey Olafsen on the results of a theoretical and experimental study of the stability of a can of soda (Dr Pepper®, of course!) on an accelerating horizontal surface—such as the dashboard of a car.

Recent Publication:

Classification of the FRW Universe with a Cosmological Constant and a Perfect Fluid of the Equation of State p = wp; Te Ha, Yongqing Huang, Qianyu Ma, Krirsten D. Pechan, Timothy J. Renner, Zhenbin Wu, G. A. Benesh, and Anzhong Wang; *Gen Relativ. Grav.* **DOI 10.1007/s10714-012-1348-1** (2012).

Faculty Research Profiles

Gerald Bryan Cleaver

Associate Professor

Research Interests:

String/M-theory Phenomenology Landscape, Model Building & Cosmology

Dr. Gerald Cleaver's research specialty is superstring theory, which unifies all forces in nature (gravity, electromagnetics, and the strong and weak nuclear forces). In superstring theory each elementary particle originates as a distinct vibration of a single type of string (or loop) of energy, much as different musical notes are produced from a single violin string. Dr. Cleaver's research was discussed and cited in Luis Ibanez and Angel Uranga, **String Theory and Particle Physics**, (Cambridge Press, Cambridge, 2012). Current research topics include the construction of phenomenologically realistic superstring models, string/M-theory cosmology, and the string landscape. Dr. Cleaver's research group is conducting several long-term systematic studies of the global physical properties of the string landscape in the free-fermionic heterotic region. Current members include Ph.D. students Jared Greenwald, Douglas Moore, and Yanbin Deng. Past members include former lecturer and postdoc Dr. Tibra Ali (now at the Perimeter Institute), Ph.D. students John Perkins (at AMD), Richard Obousy (founder Icarus International), Matt Robinson (mathematics consultant), Tim Renner (ExoAnalytic Solutions), and M.S. students Kristen Pechan (Ph.D. student at Texas A&M), and Ben Dundee (Fincad in Vancouver, B.C.). Dr. Cleaver has also recently joined the Exotic Propulsion Systems division of Obousy's non-profit organization Icarus Interstellar, one of three recipients of the DARPA/NASA 100 Year Starship grant.

Conferences:

Cleaver's research group presented three papers at the 18th International Symposium on Particles, Strings, and Cosmology (PASCOS 2012) in Merica, Mexico, June 3-8: *The Systematic Construction of Free Fermionic Heterotic Gauge Models*; *Systematic Surveys of the NAHE (Variation) Landscape*; and *Automated Systematic Generation of Flat Directions in Free Fermionic Heterotic Strings*.

At String Phenomenology 2012, Isaac Newton Institute of Mathematical Sciences, Cambridge, June 24-29, Dr. Cleaver presented *Systematic Investigations of the Heterotic String Landscape*

At the Faraday Institute for Science and Religion, St. Edmund's College, Cambridge on June 28, Dr. Cleaver presented *Philosophical and Theological Implications of a (String) Multiverse*

At the 2012 conference for the 100 Year Starship Project, Houston, September 13-16, jointly sponsored by DARPA and NASA, Dr. Cleaver presented *Spacecraft Propulsion via Chiral Fermion Pair Production from Parallel Electric and Magnetic Fields* (to appear in the peer-reviewed conference proceedings).

Additional Scholarly Activities:

Dr. Cleaver is the Associate Editor of the Journal of Physics, and the Journal of Astrophysics and Physical Cosmology. He is a referee for Modern Physics Letters A, General Relativity and Gravitation, Acta Astronautica, ISRN Mathematical Physics, Physics Essays, and Scientific Research and Essays. He was an AP Physics Exam Reader on 1-10 July.

Select Recent Publications:

Redundancies in Explicitly Constructed Ten Dimensional Heterotic String Models, with T. Renner, J. Greenwald, and D. Moore. International Journal of Modern Physics *A*26 (2011) 4451; arXiv:1107.3138.

Systematic Investigations of the Free Fermionic Heterotic String Gauge Group Statistics: Layer One Results. with D. Moore, J. Greenwald, T. Renner, M. Robinson, C. Buescher, M. Janas, G. Miller, and S. Ruhnau. Modern Physics Letters A26 (2011) 241; arXiv:1107.5758.

Investigations of Quasi-Realistic Heterotic String Models with Reduced Higgs Spectrum, with A. Faraggi, J. Greenwald, D. Moore, K. Pechan, E. Remkus, and T. Renner, European Physical Journal C71 (2011) 1842; arXiv:1105.0447.

Note on a NAHE Variation, with Jared Greenwald, Douglas Moore, Kristen Pechan, Tim Renner, and Tibra Ali, *Nucl. Phys. B* **850** (2011) 445-462.

Books:

First Principles and the Standard Model, with M. Robinson (primary author), K. Bland, J. Dittmann, and M. Serna. Published by Springer, August 2011. (First in a multi-volume set.)

"Universe and Multiverse", Chapter 13 of Delight in Creation: Scientists Share Their Work in the Church, Debra Haarsma and Scott Hoezee, editors, (Calvin Press, Grand Rapids, 2012). This chapter also appeared on The Biologos Forum in a five-week series (see biologos/blog/author/cleaver-gerald).

Faculty Research Profiles

Jay R. Dittmann

Associate Professor

Director of Undergraduate Studies

Research Interests:

High Energy Physics / Higgs Boson

Elementary Particle Physics

Large Hadron Collider at CERN

The CDF and CMS Experiments

Fermilab Tevatron Collider

The primary goal of *High Energy Physics (HEP)*, often called *Elementary Particle Physics*, is to discover the elementary constituents of matter and energy, probe the interactions between them, and explore the basic nature of space and time.

As the first experimental HEP physicist at Baylor, Dr. Dittmann laid the foundation for a new research program and built up a HEP group from scratch. Since its beginning in 2003, the experimental HEP group has grown tremendously and is involved in several cutting-edge research projects. The group currently consists of nine members including Dr. Dittmann and Dr. Kenichi Hatakeyama, two postdoctoral research associates (Drs. Azeddine Kasmi and Hongxuan Liu), three graduate students, and two undergraduate students. In addition, over the years, about 15 undergraduates have participated in experimental HEP research for honors theses, senior research projects, and summer internships.

Dr. Dittmann leads Baylor's HEP research at Fermilab in Batavia, IL, where Baylor is affiliated with the world-renowned Collider Detector at Fermilab (CDF) experiment. Despite its success for over 25 years, the experiment has recently ceased collecting of new data. The last proton-antiproton collisions at the Fermilab Tevatron occurred on September 30, 2011. Currently, a few final publications are being prepared that use the full CDF Run II data set, collected from 2001–2011.

In 2010, Baylor created a new affiliation with the CMS experiment at CERN, the location of the Large Hadron Collider (LHC) in Geneva, Switzerland. As a relatively small university group, it was an honor to be accepted into this world-class experimental collaboration, which includes many prominent U.S. universities. Baylor's acceptance into the CMS collaboration was an acknowledgment of the group's significant contributions to the research field. As Dr. Dittmann's research on the CDF experiment winds down, and his Ph.D. students complete their degrees, he is becoming increasingly involved on the CMS experiment. Dr. Dittmann spent the Spring 2012 semester located at CERN on research leave.

High energy physicists everywhere, including members of the Baylor HEP group, are celebrating the discovery of a new boson with a mass of about 125 GeV/c^2. Announced on July 4, 2012 at CERN, the new particle appears to be the long-sought Higgs boson, which provides a mechanism for electroweak symmetry breaking and explains why elementary particles have mass.

In May 2012, Dr. Dittmann's third graduate student, Karen Bland, successfully defended her Ph.D. thesis on a search for the Higgs boson decaying to two photons at CDF. Her work, together with that of Baylor postdoc Azeddine Kasmi, captured the attention of the international HEP community, and a paper based on their analysis was published in *Physical Review Letters*. A second publication, which uses the full CDF data set, was recently accepted for publication in *Physics Letters B*.

Zhenbin (Ben) Wu, Dr. Dittmann's fourth Ph.D. student, is currently preparing his dissertation on a measurement of single top quark production at CDF. Ben is one of the key players on this analysis at CDF and he has given multiple presentations of his work at CDF collaboration meetings and international conferences. He expects to graduate in December 2012.

Dr. Dittmann is a member of the Executive Board of the CDF Collaboration at Fermilab. He is a co-author of many publications in *Physical Review Letters* and *Physical Review D*. Funding for the Experimental High Energy Physics group at Baylor has been provided over the years by grants from the U.S. Department of Energy, Fermilab, and Baylor University, with external grant funds totaling over $935,000. At Baylor, Dr. Dittmann was presented with an Outstanding Professor award for research in Spring 2012.

Recent Selected Publications:

Evidence for a Particle Produced in Association with Weak Bosons and Decaying to a Bottom-Antibottom Quark Pair in Higgs Boson Searches at the Tevatron, T. Aaltonen *et al*. (CDF Collaboration), *Phys. Rev. Lett.* **109**, 071804 (2012).

Search for a Higgs Boson in the Diphoton Final State in Proton-Antiproton Collisions at $\sqrt{s}$ = 1.96 TeV, T. Aaltonen *et al*. (CDF Collaboration), *Phys. Rev. Lett.* **108**, 011801 (2012).

Faculty Research Profiles

K. Hatakeyama

Assistant Professor

Research Interests:

Experimental Elementary Particle Physics

The goal of elementary particle physics is to understand the nature of subatomic particles and their interactions at the most fundamental level. Presently, we have a theoretical model called the "Standard Model" which provides a very successful description of most of the experimental observations on elementary particles. One of the missing pieces in the Standard Model has been the Higgs boson, that provides a mechanism for electroweak symmetry breaking and explains the origin of elementary particle masses; however, finally a new boson with a mass of about 125 GeV/c^2 which appears to be a Higgs boson has been discovered by the experiments at the Large Hadron Collider (LHC) at CERN, as announced by CERN on July 4, 2012.

In spite of the success of the Standard Model in recent years, there are numerous important questions that are left unanswered in particle physics. For over half a century, it has been recognized that the Standard Model with a light fundamental Higgs boson is unstable to short-distance quantum corrections without some extension; otherwise, the light Higgs mass requires the enormous fine-tuning of the Standard Model parameters. In addition to this "fining-tuning" problem, questions such as why we live in a matter-dominated world and what is the source of dark matter and dark energy are unanswered.

Dr. Hatakeyama has been working on two premier high energy particle physics experiments, the CDF experiment at Fermilab, IL and the CMS experiment at the LHC, CERN, Switzerland to find clues to some of these unanswered questions and to find "new physics" beyond the Standard Model. After he joined Baylor in 2009, he worked on integrating the Baylor experimental high energy physics group into the CMS experiment, and Baylor became an official member institution of CMS in 2010. Since then, he is focused on the research with the CMS experiment and is searching for a signature of "Supersymmetry" in proton-proton collision events.

Supersymmetry is currently one of the most favored physics models beyond the Standard Model. Supersymmetry offers the candidate of dark matter and also solutions to the fine-tuning problems of the Standard Model, two of the central issues in the field. Dr. Hatakeyama was in charge of the data quality monitoring system for jets and missing energy in the CMS data, and since 2011 he led the missing ET working group of CMS. These activities are critical not only for this Supersymmetry search, but also for all CMS data analyses using jets and/or missing energy including the studies of the Higgs boson.

The initial Supersummetry searches using the 2010 and 2011 data did not show a significant indication of the Supersymmetric particle production; however, these searches have already shown much higher sensitivities than the data analysis by the previous experiments. Baylor graduate student, Tara Scarborough, and Baylor postdoc, Dr. Hongxuan Liu were critical contributors to this project. Now, the searches with more data are being vigorously pursued, and there is good discovery potential in the upcoming years.

