

State of the Department

Tu-nan Chang, Chair and Professor

Three years ago, I agreed to chair the department at a time when several years of financial hardship at the College was beginning to take its toll. I am happy to report that we have made progress in the past three years toward achieving our goal of becoming a first-rate research department and are looking forward to continued growth and improvement in all areas of our academic endeavors. *Following are some highlights...*

Academic Programs. One of the most exciting recent academic initiatives in the department is the creation of a Joint Caltech/USC *Center for Theoretical Physics*, thanks to the hard work of Professor **Itzhak Bars** and others in the theoretical physics group. Having launched its inaugural symposium in January at Caltech, the Center offers weekly seminars and workshops at USC. (*Please see article on page 8 for more details.*) A second major academic initiative is the development of a Master's degree program, *Physics for Business Applications*, largely through the effort of Professor **Hans Bozler** and others, with the support of a grant from *Sloan Foundation*. This new degree program offers an alternative professional track for students with a strong science and technology background for a career in corporate environments. (*Please see article on page 3 for more details.*) In addition, we have allocated more departmental resources to invite outstanding guests to present talks at our weekly departmental colloquium. For example, this year, thanks to a joint effort with the Center for Theoretical Physics, our speakers have included highly regarded scientists such as **Gerard 'tHooft** (1999 Nobel Laureate) and **Edward Witten** (Field Medalist). Professors **Bergmann**, **Bozler**, **Gould**, and **Kresin** have also been working on a three-year project to renovate our upper division laboratories with a matching fund from the College.

Faculty. During 1997-99, we hired two promising junior scientists, Professors **Stephan Haas** and **Maxim Olshanii**, who joined our faculty at the rank of Assistant Professor. The addition of Stephan and Maxim has already enhanced our faculty resources in several key areas of theoretical/computational physics. This year, we continued our faculty improvement by recruiting Professor **Chiara Nappi**, a world renowned theoretical physicist, as a full professor. The total full time faculty in the department has now increased to twenty-three, after the early retirement of Professor **Mel Daybell** this year, who has enjoyed a long and distinguished career at USC. Three of our faculty, **Gene Bickers**, **Werner Däppen**, and **Dennis Nemeschansky** were promoted to the rank of Full Professor in 1998. Congratulations also go to **Vitaly Kresin** for his recent promotion to the rank of Associate Professor with tenure.

In addition to the continuing success in their scholarly pursuits, many of our faculty have also been recognized by their peers during the past three years. Professor **Darrell Judge** was elected to the Fellowship by the *American Physical Society* in 1998, increasing the number of Fellows among faculty in the department in various professional societies to nine. Professor Werner Däppen was elected as the Churchill-College Fellow at *Cambridge* in 1999. Within the University, Professor Gene Bickers was honored with the 1999 USC Associates Award for Excellence in Teaching. Professors **Nick Warner** and **Edward Rhodes** were the recipients of the General Education Teaching Awards for 1998 and 1999, respectively. Professor **Gibson Reaves** was recognized this year when he received the Distinguished Emeriti Award for his outstanding career at USC. Professor Nick Warner and myself were honored by the College for excellence in teaching, research, and service as the recipients of the Raubenheimer Distinguished Faculty Award in 1997 and 1998, respectively. To end the list, I am happy to share with you the latest honor that I received when the USC Academic Senate presented me with a Distinguished Service Award this spring.

DEPARTMENT THANKS DONORS

The Department of Physics and Astronomy would like to thank the following individuals for their generous support:

Dr. Te-Kuei Fang

Mr. Stephen Robert Holt

Dr. Jien-Ping Jiang

Dr. Richard Vincent Johnson

Mr. Steven Eugene Lambert

Mr. Henry Martin Lee

Dr. Robert M. Leonardis

Mr. Myron Albert Mann

Dr. John Story

RHODES RECEIVES GENERAL EDUCATION AWARD

In December 1999, Professor **Ed Rhodes** was awarded the *General Education Teaching Award* from the USC College of Letters, Arts and Sciences. Professor Rhodes received the award for his contributions to the General Education Program during the '98 – '99 academic year. He was chosen on the basis of statistics and student comments on evaluation forms, course syllabi and evidence of rigorous grading. One student from his *Astronomy 100* course commented, "Professor Rhodes was excellent in every way. He explained concepts clearly and made me think about life and creation much more openly. This was an extremely beneficial course to my education. Thank you."