In addition to the Supersymmetry searches discussed above, Dr. Hatakeyama is working on the upgrade of the CMS hadron calorimeter, which is critical to fully exploit the potential of the Large Hadron Collider after the luminosity upgrade. Baylor undergraduate students Evan Bauer and Forrest Phillips have been involved in this project.

Dr. Hatakeyama is a member of the US CMS collaboration board, and he also serves as a QCD subgroup convener for a series of workshops organized under "Snowmass 2013", which is for a long-term planning exercise for the high energy physics community in the US. His research is funded by the US Department of Energy, Fermilab, and Baylor University.

Recent Publications:

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC. CMS Collaboration, *Phys. Lett. B* **716**, 30 (2012); arXiv:1207.7235

Shape, transverse size, and charged hadron multiplicity of jets in pp collisions at 7 TeV. CMS Collaboration, *JHEP* **1206**, 160 (2012); arXiv:1106.4503.

Search for new physics at CMS with jets and missing momentum. CMS Collaboration, *JHEP* **1108**, 155 (2011); arXiv:1106.4503.

Missing transverse energy performance of the CMS detector. CMS Collaboration, *JINST* **6**:P09001,2011; arXiv:1106.5048.

CMS Collaboration, "Searches for Dijet Resonances in 7 TeV pp Collisions at CMS," *Phys. Rev. Lett.* **105**, 211801 (2010); arXiv:1010.0203.

Faculty Research Profiles

Truell W. Hyde

Professor
Director, CASPER
Vice Provost for Research

Research Interests:

Theoretical & Experimental Complex Plasmas

Theoretical & Experimental Astrophysics and Space Physics

Small Satellites

In-Situ Instrumentation

In addition to his VP for Research duties, Dr. Hyde continues to maintain an active research agenda within his CASPER research group, conducting research over a variety of theoretical and experimental areas in complex plasmas. During the 2011 / 2012 academic year, Dr. Hyde collaborated with Dr. Matthews and twenty six members of their combined research groups which includes two physics faculty, Dr. Truell Hyde, Dr. Lorin Matthews; seven adjunct professors, Dr. Phillip Anz-Meador (NASA JSC), John Fitch (Birkeland Current), Dr. Peter Hartmann (Eotvos Lorand University), Dr. Georg Herdrich (Institute of Space Systems, University of Stuttgart), Dr. Andrew Zwicker (PPL, Princeton), Dr. Rainer Sandau (DLR) and Dr. Ralf Srama (Heidelberg Dust Research Group, Max Planck Institute for Nuclear Physics); seven research faculty, postdocs or staff, Jorge Carmona Reyes, Mike Cook, Dr. Jie Kong, Dr. Victor Land, Dr. Rene Laufer, Dr. Ke Qiao and Jimmy Schmoke; and seven graduate students, Angela Douglass, Brandon Harris, Theresa Ma, Mudi Chen, Jonathan Perry, Alex Price and Victor Zhang.

Ph.D. Graduates in 2011 / 2012:

Angela Douglass (2012), Victor Zhang (2012)

M.S. Graduates in 2011/2012:

Alex Price (2011)

Research Interests

Complex Plasmas. The interaction of charged dust, the formation of 2D and 3D coulomb crystals, dust coagulation, small particle clusters, ordered particle chains and the coagulation of dust in low temperature plasmas. Research in this area is of interest to fundamental soft matter physics, the nanofabrication and semiconductor industries, fusion physics, space physics, planetary ring systems, protoplanetary formation and astrophysics. The primary instrument for examining such meso- and nanoscale physics in complex plasmas is the GEC RF Reference Cell. CASPER has two (2) such GEC RF cells currently in use, one of which is equipped with a Zyvex S100 nanomanipulator system.

Dust Interactions with Spacecraft. The interaction of charged dust with spacecraft and small satellites, either in orbit around the Earth or on planetary or lunar surfaces. CASPER develops and builds dust detectors for small satellites and operates a Light Gas Accelerator to calibrate such impact detection sensors and collect the data necessary to properly assess the durability of materials in space.

Fusion Research. Dust particulate contamination in burning plasma machine designs, such as that seen in the International Thermonuclear Experimental Reactor (ITER). Within CASPER, the primary instrument for examining this issue is the new Inductive Plasma Generator (IPG), which is currently under final calibration.

Grants:

Dr. Hyde currently holds over $12 Million in active funding from the NSF, NASA, SBA, and the US Dept. of Education.

Selected publications from 2011/2012:

The Influence of Monomer Shape on Aggregate Morphology J. D. Perry, E. Gostomski, L. S. Matthews and Truell W. Hyde, Astronomy and Astrophysics, **539**, A99, 2012.

Determination of the Levitation Limits of Dust Particles Within the Sheath in Complex Plasma Experiments Angela Douglass, Victor Land, Ke Qiao, Lorin Matthews and Truell W. Hyde, Physics of Plasmas, **19**, 013707, 2012.

Charging and Coagulation of Dust in Protoplanetary Plasma Environments Lorin Matthews, Victor Land and Truell W. Hyde, The Astrophysical Journal, **744**, 8, 2011.

Dust Particle Charge in Plasma with Ion Flow and Electron Depletion Angela Douglass, Victor Land, Lorin Matthews and Truell W. Hyde, Physics of Plasmas, **18**, 8, 2011.

One-Dimensional Vertical Dust Strings in a Glass Box Jay Kong, Truell W. Hyde, Lorin Matthews, Ke Qiao, Zhuanhao Zhang and Angela Douglass, Physical Review E, **84**, 016411, 2011.

The Effect of Electrode Heating on the Discharge Parameters in Complex Plasma Experiments Victor Land, Jorge Alberto Carmona Reyes, James Creel, Jimmy Schmoke, Mike Cook, Lorin Matthews and Truell W. Hyde, Plasma Science Sources and Technology, **20**, 1, 2011.

Faculty Research Profiles

Lorin Swint Matthews

Associate Professor

Research Interests:

Complex Plasmas

Theoretical & Experimental Space Physics

CASPER

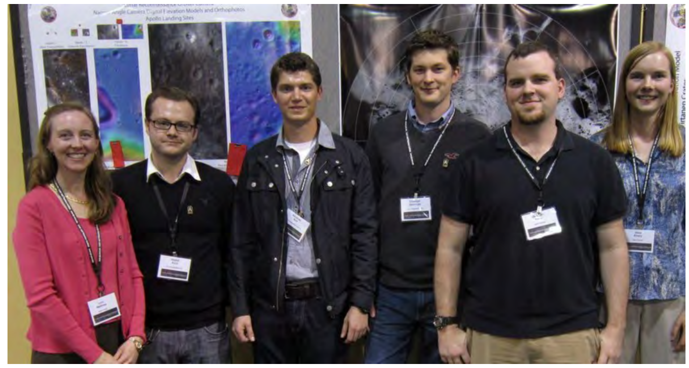
Dr. Matthews' research interests are in complex plasmas and space physics, including work in early planet formation, basic physical processes in dusty plasmas, and detection of dust in low earth orbit. Several of these projects combine theory and experiment, and most are collaborative efforts with graduate, undergraduate, and high school students, post-docs, and other faculty members in the physics department and CASPER.

In the past year, Dr. Matthews and her colleagues and students attended the Joint Fall Meeting of the Texas Sections of APS, AAPT, and SPS Zone 13 held in Commerce, TX, the 53rd Annual Meeting of the APS division of Plasma Physics in Salt Lake City, UT, the 43rd Lunar and Planetary Science Conference, in the Woodlands, TX, and hosted the 13th Workshop on the Physics of Dust Plasma here in Waco. Dr Matthews was also invited to speak at the ESA/ESTEC conference, Dust and Grains in Low Gravity and Space Environments in Noordwijk, the Netherlands, and to attend the 23rd Annual Kavli Frontiers of Science Symposium in Irvine, CA. A total of twenty-four posters and papers were presented at these conferences.

This summer, Dr. Matthews helped direct the Research Experience for Undergraduates (REU) and Teachers (RET) programs sponsored by CASPER and the Department of Physics. She supervised the work of four undergraduates, Sarah Frazier (Rice), Robert Fisher, Allen Davis (Williams College) and Will Barnes (Baylor), as well as high school student Mackenzie O'Brien.

Two of Dr. Matthews' graduate students graduated in the past year: Qianyu (Theresa) Ma received the Ph.D. in December 2011, and Jonathan Perry received an M.S. degree in August 2012.

Congratulations to Jonathan and Theresa!



L. Matthews, Helmut Koch, Christoph Gomringer, Alex Wolf, Jonathan Perry, and Jesse Kimery at the 43rd LPSC.

Recent Publications:

Perry, J., E. Gostomski, L. S. Matthews and T. W. Hyde, The influence of monomer shape on aggregate morphologies, *Astronomy and Astrophysics*, **539**, A99, 2012. doi: 10.1051/0004-6361/201117940

Douglass, A., V. Land, K. Qiao, L. Matthews, and T. Hyde, Determination of the levitation limits of dust particles within the sheath in complex plasma experiments, *Phys. Plasmas* **19**, 013707, 2012. doi:10.1063/1.3677360

Matthews, L. S., V. Land, and T. W. Hyde, Charging and coagulation of dust in protoplanetary plasma environments, *Astrophysical Journal*, **744**:8, 2012. doi:10.1088/0004-637X/744/1/8

Current Grant:

NSF CAREER: Charging and Coagulation of Fractal Dust Aggregates in Plasma Environments, $436,658

Victor Land and L. Matthews at ESA/ESTEC.

Faculty Research Profiles

Jeffrey Stuart Olafsen

Associate Professor

Director of Undergraduate Research

Research Interests:

Nonlinear/Non-equilibrium Physics

Biomechanics

Chaotic and Dynamical Systems

Granular Physics

Dr. Jeffrey Olafsen's research interests are interdisciplinary in nature, cutting across scientific disciplines to examine systems at the interface of physics, chemistry, biology, and engineering. In particular, Dr. Olafsen is interested in processes that are driven far from equilibrium and systems that are inherently nonlinear in their dynamic behavior. Unlike most research disciplines in physics, nonlinear dynamics typically extends across research topics and the investigations tend to be interdisciplinary by nature. This has advantages of incorporating techniques from many communities to attack unanswered problems. The majority of the research program so far has centered on "table top" investigations of driven granular gases, large collections of macroscopic particles for which deterministic equations exist but for which unique solutions cannot be determined for any one single particle.

The results of the investigations are applicable to a variety of different industrial processes from pharmaceuticals to grain transportation and storage. Granular physics applies to the handling of any material that is composed of a large number of macroscopic particles. Common examples are the handling and transportation of munitions, food grains and sand, and even improving the understanding of the formation of larger structures such as planets in the early solar system. Even though such media can appear to flow like a fluid, there are important differences that do not allow their behavior to be predicted with the Navier-Stokes equation, as is the case with classical fluids like water and oil. For instance, granular materials can randomly clog and jam very easily due the large amount of friction between particle surfaces. These behaviors are by definition nonlinear in nature and are extremely difficult to predict. Because of the lack of a constituitive equation, industrial processes in the past have been created on a case-by-case basis but the fundamental physics underlying such materials is not well understood.