The Department of Physics and Astronomy is proud to have Professor Rhodes on our faculty and joins with the College of Letters, Arts and Sciences in congratulating him on his outstanding instructional skills, enthusiasm and ability to generate true inquisitiveness among his students. ♦

POSTER WINS SECOND PRIZE

The poster created by **Doug Garrett** titled, "*Weak Localization in ultra thin Cs*" took second place in the First Annual **Undergraduate Research Symposium** in April 1999. The poster investigates the quantum interference corrections to resistance (weak localization) and determines the inelastic dephasing rate of conduction electrons.

At the time, Doug was an undergraduate majoring in physics and as an undergraduate, was one of the first promoters of supporting serious undergraduate research in the Department. He believes he owes the success he's had to Professor **Gerd Bergmann**. Doug said that, "Professor Bergmann's laboratory is without compare. He encourages students to participate fully in research. If it wasn't for him, I wouldn't have advanced so quickly and successfully."

When first beginning laboratory work, Doug spent many hours learning to prepare and execute each experiment. The hands-on learning took hold and increased his great curiosity for physics. The data he collected and used in the poster is now forming a base for furthering his research efforts. Doug is now a graduate student in the Department.

Doug also presented his poster at the *American Physical Society's* nationwide meeting in March 1999, in Georgia. ♦

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Students. I am also delighted to report that we have gradually increased the incoming graduate student class back to approximately 15 students this Fall after a substantial decline in recent years. The quality of our graduate students has also improved with twelve students successfully passing the Screening Examination at Ph. D. level this spring and we look forward to soon reaching our goal of a graduate student body of between 50 and 60.

Thanks to a very generous gift from **Henry Lee**, we have established two permanent annual teaching assistant awards for Outstanding Teaching Assistant and Most Improved Teaching Assistant. The recipients of the 1999 awards are **George Tikhonov** (Outstanding Teaching Assistant) and **Jeff Nuttall** (Most Improved Teaching Assistant). In addition, **Charles Rathfelder** was recognized as the Outstanding General Education Teaching Assistant by the College in 1998.

The department has started a serious effort to strengthen our undergraduate research opportunities. Led by Professors **Gerd Bergmann, Hans Bozler, Vitaly Kresin, Nick Warner** and others, we have received consecutive years of funding for undergraduate research projects from the *Office of the Provost* at USC. This funding, along with departmental and alumni support, has resulted in department undergraduates **Doug Garrett** and **Shak Hossain** receiving top awards at the USC *Undergraduate Research Symposium* as well as being able to present their work at national meetings of the *American Physical Society* and *American Association of Physics Teachers*. We were also honored as a department when B.S. Physics student **Alex Small** was named the 1998 USC Salutatorian.

Staff. Under the able leadership of **Ty Buxman**, Director of Undergraduate Affairs in Physics and Astronomy, our technical staff have worked diligently to upgrade our undergraduate laboratories. A major Hewlett Packard equipment grant has enabled **Kris Sabo, Bill Talbert, and Hung Nguyen** to systematically upgrade our instructional laboratories for service courses during the past three years. A new General Education laboratory curriculum has been successfully developed by **Robert Knol** and **David Mehrania** has been busy installing many new high tech demonstrations in the recently renovated Stauffer Lecture Hall.

Our office staff has also changed significantly with the departure of Michelle Murray, Peter Smith, and Danielle Swearingin and the recent additions of **Lisa Swanson** and **Margo Burrows**. Lisa, who joined our staff last Fall, has

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quickly mastered the faculty affairs and Margo, arriving late last year, is responsible for our alumni relations and serves as the Editor of our Newsletter. Our graduate and undergraduate affairs continue to be in the good hands of **Betty Byers** and **Beverly Ferguson**. Last, but certainly not the least, our beloved **Julia** (now a **Caulder**) has decided to devote herself full time to what she loves most - a singing career - starting this summer. She will surely be missed by all of us and we wish her a smashing success.

Coming Years. What's next? With a new College Administration this summer and a united faculty in Physics and Astronomy, we will continue our pursuit to increase our faculty strength in a few selected thrust areas as an essential component of achieving our goal of being a first-rate research department. To increase the research opportunity for our graduate students, we are in the process of identifying research programs and seeking partnerships with other academic units at USC which require students with a strong background in physics/astronomy. On the undergraduate side, we are working to enhance our major programs (e.g., biophysics) to meet the changing needs of a new generation of college students.