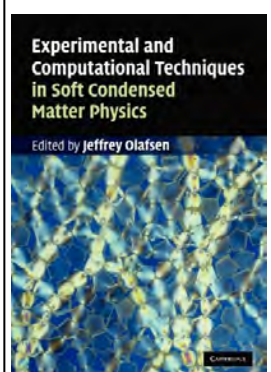
The projects themselves are diverse, from insect biomechanics to granular plasmas, low dimensional chaos, imaging and predicting structural failure of buildings, and developing new sensing techniques for detecting land mines in shallow sand beds. The students who work in the nonlinear dynamics lab are thereby trained in a more interdisciplinary manner to help create the next generation of researchers who will be called upon to solve the challenges of an increasingly interdisciplinary research landscape. The majority of the previous investigations have been pursued by undergraduate researchers in the lab, a benefit of the experiments being "table top" in size and scope, perfect for an undergraduate laboratory research experience. As the pilot projects, originally pursued by the undergraduates, mature, they are handed over to graduate student researchers who have longer periods of time to invest in more thorough scientific investigations.

In 2012, Dr. Jeffrey Olafsen was presented with an Outstanding Professor award for teaching at Baylor University.

Publications:

L. J. Olafsen, I. K. Eaves, and J. S. Olafsen, "Synchronized Mid-infrared Beam Characterization of Narrow Gap Semiconductors," *AIP Conference Proceedings* **1416**, 88–90 (2011).

Z. F. Alemdar, J. Browning and J. Olafsen, "Photogrammetric Measurements of RC Bridge Column Deformations." *Engineering Structures*, **33**, 2407-2415 (2011).



J. Olafsen "Image Acquisition and Analysis in Soft Condensed Matter." Chapter appearing in Experimental and Computational Techniques in Soft Condensed Matter Physics, Cambridge University Press, September 2010.

J. Olafsen (ed.) Experimental and Computational Techniques in Soft Condensed Matter Physics, Cambridge University Press, September 2010.

K. Combs and J. S. Olafsen, "Energy Injection in a Non-Equilibrium Granular Gas Experiment." *AIP Conference Proceedings* **1145**, 997-1000 (2009).

K. Combs, J. S. Olafsen, A. Burdeau, and P. Viot, "Thermostatistics of a single particle on a granular dimer lattice: Influence of defects." *Physical Review E* **78**, 042301 (2008).

I. S. Aranson, A. Snezhko, J. S. Olafsen, and J. S. Urbach, Comment on 'Long-Lived Giant Number Fluctuations in a Swarming Granular Nematic.' *Science* **320**, 612 (2008).

Faculty Research Profiles

Linda Jean Olafsen

Associate Professor

Research Interests:

Semiconductor physics

Mid-IR lasers

Infrared beam profiling

Glucose monitoring/ Biosensors

Dr. Linda Olafsen leads the semiconductor laser optics laboratory, an experimental research group focused on the optical and electronic properties of layered semiconductors, particularly antimonide-based quantum well heterostructures designed to operate in the mid-infrared. These "wave-function engineered" devices have within their structures elaborate combinations of finite quantum wells and tunneling barriers, making them very practical applications of introductory quantum mechanics. The target wavelength range is between 3 and 5 μm, and these wavelengths are important for countermeasures and for developing chemical sensors that are at least 100 times more sensitive than those operating in the near-infrared. Her laboratory has a unique capability for tuning the near-infrared optical pumping wavelength using an optical parametric oscillator, and she is working to more directly connect optical pumping and electrical injection experiments in the development of mid-infrared devices.

To that end, with support from University Research Council funds, Dr. Olafsen and Ph.D. student Jeremy Kunz trained and utilized the Microelectronics Research Center clean room facility, part of the J. J. Pickle Research Campus at the University of Texas at Austin. The title of the project was "Transparent Contacts for Dual Optical and Electronic Excitation in Mid-Infrared Semiconductor Lasers," and preliminary investigations were conducted using indium tin oxide, indium oxide, tin oxide, and zinc oxide on doped gallium antimonide substrates and light emitting diodes. The group also has initiated a collaboration with Dr. James Tour's laboratory at Rice University to investigate the feasibility of graphene not only as a transparent contact but also to dissipate heat. This study will have broad applicability for optoelectronic devices, and it will specifically aid investigations of mid-infrared semiconductor lasers, enabling dual optical and electronic pump-probe measurements, among other interesting studies that illuminate the physics of these heterostructures.

Last fall, Dr. Olafsen enjoyed a unique opportunity as an invited speaker at the Conference for Undergraduate Women in Physics at the University of Nebraska. The theme of the conference was Materials Girls (a combination of Rosie the Riveter and a song older than most of the participants!), and Dr. Olafsen's presentation was "Semiconductor Materials: A Practical Application of Quantum Mechanics." In addition to running into two former Baylor/CASPER REU students (Natalie Walker and Audrey Burkart), she was a panelist in a career discussion, particularly apt with 4-month-old daughter Susanna along.

With the arrival of Dr. Marlan Scully, Baylor University Distinguished Researcher, Dr. Olafsen was invited to participate in the 2012 TAMU-Casper College Summer School on Quantum Science and Engineering, held 15-21 July 2012 at Casper College in Casper, WY. She presented "Optical Pumping of Type-II W Antimonide-Based Semiconductor Lasers" that led to great interaction with students in the audience, and she enjoyed opportunities to interact with other participants from Texas schools such as Texas A&M, University of Texas, Tarleton State, and Rice as well as institutions beyond Texas including Princeton, Harvard, and the Technical University of Munich.

The most recent conference opportunity came at the 11th International Conference on Infrared Optoelectronics: Materials and Devices (MIOMD-XI), 4–8 September 2012 at Northwestern University, Evanston, IL. Dr. Olafsen presented a paper and 5-minute talk on "Nonlinear Temperature Variation of Resonant Pump Wavelength in Optically Pumped Mid-Infrared Semiconductor Lasers," for which former REU students Lauren Ice and Ben Ball were co-authors.

It also was a busy year outside the research laboratory. Dr. Olafsen is the incoming Chair of the Materials Research Society Congressional Visits Day subcommittee. She took two trips to Washington, DC, including leading the visit by six members of the MRS Board of Directors. She continues to share the message with members of Congress that basic research in science should be a national funding priority, particularly as it relates to innovation, education, and economic prosperity.

Recent Publications:

L. J. Olafsen, "Tunable Optical Pumping Technique for the Development of Mid-Infrared Semiconductor Lasers," appearing in New Developments in Photon and Materials Research, edited by J. I. Jang, Nova Science Publishers (2012).

L. J. Olafsen, I. K. Eaves, and J. S. Olafsen, "Synchronized Mid-infrared Beam Characterization of Narrow Gap Semiconductors," *AIP Conference Proceedings* **1416**, 88–90 (2011).

Faculty Research Profiles

Kenneth Taesung Park

Associate Professor

Research Interests:

Surface Defects of Transition Metal Oxides

Interface between Metal and Thin Films of Organic Molecules

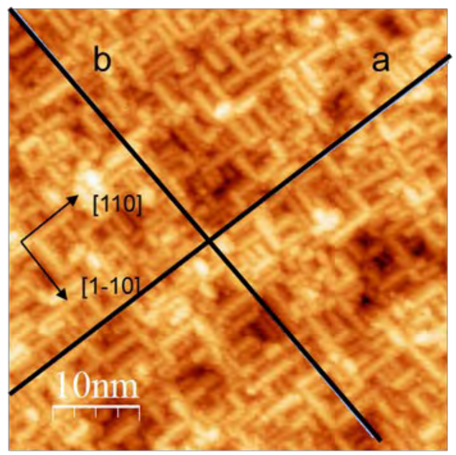
Dr. Park and his collaborators have been studying surface defects in single crystal TiO_2 to gain understanding of their structure-property relationship. With numerous, stable sub-stoichiometric species known in the Ti-O phase diagram, they can form local structures and properties that are markedly different from those of the mother compound. Consequently, partially reduced oxides of the binary system can become increasingly complex and heterogeneous in structure and properties.

The formation of sub-stoichiometric defects and local electronic structures have been elucidated using scanning tunneling microscopy (STM) and first-principle theory calculations. Once Ti interstitials are driven out to the (110) surface, they readily dissociate molecular oxygen as highly under-coordinated cationic defects. The dissociated oxygen atoms surround a Ti interstitial to form an oxygen plane of a partial octahedron. The line defects of sub-oxides with face-sharing octahedra further serve as basic building blocks for surface reconstruction, for example (1x1) and (1x2) phases. In addition to the sub-oxide species, the Ti interstitials also can form fully stoichiometric defects in the shape of topographically distinct dots, observed in STM. Due to broken bonds and small size, their atomic structure is significantly altered from that of bulk and contains both cationic and anionic coordination defects. In particular, a single-coordinated oxygen atom of the defect and surface bridging O atoms provide an exceptionally strong bonding site for gold atoms. The Au atoms attached to the TiO_2 defect exhibit a number of key features expected from catalytically active Au nanoparticles.

Unlike the most thermodynamically stable (110) surface, TiO_2(001) is known to undergo extensive surface reconstruction due to high surface energy. The two distinctive phases of reconstructions have been reported using low energy electron diffraction (LEED) in the past: {011}- and {114}- faceted structures for below and above 900 K, respectively. However, our recent results show that even the {114}- faceted structure can be increasingly complex, possessing a mixture of {112} and {114} micro-facets (Figure). The common feature of these reconstructions is the linear structure, and this basic building block is believed to be of stoichiometric nature. A specific atomistic model has been proposed by Dr. Park and his student Nancy Yu, and a manuscript is currently being written.

Recent Publication:

"Evidence of Coulomb Blockade Behavior in a Quasi-zero Dimensional Quantum Well on TiO_2 Surface," V. Meunier, M. H. Pan, F. Moreau, K. T. Park, and E. W. Plummer, Proc. Natl. Acad. Sci. U.S.A. **107** (2010) *doi: 10.1073/pnas.1009310107*.



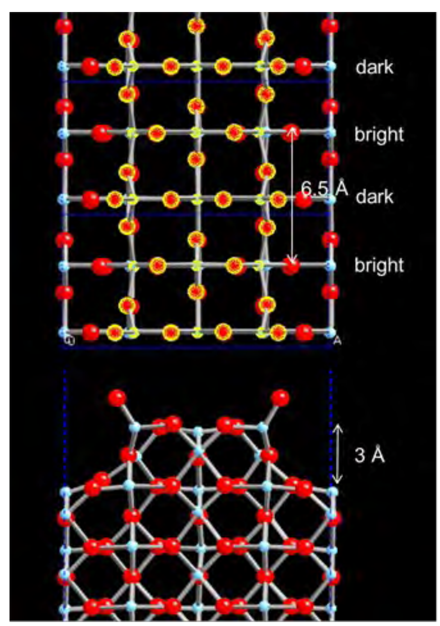


Figure (Top) STM image from TiO_2(001) (Bottom) the proposed atomistic model of the linear structure.

Faculty Research Profiles

Dwight Russell

Associate Professor

Research Interests:

Materials Science

Surface Science

Astronomy

Activities:

This year my activities have covered three main areas: teaching intro astronomy, examining plans for an observatory and planetarium, and research on alkali halide surfaces.

While the introductory astronomy course continues to be a popular course with class sizes approaching 300 students, our new astronomy degree options continue to grow. The first course in the new degree plans, Phy 2455- Foundations in Astronomy, is being offered in its fourth year. The field of astronomy certainly helps out by providing a flood of new and exciting discoveries. It is easy to say that the last fifteen years of astronomy are as significant in the increase and impact on our understanding of the physical universe as at any time in history. It truly is an exciting time to introduce students to the study of astronomy.

Two new research efforts in Astronomy have begun. At the American Astronomical Society meeting I reconnected with an old student of mine, Dr. Sachin Shenoy, who is now working at NASA AMES on infrared astronomy. We have begun a research effort to catalog background stars for dark clouds in and near the Galactic plane. These stars can be used to map dark cloud densities. An undergraduate astrophysics major, John Grzehowiak, is supported by a Baylor URC grant to work on this project In future research we hope to utilize these stars in infrared adsorption studies of chemistry occurring in these dark clouds. The second project is an exoplanet detection project performed at the PJMO observatory this summer with REU summer research student Lydia Shannon with help from Dick Campbell and Willie Strickland. A transit of the exoplanet TReS-3 was measured successfully. The exoplanet work will be presented at the Fall TSAPs meeting in October.