Finally, I would like to congratulate you for your outstanding achievement after you left USC. For those of you who have contributed generously to the department, I thank you and I want to assure you that we are confident that, together, we will achieve our goal soon. Also, I would like to invite you to join us in the Fall at our annual get-together luncheon for faculty, staff, alumni, and former associates, if you are in the area. (Please check with Margo for the time and location in late August.) Stay in touch (213-740-1133 and tnchang@usc.edu) and we wish you all the very best. ♦

PROFESSIONAL MASTER'S PROGRAM

The Department of Physics and Astronomy has created a new Master's degree program in collaboration with the *Alfred P. Sloan Foundation*. The two year master's program is designed to blend pure science classes with business applications in order for our graduates to have a marketable degree in the corporate environment. Three other newly created masters programs are also being offered at USC. They include the **Professional Master's in Computational Linguistics**, the **Professional Master's in Computational Molecular Biology**, and **Environmental Science and Technology**.

Dr. Hans Bozler is spearheading the effort at USC, working with various departments and the Sloan Foundation in designing well-rounded, comprehensive degree programs. Dr. Bozler asked employers, "Why do you hire physicists?" The answer was their ability to organize disparate information and develop models of all sorts, and to do something that's predictive with those models. He hopes that a few of the professional master's students will go for their Ph.D. "The biggest concern among the faculty was that we don't do anything to jeopardize our Ph.D. program by siphoning off students or resources. I think we were able to convince them that it's not a zero-sum game, that this could actually increase the flow of good students through the Department."

Longtime advocate of science education reform and currently an adviser to the Alfred P. Sloan Foundation, **Sheila Tobias** believes that the new professional master's programs will be, "The hot professional degrees of the 21st century. It's just like the way the MBA was the quintessential 20th century degree." In the longer term, she hopes that, "By supplying industry with such versatile people, they'll say, 'We want more people like that'. It's the reverse of the usual demand-supply equation."

The **Professional Master's in Physics for Business Applications** is designed to attract recent graduates or technically trained workers who hold a bachelors degree in physics, applied mathematics, or physical science. The curriculum for the program consists of a core of physics courses, a special track in business with an emphasis in one of several areas, discussions of emerging technologies and a Capstone Experience which may include internships for those not working in industry.

Dr. Bozler believes that this streamlined graduate education will greatly aid in the success of the graduates. He sees the program as a pathway for major corporations to find and employ greater numbers of science trained people. Today, corporations must choose between scientists or business graduates when what they really need is a scientist with business knowledge. We want to provide that individual. Dr. Bozler feels that this will only increase our enrollment and prestige. He looks forward to the time when our graduates will be in a position to hire others.

USC and The Department of Physics and Astronomy are constantly striving to provide exceptional educational opportunities for our graduates. The professional master's programs are yet another example of USC being in the forefront of innovative education. By listening to employers, students and researching trends we believe that we are serving the needs of our students as well as the community. The programs have received much notice. The *LA Times*, *Physics Today* and *Science Magazine* are among the publications that have written about the emerging professional master's programs.

For more information regarding the programs, or on the Alfred P. Sloan Foundation please visit our web site at <http://www.usc.edu/dept/physics/SloanWeb>. ♦

THE DEPARTMENT WELCOMES TWO NEW FACULTY MEMBERS

In our ongoing efforts to build and strengthen the Physics and Astronomy Department, we have appointed two highly regarded scientists to our faculty.

PROFESSOR CHIARA NAPPI

Visiting Professor **Chiara Nappi** has accepted the position of Full Professor in the Department of Physics and Astronomy as of January 2000. We are delighted to welcome this highly respected physicist to our faculty.

Dr. Nappi was born and educated in Naples, Italy. She received her Ph.D. from the *University of Naples* and was invited for her post-doc work as a NATO fellow at *Harvard University*. Dr. Nappi was a lecturer at Harvard, before accepting a Radcliffe Fellowship at the University. She went on to *Princeton* as a Visiting Professor. She is also a long-term member of the Institute for Advanced Study.

As a Visiting Professor in the Department of Physics and Astronomy at USC in the Fall of 1999, Dr. Nappi taught *Physics for the Life Sciences* (Physics 135) and found it to be a learning experience. She admits to being on the tough side in class, but says, "I expect the students to exhibit at least some of the commitment and dedication that I devote to the class." She worked to engage the students by linking physics concepts to specific medical applications (e.g. liquid pressure to blood pressure) for the predominantly pre-med class.

Dr. Nappi's research interests are extensive. She began her work in mathematical physics, which has helped her tremendously throughout her career. After her initial interest in constructive field theory and rigorous statistical mechanics, she worked on the skyrmion description of nucleons, at the interface

of particle physics and nuclear physics. In the mid 1980's, she began her involvement in string theory, shifting her focus from particle phenomenology to string phenomenology. Since then, she has been working on low-energy effective actions for string theory such as Born-Infeld and Fierz-Pauli Lagrangians and their solutions. She also investigated the effects of boundaries and higher loops corrections on the string effective actions. In recent years, she has been particularly interested in black hole solutions, an interest grounded in her former work on two dimensional dilatonic gravity. She is currently studying the thermodynamics of black holes in string theory; in particular, the relation between the entropy of higher dimensional black holes and that of black holes in two dimensions.

Dr. Nappi is working with the **Center for Theoretical Physics**, a newly organized institute developed between the physics departments at Caltech and USC (*for further information about the Center, please see page 8*). She is very excited with the joint effort and is looking forward to collaborating with colleagues from Caltech and UCLA.

Dr. Nappi is married to Dr. **Edward Witten**, a physicist at Caltech, who recently lectured at the Center on the *K Theory and its connection to branes in string theory*. They have three children.

We are extremely pleased that Dr. Nappi has accepted the position of Full Professor and are looking forward to working with her. ♦

DEPARTMENT COLLOQUIUM

The Department of Physics and Astronomy hosts an on-going colloquium every Monday at 4:15 p.m. Our invited guests this year have included: **Gerard 'tHooft**, Nobel Prize in Physics - 1999, discussing *The Glorious Days of Physics: Renormalization of Gauge Theories*, **Qingshi Zhu**, Department of Chemical Physics and President, University of Science and Technology, China speaking on *Green Chemistry in China* and **USC alumni, Bob Rutledge** from the Space Radiation Laboratory, California Institute of Technology lecturing on *X-ray Astronomy of Compact Objects: Galactic Neutron Stars and Black Holes*.

You are invited to join us at the colloquium. For a schedule and location please see our department web site at <http://physics.usc.edu>. ♦

PROFESSOR MAXIM OLSHANII

The Department of Physics and Astronomy is pleased to announce the appointment of **Maxim Olshanii** as an Assistant Professor. We are excited with the appointment, as we believe Professor Olshanii will contribute greatly to our faculty.

Born in Moscow, Dr. Olshanii received his M.S. from the *Institute of Engineering Physics* in Moscow and went on to the *Institute of Spectroscopy*, also in Moscow, for his Ph.D. He then continued his work at the esteemed *Ecole Normale Supérieure* in France, first as a post doctoral fellow and then as an invited professor. While in France, he received a French language diploma from the *Sorbonne*. Before accepting his current position with USC, he was a research scholar at *Harvard University*. During the summer of 2000, Dr. Olshanii has been appointed as an invited professor at the *Ecole Normale Supérieure* and also the *Paris Nord University*.

Professor Olshanii's research interests are varied, and include working on the interface between Atomic Physics and Condensed Matter Physics. His early formal training was in Atomic Physics, and with the finding of Bose Einstein Condensates he is discovering links in Condensed Matter. His early work aids in his understanding in linking the disciplines. The themes he has recently addressed include Berry's phase in atom-light interactions and exploring possible configurations in dark-states-based laser cooling atoms. His current area of research is the

implementation of the Multiple Scattering Theory ideas in many-body theory of dilute trapped Bose and Fermi gases.

Since accepting his current position, he has applied for two research grants. The first, already approved, is from the **Zumberge Foundation**. This is to support his research into *Spatial Symmetries of Laser Fields, Plato Solids, Dark State Cooling, and Atom Lasers*. His interest in laser cooling began while collaborating with **Claude Cohen-Tannoudji**, 1997 Physics Noble Prize winner. The other grant is from the **National Science Foundation** in support of *Atoms in Tight Traps: Theory of Scattering in Restricted Geometries and Applications*.

During the Spring 2000 semester, Professor Olshanii taught the course *Physics for the Life Sciences* (Physics 135) and found it interesting working with the students. He is attempting to, "Get the class past memorization, which they are very good at, and helping them develop intuition." He went on to state, "The students tend to want less theory and more tricks for solving problems. However, if they know where the physical law comes from, then they will know two things; 1) the limits of applicability of the law and, 2) if they can see how the law is derived, they can then translate it to more difficult situations."

Professor Olshanii is married with two children.

We are delighted that Professor Olshanii has joined our faculty and are enthusiastic about the future. ♦

LOS ANGELES PHYSICS TEACHERS ALLIANCE GROUP

The **Los Angeles Physics Teachers Alliance Group, LAPTAG**, was created several years ago so that universities and colleges could interact strongly with high schools in order to further the educational process. The organization has approximately 60 members in 32 institutions.