Editor's Note: *A focus article on the exoplanet research with more details is on page 28 of this newsletter!*

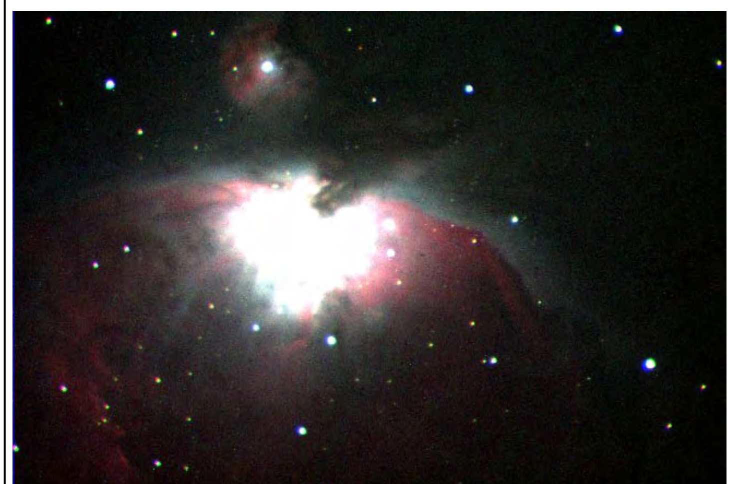
Recent Publication:

Role of Surface Dimer and Gas-Phase Excitation Models in Electron Stimulated Desorption of Ions from Sodium Chloride (100) Crystals, D. P. Russell, W. Durrer, *Rad. Eff. and Def. in Solids* **160**,151 - 154 (2005).

Other Publications:

Elastic interactions and the metallurgical and acoustic effects of carbon in the Caribbean steel drum, Ferreyra E, Murr LE, Russell DP, Bingert JF, *Materials Characterization* **47** (2001) 325-363.

Electron and Photon-Stimulated Desorption of Atomic Hydrogen from Radiation-Modified Alkali Halide Surface, L. T. Hudson, N. H. Tolk, C. Bao, P. Nordlander, D. P. Russell, J. Xu, *Phys. Rev. B* **62** (15) 10535 – 10543 (2000).



Students in our Astronomy & Astrophysics majors learn how to perform image analysis using the MATLAB platform.

We had more graduates in Astronomy and Astrophysics this spring than from our traditional undergraduate physics degree!

Faculty Research Profiles

Anzhong Wang

Professor

Research Interests:

Brane Worlds in String/M-Theory

Horava-Lifshitz Theory

Advanced Numerical Analysis of Observational Data

Black Holes, Thermodynamics & AdS/CFT Correspondence

GCAP (Gravity, Cosmology, and Astroparticle Physics Group), founded in 2006, is one of the Particle Physics Groups in Physics Department, and one of the three theoretical research groups in CASPER. Currently, it consists of four Baylor faculty members, Dr. Anzhong Wang, the head of the group (Physics), Dr. Klaus Kirsten (Math), Dr. Qin (Tim) Sheng (Math), and Dr. Yumei Wu (Physics); four adjunct professors, Dr. Rong-Gen Cai, from the Institute of Theoretical Physics, Chinese Academy of Science, Dr. Yungui Gong, from College of Mathematics and Physics, Chongqing University of Posts and Telecommunications, Chongqing, Dr. Jianxin Lu from Interdisciplinary Center for Theoretical Study, the University of Science and Technology of China, and Dr. N. O. Santos, from Queen Mary College, London University and the Brazilian National Scientific Computation Lab (LNCC); one recent Baylor graduate, Janie Hoormann; and three graduate students, Ahmad Borzou, Yongqing Huang, and V. H. Satheeshkumar. Recent research topics include the Horava-Lifshitz theory of quantum gravity, its applications to cosmology and astrophysics; the nature and origin of the late cosmic acceleration; branes in string/M theory, and their applications to astrophysics and cosmology; highly efficient and effective computer simulations; and Casimir effects, and their applications to astrophysics and cosmology.

Very recently, Horava proposed a new theory of quantum gravity motivated by the Lifshitz theory in solid state physics. The Horava-Lifshitz theory is non-relativistic, and power-counting renormalizable. The effective speed of light diverges in the UV, and this potentially resolves the horizon problem without invoking the inflationary scenario. In addition, almost scale-invariant super-horizon curvature perturbations can be produced without inflation. With an additional U(1) symmetry, the universe is necessarily flat. As the theory was still in its infant time, a comprehensive understanding of it is highly demanded.

One of the remarkable discoveries over the past decade in astronomy is that currently our universe is at its accelerating expansion. In Einstein's theory, to account for such an acceleration, a new component to the matter fields of the universe with a large negative pressure is needed, the so-called dark energy. A fundamental question now is the nature and origin of dark energy. The hierarchy and cosmological constant problems are other outstanding problems in particle physics and cosmology. To solve these problems, brane-world scenarios were proposed, in which our four-dimensional universe is considered as a brane embedded in a high dimensional bulk. An important result of such investigations is that high dimensional black holes are predicted to be produced in the TeV energy scale, which shall be explored directly by colliders in laboratories, such as LHC.

In addition, theories of gravity, including general relativity, predict the existence of black holes and gravitational waves. Forthcoming CMB polarization experiments, pulsar timing arrays, and terrestrial/space-based interferometers will probe a wide range of frequencies of the gravitational waves. On the other hand, black holes, their thermodynamics and formation from gravitational collapse have been some of the main focuses in gravitational physics in the last couple of decades. Our studies on these subjects are both analytical and numerical.

The Casimir effect is understood as physical forces arising from a quantized field. A typical example is of two uncharged metallic plates in a vacuum, placed a few micrometers apart, without any external electromagnetic field. We are investigating these effects among branes in string/M theory.

Recent Publications:

Static electromagnetic fields and charged black holes in general covariant theory of Horava-Lifshitz gravity. A. Borzou, K. Lin, and A. Wang, *JCAP*, **02**, 025 (2012).

General relativity limit of Horava-Lifshitz gravity with a scalar field in gradient expansion. A.E. Gumrukcuoglu, S. Mukohyama, and A. Wang, *Phys. Rev. D* **85**, 064042(2012).

General covariant Horava-Lifshitz gravity without projectability condition and its applications to cosmology. T. Zhua, F.-W. Shu, Q. Wu, and A. Wang, *Phys. Rev. D* **85**, 044053 (2012).

Classification of the FRW universe with a cosmological constant and a perfect fluid of the equation of state $p = w\rho$ T. Ha, Y.-Q. Huang, Q. -Y. Ma, K. D. Pechan, T. J. Renner, Z.-B. Wu, G. A. Benesh, and A. Wang, *Gen. Relativ. Grav.* **44**, 1433-1458 (2012) [arXiv:0905.0396].

Faculty Research Profiles

B. F. L. Ward

Distinguished Professor

Research Interests:

Theoretical Physics

Particle Physics

Quantum Field Theory

Interactions of all known subatomic particles can be described by a single theoretical framework known as the "Standard Model". This model describes matter in terms of leptons (including electrons, neutrinos, ...) and quarks, together with their interactions via force-carriers called "gauge bosons", which include the photon, W and Z bosons, and gluons. The theory is modeled by a gauge group SU(2)L x U(1) x SU(3)c which encompasses all known forces except gravity, which is too weak on small scales to have been observed in any particle physics experiments. An important constituent of the standard model is the Englert-Brout-Higgs boson, usually just called the 'Higgs' boson, which is associated with a scalar field which causes most of the particles in the standard model to acquire a mass. Until recently, the Higgs had not been observed.

Large high-energy physics laboratories such as the ones at Fermilab, SLAC, and CERN, have been very successful in verifying the predictions of the standard model, with the exception of finding the Higgs boson. Discovering and uncovering the properties of the Higgs boson was therefore one of the primary goals of particle colliders currently active or under construction, including the Large Hadron Collider (LHC) at CERN. On July 4, 2012, a candidate for the Higgs was announced by the ATLAS and CMS Collaborations at the LHC with a mass near 126 GeV. The focus now is to measure its properties precisely in high energy colliding beam devices such as the LHC and the possible International e^+e^- Linear Collider. Interpreting the results of such high-energy collisions in terms of the standard model requires high precision calculations of the various processes and backgrounds which are to be observed.

The theoretical high energy physics phenomenology group at Baylor focuses on rigorous quantum field theoretic investigations with an emphasis on the theory of higher order radiative corrections to the $SU(2)_L \times U(1) \times SU(3)^c$ model of elementary particle interactions. Dr. Ward is engaged in constructing computer realizations of the quantum field theory calculations required for such high-precision tests of the Standard Model. Collision properties are calculated in the context of realistic detector simulations using "Monte Carlo" event generators, which randomly generate scattering events based on the predictions of quantum field theory. Monte Carlo realization of the radiative corrections has played an essential role in precision Standard Model tests and new physics probes in the LEPII final data analysis, and in the preparation of the physics for the CERN LHC. These calculations also have immediate consequences for the ongoing final studies at the now closed lower-energy FNAL Tevatron and for precision Standard Model tests at the B-Factories and at the Φ-Factory. High precision is achieved via resummation methods based on the theory of Yennie, Frautschi and Suura (YFS), which have been extended to non-Abelian gauge theories like QCD.

The YFS methods, which allow one to resum the infrared terms in quantum field theory, can also be extended and applied to perturbative quantum gravity. Dr. Ward has been investigating this, and in the process has found a new way to analyze classes of quantum gravity graphs which may otherwise have been expected to produce divergences. This may provide a fruitful new approach to the long-standing problem of quantizing gravity. His recent estimate of the cosmological constant gives further evidence of the correctness of the approach.

During 2010-2011 Dr. Ward was invited to visit the CERN theory unit on research leave for 8 1/2 months to continue his development and implementation of the new MC-HERWIRI 1.031 which realizes his new IR-improved DGLAP-CS theory for precision QCD predictions for LHC physics scenarios. He was invited to present his latest results with HERWIRI 1.031 in the CERN TH-LPCC LHC Theory Institute on 8/5/2011, and in the CERN NLO Parton Shower Workshop on 2/28/2012. In addition, during the leave he was invited to present on his new approach to quantum general relativity, resummed quantum gravity at the University of Barcelona, University of Madrid and SISSA in Trieste, Italy. More recently, he was invited to speak on Herwiri1.031 and on the latest results from his new approach to quantum gravity in the 2012 International Conference on High Energy Physics in Melbourne, Australia on July, 5, 2012 and again at the 2012 Oberwoelz QCD Conference in Oberwoelz, Austria on September 5, 2012.

Recent Publications:

S. Joseph, S. Majhi, B. F. L. Ward, S. A. Yost, "New Approach to Parton Shower MC's for Precision QCD Theory: HERWIRI1.0 (31)", *Phys. Rev. D* **81**, 076008 (2010).

B. F. L. Ward, "Magic Spinor Product Methods in Loop Integrals", *Phys. Rev. D* **83** (2011) 113014.

B. F. L. Ward, "New Approach to GUTs", *Eur. Phys. Jour. C* **71** (2011) 1686.

B. F. L. Ward, "On Estimates of Radiation by Superluminal Neutrinos", *Phys. Rev. D* **85** (2012) 073007.

B. F. L. Ward, S. K. Majhi, S. A. Yost, "Exact Amplitude-Based Resummation in Quantum Field Theory: Recent Results", in *PoS* (RADCOR 2011)(2012) 022.

Faculty Research Profiles

Walter Wilcox

Professor

Physics Graduate Program Director

Research Interests:

Lattice QCD

Deflation Algorithms

Finite Quark Matter

Teaching interest:

Physics textbooks

I earned a Ph.D. in elementary particle physics from UCLA in 1981 under the guidance of Dr. Julian Schwinger. I have also taught and done research at Oklahoma State University (1981-1983), TRIUMF Laboratory (1983-1985) and the University of Kentucky (1985-1986). I have been awarded grants from NSF in theoretical physics, and, in collaboration with Ron Morgan, in applied mathematics. My research focuses on the development and use of numerical methods in the field of theoretical physics known as "lattice QCD". Equally interested in teaching physics, I have had a new undergraduate textbook, "Quantum Principles and Particles" (CRC Press) published this year. My OPEN TEXT PROJECT website (http://blogs.baylor.edu/open_text/) offers many free physics teaching materials.

My main area of research is the study of the interactions of particles known as quarks and gluons. One of the significant recent developments in quantum field theory is the recognition that solution techniques involving computers are crucial in this field. The theory of quark and gluon interactions is called Quantum Chromodynamics (QCD). "Lattice QCD" represents a numerical attempt to solve, and compare to experiment, physically observable quantities using a discrete space-time lattice of points. State of the art numerical methods are used to solve the theory on high performance computers. Lattice QCD benefits from a synergy of field theory, experimental particle physics and computer technology. I also have an interest in quark models which explore the possibility of high-multi-quark hadronic states, also called finite quark matter.

In collaboration with Ron Morgan of the Baylor Mathematics Department, our work in Lattice QCD is centered on three areas: extension of matrix deflation algorithms, noise suppression using new eigenspectrum subtraction algorithms, and measurement of hadron electromagnetic properties, including electric and magnetic polarizabilities. In the area of deflation, our work is centered on developing new mathematical techniques to speed up the solution of ill-conditioned linear equations, especially for lattice QCD (where it is termed "fermion matrix inversion") which affects lattice QCD simulations at small quark masses. One new solution technqiue we are improving is called a “seed method”. In addition, it turns out that at small quark masses the numerical methods used to isolate physical signals in lattice QCD become swamped with statistical noise. Ron Morgan, Abdou Rehim and I are continuing an investigation of a new technique, pioneered by my student Victor Guerrero, called "hermitian forced eigenspectrum noise subtraction" which dramatically improves the simulations, especially when combined with a previous technique called perturbative subtraction. In addition, work on electromagnetic properties on parallel systems at Jefferson Lab uses the deflation algorithms developed in collaboration with Ron Morgan.

I am also continuing work on a new analytic model of hadron structure based upon the semi-classical Thomas-Fermi (TF) statistical model, in collaboration with my student Andy Liu. The TF approach is normally used to model atomic interactions, but I have applied it instead to assemblies of quarks. It turns out to be a natural application of the method. The quarks move in a collective potential and are confined by a vacuum pressure term. There are nonrelativistic and relativistic versions of the model, which can also be generalized to include quark sea contributions or spin interactions. I am developing it for more expensive lattice simulations in the search for high multi-quark hadronic states.

Based upon my trademarked OPEN TEXT PROJECT (OTP) efforts, I have continued my foray into the textbook publishing business. The undergraduate quantum textbook based upon my OTP source called "Quantum Principles and Particles" (QPP) was published by Taylor and Francis (CRC Press in the US) earlier this year. QPP includes material which overlaps with particle physics, including a number of interesting particle applications. A solutions manual has also been prepared. The OTP graduate electrodynamics textbook, "Macroscopic Electrodynamics" (ME), co-authored with Dr. Chris Thron of Texas A&M University-Central Texas, was accepted for publication by World Scientific last year. ME is a comprehensive two-semester graduate level textbook on classical electrodynamics for use in physics and engineering programs. ME emphasizes principles and practical analysis techniques and is written directly to the student in a clear minded but informal and friendly way. The text is presently being extensively modified and prepared in LaTeX format, will include a solutions manual, and be published in 2013.

Recent Publications:

“Deflated and restarted symmetric Lanczos methods for eigenvalues and linear equations with multiple right-hand sides”, A. M. Abdel-Rehim, R. B. Morgan, D. A. Nicely, and Walter Wilcox, *SIAM J. Sci. Comput*. Volume 32, Issue 1, pp. 129-149 (2010).

"Thomas-Fermi Statistical Models of Finite Quark Matter", Walter Wilcox, *Nucl. Phys. A* **826** (2009) 49–73.

Faculty Research Profiles

Zhenrong Zhang

Assistant Professor

Research Interests:

Surface Chemical Physics

Scanning Tunneling Microscopy

Heterogeneous Catalysis

Oxide Nanostructure and Thin Film Growth

Dr. Zhang's research interest is to understand energy and environment related reaction mechanisms and dynamics on model oxide catalysts at the molecular-level for designing nanocatalysts with desired reactivity and selectivity. The current research project is to understand how the local structure influences the photo-conversion of CO_2 with H_2O to liquid fuel related hydrocarbons on inverse model oxide nanocatalysts (i.e. metal supported oxide nanocatalysts). "Inverse" model catalysts offer the selection that is not possible in "regular" model catalysts but are important in energy and environmental applications. The approach will be to 1) synthesize ordered oxide (ZrO_x and TiO_x) nanostructures and ultrathin films on the metal single crystal surfaces, and 2) probe the thermally and photo-activated surface reaction processes (adsorption, dissociation, diffusion and orientation dynamics) of molecular species (reactant molecules, possible intermediates and product molecules) on these oxides. Meanwhile, Drs. Park and Zhang closely collaborate on diverse projects in surface chemical physics.

In the last two year, Zhang's group successfully set up the custom-modified scanning tunneling microscope (STM) (SPECS) apparatus. Since the fall semester of 2011, two graduate students, Yaobiao (Eric) Xia and Bo Zhang have been actively taking data for their theses. Eric is working on photocatalytic reactions on rutile TiO_2(110). Bo is working on catalytic reactions on anatase TiO_2(001). A manuscript based on their work has been recently submitted to Journal of Physical Chemistry Letter (See the Figure). In addition, 3 undergraduates have participated in surface chemical physics research for honors theses, senior research projects, and summer internships.

Dr. Zhang serves on a standing EMSL Peer user research proposal Review Panel. Funding for the surface chemical physics group at Baylor has been provided by American Chemical Society Petroleum Research Fund.

Professional Activities:

Bo Zhang and Yaobiao (Eric) Xia presented two posters at the Southwest Catalysis Society 2012 Spring Symposium, held in Houston, TX. Also attending was Dr. Zhenrong Zhang. Bo Zhang's poster title is "Adsorption and Diffusion of Acetone on Rutile TiO_2 (110)". Yaobiao Xia's poster title is "Acetone Assisted Diffusion of Oxygen Vacancies on TiO_2 (110)" Yaobiao Xia won a best poster prize at the symposium.

Amir Ali (undergraduate student) presented a poster entitled "TiO_2(110) Sample Preparation & Installation of Molecular Doser" at URSA Scholars week. The poster was chosen as one of the URSA Scholars Week Outstanding Poster Presentations.

Dr. Zhenrong Zhang and Bo Zhang attended Surface Analysis 2012 hosted at Environmental Molecular Sciences Laboratory in Richland, Washington State, June 19-22, 2012. Bo Zhang presented a talk entitled "Adsorption and diffusion of acetone on rutile TiO_2 (110)". Dr. Zhang moderated the Catalysis session.

Dr. Zhenrong Zhang and Bo Zhang spent the summer of 2012 at the Pacific Northwest National Laboratory. They worked with their collaborators on the Catalytic Oxidation of Organics on Rutile TiO_2(110) and Anatase TiO_2(001).

Recent Publications:

S. Li, Z Li, Z, Zhang, B. D. Kay, R Rousseau, Z. Dohnálek, Preparation, Characterization, and Catalytic Properties of Tungsten Trioxide Cyclic Trimers on FeO(111)/Pt(111), *J. Phys. Chem. C,* **116** (2012) 908–916.

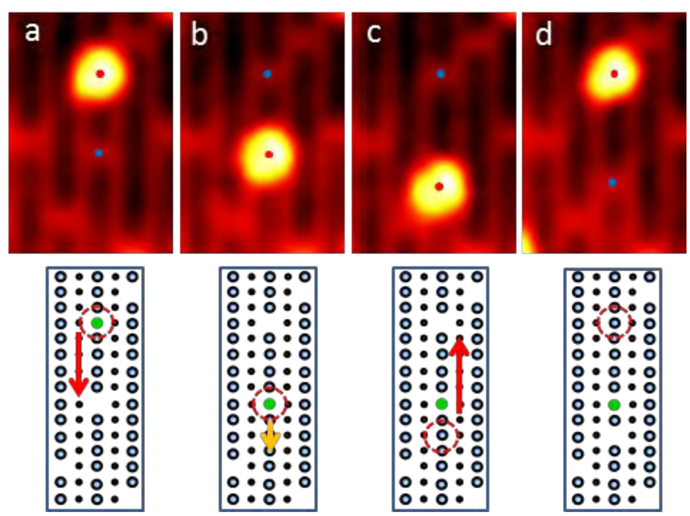


Figure. STM images recorded as a function of time (t = 0, 12, 18, 21 min) on the same area of acetone pre-adsorbed TiO_2 (110). The corresponding ball models illustrate the diffusion of vacancy mediated by acetone diffusion at 300 K.

Lecturer Profiles

Karen Bland

In 2006, Karen Bland came from her home in Virginia to pursue graduate level studies in physics at Baylor University. She recently graduated in August, 2012 with her PhD in experimental high energy physics, with research focusing on a search for the Higgs boson using the CDF detector at Fermilab. She is now a temporary lecturer for the physics department, teaching labs and helping the department out in other areas where there is need. She also continues to work with the CDF collaboration, particularly with analyses involving photons.

Daniel Bolton

Daniel Bolton is in his second year as a full-time Lecturer at Baylor. He earned a BS in engineering physics from the Colorado School of Mines in 2006, and completed his PhD in theoretical nuclear physics in 2011 at the University of Washington in Seattle. In addition to lecturing, Daniel continues to work on projects related to his dissertation, primarily in the field of Lattice Quantum Chromodynamics.

Daniel also serves as the faculty advisor for the Society of Physics Students.

Daniel and his wife Laura, who also has a degree from the University of Washington (an MS in biochemistry), rejoiced at the birth of their first child, Joy Ruth, on September 13. They would like to thank everyone for their prayers and support. The Bolton family also includes their dog Daisy, a 1 year old Lab mix. Daniel enjoys distance running and hiking Colorado's 14er's (14k ft. mountains) on trips back home. Though not a native Texan, Daniel has quickly become fond of real Texas barbeque!

Randy Hall

Randy Hall has been a lecturer in the Baylor Physics Department since 2008. He received his Bachelor of Science degree in Physics and Mathematics from Baylor in 1971 and a Master of Science degree in Mathematics from Baylor in 1972. Randy did additional graduate work in Mathematics and Computer Science (1973 – 75) at the University of Texas at Austin. He also serves as lab coordinator in the Department.

Randy was president and CEO of DIGATEX, Inc., a developer and supplier of route accounting and management software for soft drink bottlers and other food and beverage distributors (1978 – 2007). He has also taught at the University of Texas at Austin (Computer Science) and Austin Community College (Mathematics). He is married to Cathey L. Hall (BSEd Baylor 1973) and they have a daughter Jessica (BBA Baylor 2006) who is an attorney in Southlake, Texas. Randy also works with software development for CASPER (the Astrophysics research group).

Linda Kinslow

Linda Kinslow has been teaching at Baylor University for ten years. She had previously coordinated the undergraduate physics labs in the Department. Prior to coming to Baylor she worked for BP as a exploration geophysicist. Dr. Linda Kinslow earned her PhD degree from Baylor.

Lecturer Profiles

Ray Nazzario

While currently a Senior Analyst Programmer for Information and Technology Services (ITS)., Ray, who obtained his PhD in 2002 from Baylor University, is also a temporary part-time lecturer in the Department of Physics who is primarily associated with the tutorials for PHY 1420 & 1430. In addition, Ray is a member CASPER.

Edward Schaub

If you've been in the department recently, you may have noticed a new, yet somehow strangely familiar, lecturer teaching a couple of courses this fall. Your eyes do not deceive you. Our very own Ed Schaub once again has returned to help teach where we have need.

Ed Schaub has been involved in the Baylor Physics department for more than 25 years, first as an instrumentation engineer on the NASA CRAF/CoDEM project under the leadership of Dr. Merle Alexander, and most recently as a full-time lecturer.

Previous to his Baylor employment, Ed Schaub held a number of positions in industry. He was a production engineer with Texas Instruments in the Government Products Division and a research engineer with AFS Research Corporation investigating alternate energy resources.

Mr. Schaub holds an M.S. in Physics and an M.S. in Environmental Studies. With 30 years as part of the Baylor family, the feelings run deep for how much we love Ed - as both a gentleman and a physicist.

John Vasut

John Vasut received his PhD from Baylor University in 2001 and has been working as a full-time lecturer in the department since 2002. John is the advisor for the Baylor chapter of the American Student Dental Association. He was named Advisor of the Year at the 14th Annual Baylor Advisor Appreciation Banquet held on April 16, 2007. John runs marathons in his spare time.

Yumei Wu

Yumei Wu received her PhD from University of Ioannina in Greece in 1992 and had been an associate professor in the department of mathematics at the Federal University of Rio de Janeiro, Brazil from 1995 to 2007.

Yumei then joined the department as a lecturer.

In addition to lecturing, she continues to do theoretical research on dynamic systems & applications to gravity and cosmology.

Editor's note: Yumei was also kind enough to provide the devotional for this year's Annual Newsletter on page 34.

She recently published the papers:

A. Wang and Y. Wu, Cosmology in nonrelativistic general covariant theory of gravity. *Phys. Rev. D* **83**, 0443031 (2011).

A. Wang and Y. Wu, Thermodynamics and classification of cosmological models in the Horava-Lifshitz theory of gravity, *JCAP* **07**, 012 (41 pages) (2009) [arXiv:0905.4117] .

National Academy Member Brings Laboratory to Baylor

Editor's note: Large portions of this story are reprinted from a Texas Business article on TexasBusiness.com

Dr. Marlan Scully

Internationally renowned physicist and member of the National Academy of Sciences, Marlan O. Scully, who is best known for his work in theoretical quantum optics, has been named distinguished research academician of science and engineering at Baylor University.

Scully, who will relocate his research labs to the Baylor Research and Innovation Collaborative (BRIC), has made outstanding research accomplishments over his long career in the areas of quantum optics, laser physics and bioengineering. He wrote definitive textbooks on quantum optics and laser physics and has published his research in more than 700 articles in professional journals such as *Nature* and *Science*. He has also written for popular venues like *Scientific American* and *Physics Today*.

"Dr. Scully is truly a Renaissance researcher," said Truell Hyde, Baylor University vice provost for research. "His knowledge and research interests span many fields, and we look forward to his continued research contributions here at Baylor."

In addition to his membership in the National Academy of Sciences, Scully is a member of the Academia Europa, the Max Planck Society, and the American Academy of Arts and Sciences, among others. He has received numerous awards and honors including the Elliot Cresson Medal of the Franklin Institute, the Schawlow Prize of the American Physical Society, the Townes Medal of the American Optical Society, the Herbert Walther Award of the German Physical Society, and a Guggenheim Fellowship. He was recently appointed Loeb Lecturer at Harvard University.

"I am excited to become part of the Baylor community and explore the theological and philosophical implications of quantum mechanics, entropy and statistical time," said Scully.

"Baylor is a unique, academically excellent Christian university, and I look forward to working with fellow researchers as Baylor reaches the next level of research excellence."

Scully did his undergraduate work at the University of Wyoming and Rensselaer Polytechnic Institute and his master's and doctoral work at Yale University. He is a member of the faculties at Texas A&M University and Princeton University. He is the Herschel Burgess Chair and Distinguished Professor in the department of physics at Texas A&M and is the director of its Center for Theoretical Physics and the Institute for Quantum Science and Engineering. For the past decade, he has held a professorial position at Princeton.

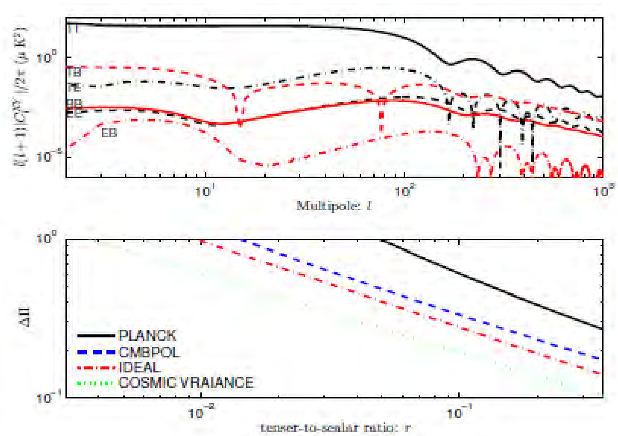
Dr. Scully, late in the Fall of 2011, hosted a reception with members of the physics department to renew old acquaintances and meet newer members of the department.

On Thursday, September 27, 2012, the Office of Vice Provost for Research held a reception honoring Dr. Scully as the 2012 recipient of the Frederic Ives Medal / Jarus Quinn Prize. Dr. Scully gave a brief presentation on Physics and Faith and Dr. Elizabeth Davis, Executive Vice President and Provost gave remarks shortly thereafter during the reception.

The Frederic Ives Medal/Jarus Quinn Prize is the highest award conferred by The Optical Society. It has been awarded for Dr. Scully's groundbreaking research in quantum optics. Dr. Scully will be giving a colloquium as part of the Department's Homecoming Activities *(see p.34)*

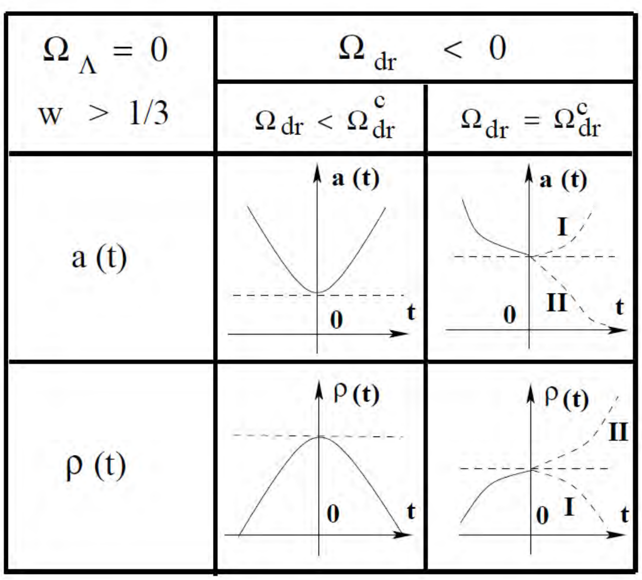
Special Research Focus: Horava-Lifshitz Theory of Quantum Gravity

Quantum field theory provides a general framework for the description of all known interactions except gravity. While the well-established Einstein's theory of general relativity (GR), has been very successful in its applications to astrophysics and cosmology, it has been known for a long time that GR is not renormalizable, and thus is considered only as a low energy effective theory and cannot describe quantum physics of gravity. On the other hand, because of the universal coupling of gravity to all forms of energy, it is expected that gravity too should have a quantum mechanical description. Motivated by this strong anticipation, quantization of gravity has been one of the main driving forces in theoretical physics in the past decades in a wide range of approaches, including string/M-Theory and loop quantum gravity.



Top panel: The CMB power spectra generated by polarized PGWs with r = 0.1 and π = 1. Bottom panel: The uncertainties Δπ as a function of r for potential observations.

Recently, Horava [1] proposed a theory of quantum gravity in the framework of quantum field theory. The spacetime metric is considered as an elementary field in the language of the standard quantization such as the path-integral formulation. One of the essential ingredients of the theory is the inclusion of higher-dimensional operators, so that the ultraviolet (UV) behavior is dominated by these operators which render the theory power-counting renormalizable. In the infrared (IR) the lower dimensional operators take over, presumably providing a healthy low energy limit. Improvement of the UV behavior by higher-dimensional operators has been known for some time [2] but in those previous attempts, higher time derivative terms were also included, which led to ghost degrees of freedom. The major modification put forward by Horava's theory is that the power-counting renormalizability is achieved without inclusion of higher time derivative terms. This is realized by invoking the anisotropic scaling between time and space, so that higher-dimensional operators include spatial derivatives only. This is reminiscent of Lifshitz scalars in condensed matter physics, hence the theory is often referred to as the Horava-Lifshitz (HL) gravity. Because of the anisotropic scaling, the theory cannot be invariant under the general diffeomorphism. Instead, the fundamental symmetry of the theory is the invariance under the so-called foliation-preserving diffeomorphism, i.e. the space-independent time reparametrization plus the spatial diffeomorphism.



The evolution of the universe with the potential given for $\Omega_\Lambda = 0$, $\omega > 1/3$ and $\Omega_{dr} < 0$. A bouncing universe is allowed in either of these two cases.

(Continued on next page)

Special Research Focus: Horava-Lifshitz Theory of Quantum Gravity

Since its introduction, there have been many cosmological applications of the HL gravity and various remarkable features have been found [3]. In particular, the higher-order spatial curvature terms may ameliorate the flatness problem; the anisotropic scaling provides a solution to the horizon problem and generation of scale-invariant perturbations even without inflation; a new mechanism for generation of primordial magnetic seed field exists; dark matter and dark energy can have their pure geometric origins; circularly polarized gravitational waves can also be generated in the early universe; and so on.

Despite all of the remarkable features described above, it was found that the theory is plagued with several problems, such instability, strong coupling, and different speeds of particles even in the gravitational sector.

To address these problems, various models have been proposed. Among these models, the ones [4, 5] with an additional U(1) symmetry seem very promising, and are absent of all problems found so far. Certainly, there are still many challenging questions to be answered, before it is considered as a viable theory of quantum gravity. These include the quantization of the theory, and the couplings of matter and gravity.

[1] P. Horava, *Phys. Rev. D* **79**, 084008 (2009).

[2] K. S. Stelle, *Phys. Rev. D* **16**, 953 (1977).

[3] S. Mukohyama, *Class. Quant. Grav*. **27**, 223101 (2010).

[4] P. Horava and C. M. Melby-Thompson, *Phys. Rev. D* **82**, 064027 (2010).

[5] T. Zhu, Q. Wu, A. Wang, and F.-W. Shu, *Phys. Rev. D* **84**, 101502(R) (2011).

Professor Anzhong Wang's group (left to right): Xinwen (Richard) Wang, Bahram Shakerin, Yongqing (Steve) Huang, Dr. Anzhong Wang, Dr. Jie Yang (a visiting professor to his group since August 2012), Jared Greenwald (Dr. Jerry Cleaver's student), Yuanbin Den (also Dr. Cleaver's student), and V. H. Satheeshkumar.

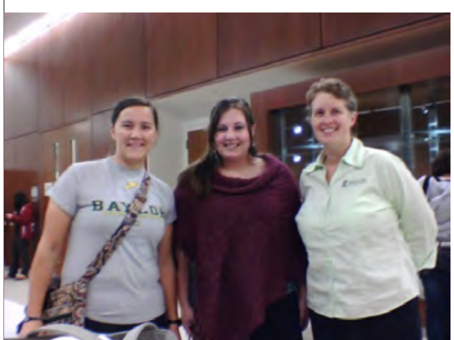
Newsletter Highlights:

September/October 2011

Baylor Physics was spread around the globe this past summer. Anzhong Wang conducted cosmological research with collaborators both in China and in Japan. Bennie Ward was pursuing particle research in Geneva at the Large Hadron Collider from January through August.

Ken Hatakeyama also performed research in Switzerland as well as at Fermilab in Illinois. Jay Dittmann was in Illinois for his Fermilab shift in August. Zhenrong Zhang returned to the Pacific Northwest National Laboratory in Washington to collaborate on projects. Walter Wilcox journeyed to the Ukraine on a mission trip; and Greg Benesh spent a month in collaborative research at the University of Cambridge's Cavendish Laboratory.

November/December 2011



Dr. Linda Olafsen presented "Practical Quantum Mechanics: Semiconductor Materials for Mid-Infrared Lasers," as one of the plenary speakers at the Conference for Undergraduate Women in Physics III: Materials Girls, hosted by the University of Nebraska-Lincoln October 20-22. She also was invited to participate in a career panel as part of the conference. (Four-month-old daughter Susanna attended her second conference since her birth in June of 2011!)

The meeting turned out to be full of small-world moments. Former Baylor REU participants Natalie Walker (2010, a senior at Purdue University, Calumet) and Audrey Burkart (2011, a sophomore at Augustana College) presented posters on their Baylor research. Hannah, Natalie and Dr. Olafsen are pictured at the left.

January/February 2012

As part of the Physics Department Homecoming events, Dr. Zhenrong Zhang and our Department Chairman, Dr. Greg Benesh, were joined by Dr. Truell Hyde, Vice-Provost for Research, and Dr. Lee Nordt, Dean of the College of Arts and Sciences, for a ribbon cutting ceremony to mark the opening of the new Scanning Tunneling Microscopy Lab in the Baylor Sciences Building. Dr. Zhang made a short presentation to begin the ceremony and showed off some of the images, supporting equipment, and capabilities of the new state-of-the-art facility. The 3 pm ceremony preceded the Homecoming Coffee held by the Department in the Clock Tower Room to welcome back alumni of the department and share stories over refreshments and archived pictures of bygone days.

Newsletter Highlights: March/April 2012

The second annual Excellence in Detector and Instrumentation Technology (EDIT 2012) was held at Fermilab National Accelerator Laboratory from February 13 to 24, and our graduate student, Tara Scarborough, was one of the 64 students selected to participate in this school designed to provide hands-on experience with many important aspects of high energy physics experiment detectors and instrumentation technology. The two weeks of the school included small-component-based experimentation from standard photomultiplier tube (PMT), liquid argon, xenon gas, CCD, and silicon pixel and strip detectors. The culmination included a full test beam facility data taking experience where students designed the experiment and chose the detectors, wired it all and into the data acquisition systems and acquired actual results. Expert instructors and participants from all over the world worked together to make the opportunity worthwhile for individuals with any level of previous experience. The next year's school (EDIT 2013) is scheduled for the KEK facility in Japan. Here are a few pictures from the school.

May/June 2012

Dr. Linda Olafsen visited Washington, DC on April 25 along with 16 colleagues from the Materials Research Society as part of the 2012 Science Engineering Technology Congressional Visits Day. Along with Dr. Marcus Shute, Vice President for Research and Sponsored Programs and Professor in the Department of Physics and Dual Degree Engineering Program at Clark Atlanta University, she visited congressional offices from Georgia and Texas, including Representatives John Lewis (GA) and Bill Flores (TX) and Senators Saxby Chambliss (GA), Johnny Isakson (GA), John Cornyn (TX), and Kay Bailey Hutchison (TX).

Summer 2012

If you are a regular reader of the Department Newsletter, you know the department has been growing its number of undergraduate majors while also leading the University in the number of professional publications by graduate students. It is, therefore, no surprise that the numbers of our graduating students are also expanding. Between the May and August commencements, the department graduated seven undergraduates, two master's students and four PhD's. That's a lot of green and gold! In addition, the undergraduates themselves were distributed throughout the commencement ceremony receiving not only the physics degree, but also our new bachelor's degrees of astronomy and astrophysics.

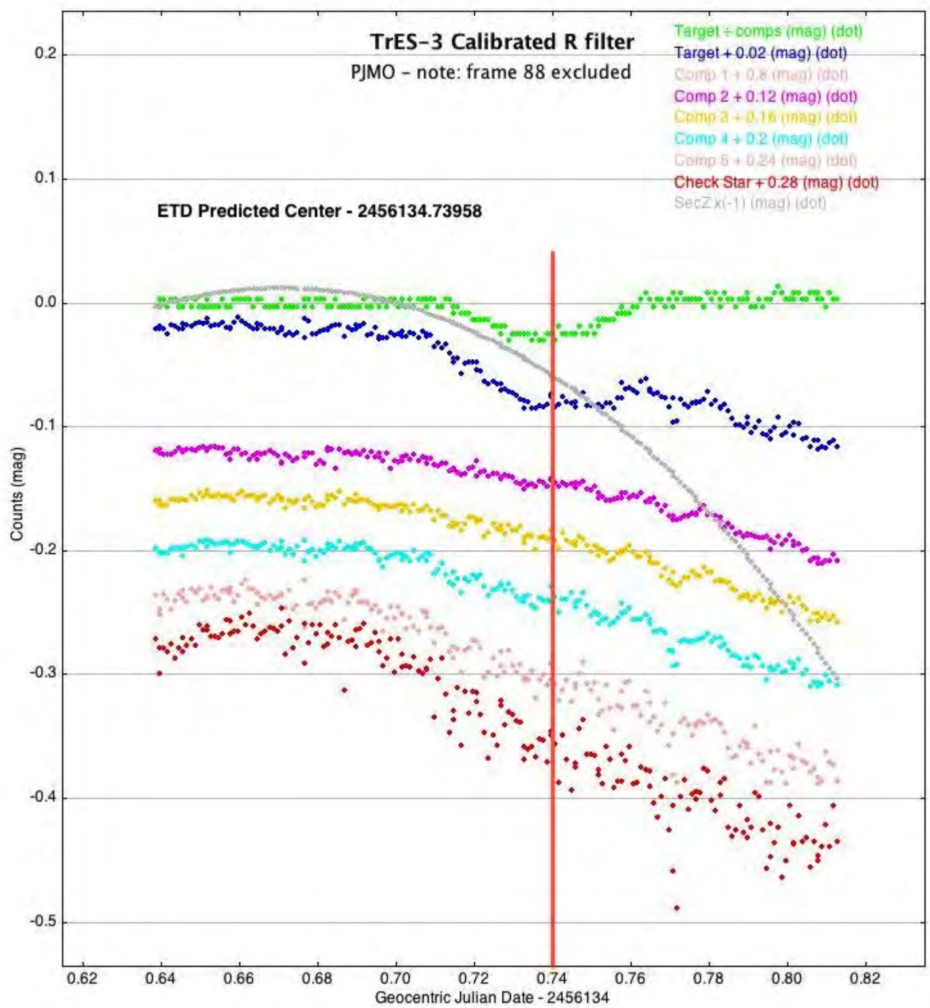
Endowment Focus: Undergraduate Research

Editor's note: Department Excellence funds are used to support a variety of needs in physics, including stipend support to assist undergraduate students in the completion of their research, which can span more than one summer of investigation in a lab on campus at Baylor University. In order to highlight the type of undergraduate research pursued under the guidance of faculty within the Physics Department, we include here a focus article on one (of many) summer undergraduate experiences available on campus. This article comes to us courtesy of Dr. Dwight Russell.

Baylor Begins Exoplanet Transit Studies at the Meyer Observatory

The study of exoplanets is a new and active field in astrophysics that involves observations of planets orbiting stars other than our Sun. This statistical study of planetary systems is important because it provides us with information on how planets form and evolve, and can confirm or deny the uniqueness of our own solar system. If an exoplanet passes in front of its host star while in the plane of view of our solar system, it creates a transit that is viewable from Earth.

During the summer of 2012, CASPER/REU research student Lydia Shannon and Baylor faculty, Dick Campbell, Mech. Eng.,and Dwight Russell, Physics, successfully observed exoplanet transits at the Paul and Jane Meyer Observatory (PJMO) with the aid of Central Texas Astronomical (CTAS) member Willie Strickland. In addition to successfully observing the exoplanet transits at PJMO, the data was used to test the image-processing program Astro-ImageJ and its ability to analyze observations of objects with varying light curves. An algorithm was created for the processing of more than three hundred images taken over several hours during each of these transits and creating the corresponding light curves. From these curves, data about the ingress, egress, and magnitude drop of each transit were obtained, and the radius, semi-major axis, and velocity of each planet were calculated.



The graph shows the light curves for the TrES-3b transit. The blue curve is the raw transit data. The green curve shows the transit light curve corrected for instrumental and atmospheric effects. The gray line shows variation due to atmospheric thickness along the line of sight. The other curves are for nearby comparator stars used for calibration. The vertical red line marks the center of the transit. The ratio of the radius of the planet to that of the host star can be determined directly from the drop in light intensity at the center of the transit.

Our result places TrES-3b in the class called 'Hot Jupiters' with a radius roughly 1.3 times the radius of Jupiter. This demonstrates that the method applied at PJMO for observing and analyzing exoplanet transits is reliable.

Baylor University Department of Physics Scholarships

How you can help

People sometimes ask how they can help us in accomplishing our departmental goals. One important way in which all of our alumni and friends can help is by giving to the Physics Endowment and Excellence Fund (032 MAUN). Excellence funds are used on a variety of projects. For example, this past year excellence funds were used to support the stipend and accommodation for an undergraduate student pursuing summer-long research

In addition to the excellence fund, there are a number of department scholarships that are designed to assist undergraduate and graduate students. One of the great benefits of having these scholarships is the good that can be accomplished by gifts of ***any*** size made to these funds. Please consider giving as you can.

A complete list of Physics Department funds and their uses appears below:

Physics Endowment and Excellence Fund (032 MAUN)

Physics general fund to promote excellence within the Department.

Cy Lynch Physics Scholarship (032 SBUX)

This scholarship is merit-based for graduate students.

Gordon K. Teal Physics Scholarship (032 SBVA)

This scholarship is for physics majors with outstanding grades.

Herbert Schwetman Physics Scholarship (032 SBUZ)

This scholarship is merit-based for physics majors.

Physics Department Special Scholarship (032 SBUY)

Funds to benefit the departmental scholarship program.

Roy W. Stiegler, Jr., Endowed Physics Scholarship Fund (032 SDFN)

This scholarship is need-based for physics undergraduate and graduate students.

Shim and Theresa Park Physics Scholarship (032 SCPS)

This scholarship is merit-based for international students.

Alumni News

Editor's Note: This story is reproduced from the October 2011 issue of the publication On Target *from the US DOE Thomas Jefferson National Accelerator Facility. The article was written by Judi Tull, Feature writer.*

A massive cultural shift throughout the United States led Charlie Reece, deputy director of Jefferson Lab's Institute for Superconducting Radiofrequency Science and Technology, to physics. Growing up in Oklahoma City, the son of an oral surgeon, Reece was among a group of students sent to a magnet school/science center at the beginning of his sophomore year in high school as part of desegregation efforts in that city.

The teacher in his high school to whom he was assigned for two years of chemistry and physics was, he recalled recently, "a lousy teacher." The class was completely self-study, but thankfully with a scripted curriculum that included films and experiments.

"There were only four of us in that class," Reece recounted, "so we did it all ourselves. I found it all pretty fascinating."

By the time he was admitted to Baylor University in Texas, he found himself concerned about whether he was sufficiently prepared for college-level physics classes, considering that he'd basically taught himself. No need to worry, though. He entered the honors program there, and in 1978 graduated *summa cum laude* and a member of Phi Beta Kappa.

He had first encountered RF or radiofrequency cavities when he worked on a project between his junior and senior years. He found it interesting, but it didn't turn his head. He entered the University of Rochester in New York intent on focusing on quantum optics, and received his master's degree in 1980. Taking an opportunity to work under Professor Adrian Melissinos, he shifted to a general relativity research program that aimed to exploit the properties of SRF cavities. Work on this project included getting help from several researchers at Cornell University in New York who were later to become life-long colleagues. Reece completed his Ph.D. work at Rochester in 1983. His first postdoctoral position was as a research associate in the SRF group led by Maury Tigner and Ron Sundelin at Cornell from 1983-1987.

He met his wife, Kimberly, at Rochester where she was studying microbiology as an undergraduate. She had just started into a graduate program in molecular genetics when he was offered the position at Cornell. They faced what Reece (and the scientific world) commonly calls "the two-body problem," when a professional couple is challenged to find a good solution for both partners. Kimberly was able to transfer to a groundbreaking molecular genetics lab at Cornell.

In 1986, Jefferson Lab's then-Director, Hermann Grunder, recruited Ron Sundelin, Peter Kneisel, Reece and others from Cornell to come to Newport News, with the intention of having them on the team that would build CEBAF as the first of a new generation of accelerators. The group landed in Virginia in the summer of 1987.

"We had a baby on the way," Reece remembers. "My Cornell salary wasn't much, and my wife was in the thick of finishing her dissertation research. This seemed like a good place to come; it felt like a real calling, but the transition was scary."

A theme runs through Reece's professional life. "I like investing my efforts to create opportunities for others," he notes. And during his 24 years at the lab, he's had a wealth of opportunities to do just that.

Charles Reece
(BS Physics,1978)
graduated Baylor
summa cum laude
and a member of
Phi Beta Kappa

His initial challenge was developing the technical infrastructure required to build an SRF-based CEBAF. He had prime responsibility for designing, developing, and then using the lab's cavity fabrication and testing infrastructure during the CEBAF construction. He has contributed to the characterization of performance-limiting phenomena and made significant contributions to the translation of state-of-the-art techniques and understandings into SRF operating systems. He led the push to obtain 5.7 GeV (billion electron volts) performance from the CEBAF cryomodules – originally designed for 4 GeV. He also later led the development and testing of the cavity design to be used in the CEBAF 12 GeV Upgrade.

Alumni News (continued)

In 1993, he was appointed to lead development of the lab's first comprehensive Environmental, Health and Safety manual. He had the idea of putting the manual on the then-emerging internet for easy access by staff. "I was presenting my idea," Reece recalled with a laugh, "and Christoph [Leemann, then associate director of the Accelerator Division] said, 'What's this web stuff? Is this a waste of time? Is there really any future in it?'"

Reece has served as SRF Processes and Materials Group leader and by 2000 was a senior staff scientist. He was named the lab's SRF Institute deputy director in 2002. He and Michael Kelly co-advise graduate students, work that Reece finds stimulating and satisfying. He is also the champion and "chief dreamer" for the custom web-based technical procedures and data management system, *Pansophy*, which is used by the SRF Institute and some other elements of the 12 GeV Project. Reece has, he acknowledges, worn a lot of hats during his time at the lab.

His experience and interests span the full range of sciences and research necessary for SRF particle acceleration, from basic materials characterization and development to acceleration system design, fabrication, integration and operational optimization. He is currently managing some basic R&D projects on the electropolishing of niobium and the development of future alternative materials for SRF particle accelerators. Recently, he has also been managing the layout and process flow for the SRF portion of the new Technology and Engineering Development Facility. He looks forward to the lab's future. "By 2013, the facilities at Jefferson Lab for SRF will be peerless," he noted. "The world will be green with envy."

Reece and his family live in York County. His wife is now a Virginia Institute of Marine Science professor at The College of William and Mary, where she focuses her attention on molecular genetic analyses of shellfish species and their pathogens; their daughters, Carolyn and Katie, are both university students. Reece claims to have "farmer blood" running through his veins and takes good-natured pride in how well his gardening efforts feed the local deer, rabbits and raccoons.

He also serves on the national executive board of the Presbyterian Association on Science, Technology and Christian Faith, which joins clergy and professionals from various scientific fields to foster conversation and mutual understanding between different aspects of science, technology and theology. Reece also serves as a teacher and a tenor in his local Christian fellowship, KirkWood.

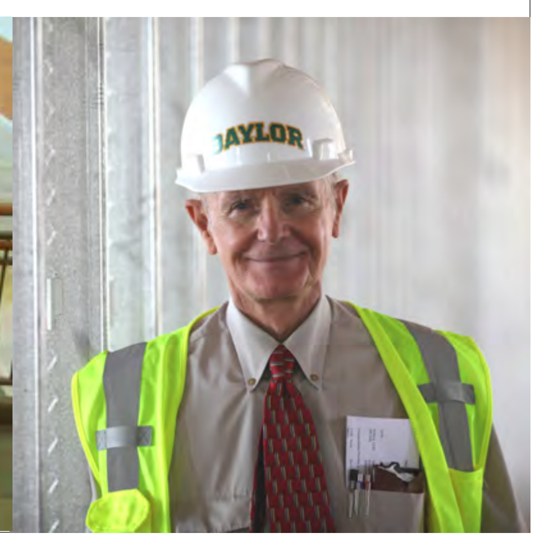
"All these pieces fit together perfectly well for me," he concluded. "I am quite happy to invest myself to enable other people to do good science and good work."

By Judi Tull, Feature writer

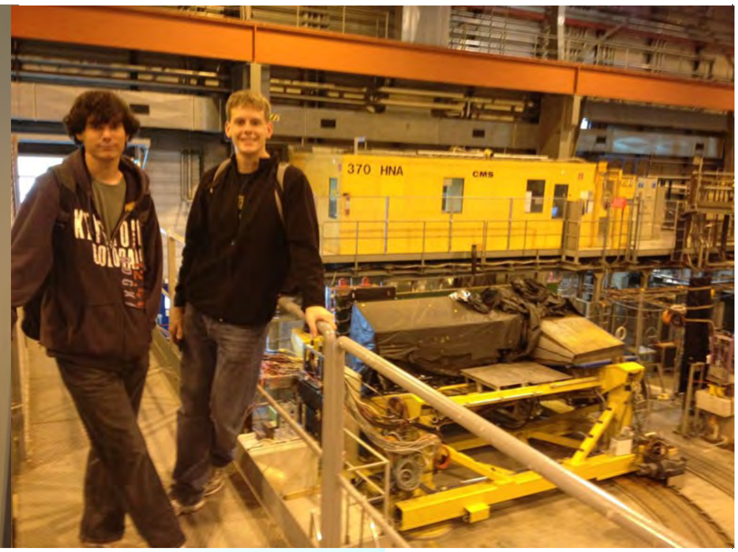
Charlie Reece, deputy director of Jefferson Lab's SRF Institute, pauses from his tasks for a moment to share a little about his personal history with superconducting radiofrequency (SRF) work. He holds a single cell from a niobium cavity.

Department in Pictures

(Above) Dr. Nancy Yu is hooded by Drs. Greg Benesh and Ken Park (thesis mentor). Dr. Benesh with Nathan Beasley and Will Barnes at the Honors Convocation. Dr. Jay Dittmann and his sons in Paris. (Below) Summer REU students and Dr. Marlan Scully.



Department in Pictures (continued)



(Above left) Joy Bolton being shown off by proud parents Daniel and Laura Bolton. (Above right) Forrest Phillips and Evan Bauer visit the Large Hadron Collider at CERN. (Far Left) Jeremy Kunz doing photolithography at the MRC in Austin. (Middle) The BSB façade underwent repair and renovation this summer. (Below left) Drs. Walter Wilcox and Wickramasinghe Ariyasinghe joined by several graduate students at a Habitat for Humanity project. (Below) Dr. Linda Olafsen with colleagues at Dr. Marlan Scully's summer workshop in Casper, Wyoming.

A Devotional

Editor's Note: We would like to thank Dr. Yumei Wu for providing this year's devotional for the Annual Newsletter.

NGC 7203 (The Iris Nebula) courtesy of the Astronomy Picture of the Day

"But you will receive power when the Holy Spirit comes into your life. You will tell about Me in the city of Jerusalem and over all the countries of Judea and Samaria and to the ends of the earth." — Acts 1:8

In our earthly daily life, each of us plays different roles at different times, being a teacher, being a parent, being a mentor to someone. So we are very busy playing the roles, and trying to play them well at the same time. In God's kingdom, what is the role we should play? From Acts 1:8, God tells us exactly what we should do: there is a purpose for us to be here in this world, there is a role for us to play, that is to tell the world what the Good News is, tell the world who our Lord Jesus Christ is. In this earthly world, all other things are unimportant when compared to the Good News of Jesus Christ.

Almost one third of the world's population has never heard about Jesus Christ. As a Christian, God clearly tells us the most important job that we need to do, with the power of the Holy Spirit, is to tell others of His Son, so many people will follow him. The peace will be in their hearts, the love will be spread in the world, and the love will stay in people's hearts, so there will be less and less room for hate. This summer I had visited some churches in Baotou, China; I saw that people are searching for God, people need God in their lives. In the past few years, big church buildings have been built and so many people come to the churches, and have become followers of Christ.

"We are the witness of the Good News, and we have the responsibility to share it with others."

We may think we just cannot play the role well, actually what we need to do is to act and spread the words of God, then the power of God shall work and make the things possible. We are the witness of the Good News, and we have the responsibility to share it with others, so more people can be blessed just like us. Tell the world that "For God so loved the world that he gave his one and only Son that whoever believes in him shall not perish but have eternal life. For God did not send his Son into the world to condemn the world, but to save the world through him." (John 3:16-17)

Homecoming Events Announced

You may see a physics professor (or two!) in the Homecoming Parade this year!

The Department of Physics will once again hold events in conjunction with Baylor University's Homecoming Weekend.

Please join us on Friday, November 2nd at 3:00 pm in Room D.109 of the Baylor Sciences Building. Dr. Marlan Scully will present us with a public colloquium at that time. Plan to also join us after the talk in Room E.301 (the tower room of the E-wing on the 3rd floor) for a Homecoming Reception that will start at about 4 pm and go until 6 pm.

Alumni! What have you done with your Physics Degree?

Please fill out this survey because we'd really like to know how Physics has shaped your career, so we can better communicate the options to our current and potential Physics Majors and graduates.

Name: ______________________________

Graduating Class: ______________________________

Address: ______________________________

____

E-mail address: ______________________________

Phone Number(s): ______________________________

Present Position: ______________________________

Family News:

Career News:

Suggestions for the Department (What would bring you back to campus for a visit?):

(please give a short answer here, or email Physics_Newsletter@baylor.edu)

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Stamp

Here

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We'll make it easy for you — just fold along this line!

We really want to hear from you - so this is how easy we've made it. Detach this last page of the newsletter, give us your most up to date contact information and news, fold along the solid line above, tape closed so the address above shows on the outside, affix a stamp in the box above, and drop it in the mail.

The Constellation *Ursa Baylor*