Assistant Professor **Stephan Haas** from the USC Department of Physics and Astronomy has recently become involved with LAPTAG, in order to raise the general awareness of physics and indirectly benefit the community. The group's Saturday bi-monthly meetings are attended by 30 to 40 teachers with some students also present. Professor Haas would love to expand the program. His chief objective is to have more local schools participating. "If I can reach one enthusiastic kid, the program has succeeded," he believes. However, he realizes that many high schools today have more pressing issues than concentrating on their physics departments. He stated, "I must be realistic in setting these goals. Right now, I must plan on ways to augment the program, perhaps one-on-one meetings and tours with teachers invited to our campus and also personally contacting some of our local schools."

One goal of the program is to get in touch with students at a young age, to stir their enthusiasm in physics. One way in which LAPTAG approaches the issue is to involve high school students and their instructors in exciting research projects. The experiments tie all participating institutions together and allows for strong, continual interaction among the participants.

One recent experiment involved stimulating an earthquake by setting off a controlled explosion and timing the delay and propagation of waves, then measuring the delay with high precision measuring devices.

The professors are available to go to high schools where they will bring demonstrations and also lecture the class. In the past, Professors **Feinberg, Bickers** and **Däppen** have had classes come to the USC Physics Department to tour the lab facilities. Eventually, Professor Haas would like to have a regular schedule of visiting physics classes touring our Departments facilities.

You may visit the program's web site located at <http://coke.physics.ucla.edu/laptag/index.html> for more information. ♦

BICKERS RECEIVES USC ASSOCIATES AWARD

In Spring 1999, Professor **Gene Bickers** was honored with the *Associates Award for Excellence in Teaching*. Over the past decade, Professor Bickers has been one of our most versatile and effective teachers. Both as a teacher and advisor, he has had a lasting impact on the lives of countless students. His innovative classroom presentations, including his infamous 'walk on fire' demonstration, are among the most popular in the university. He has also established an exemplary record in graduate student guidance. As the *Associate Chairman of the Department*, Professor Bickers has contributed tremendously to new curriculum and outreach programs. His efforts led to an equipment grant of more than \$100,000 from Hewlett-Packard for the undergraduate physics instructional laboratories.

The Department of Physics and Astronomy joins with USC in honoring Professor Bickers for his enthusiasm and creativity in working with students and colleagues and for his remarkable dedication. ♦

UNDERGRADUATE RESEARCH FUNDING

For the second consecutive year, the Department has received funding from the **Undergraduate Research Program** in the *Office of the Provost*. The goal of this competitive program is to improve undergraduate research programs by supporting and encouraging the students to participate in research projects.

In the first year, Professor **Gerd Bergmann** was awarded funds to support four undergraduate students working in his research laboratory during the summer. This work resulted in winning poster presentations by **Doug Garrett** and **Mohammed Shakawat Hossain** respectively at the first and second annual *Undergraduate Research Symposium*.

This year a collaboration of Professors **Bozler, Kresin** and **Warner** has been awarded funds. They are providing research opportunities for three undergraduate students. The results will be presented at the *Undergraduate Research Symposium* in 2001.

Providing opportunities and support for undergraduates to participate in research and the Undergraduate Research Symposium are two ways in which the Department is focusing its efforts of enhancing and strengthening our undergraduate research. ♦

UNDERGRADUATE INVITED TO PRESENT

Mohammed Shakawat Hossain ('Shak'), a USC undergraduate physics major working in Professor **Gerd Bergmann's** laboratory, was invited to present his research paper "*Giant Moments of Fe and Co on and in Na Films*" at the *American Association of Physics Teachers* annual meeting. The week-long meeting was held in January 2000 in Orlando, Florida. Shak was among ten student presenters and his paper, the only one focusing on solid state physics, stirred considerable interest and was very well received.

The *American Physical Society* invited him to present his results at their annual nationwide meeting in Minneapolis on March 21, 2000. Professor Bergmann also presented research findings at this prestigious conference.

In addition, Shak displayed his poster at the USC Second Annual *Undergraduate Symposium for Creative and Scholarly Research*, sponsored by the **Office of the Provost**. The poster received first place honors and Shak was awarded the top \$500 prize. The Symposium was held on April 26, 2000 at USC and highlighted outstanding scholarly and creative work by undergraduate students in the following disciplines: Arts and Humanities, Life Sciences, Physical Sciences, Mathematics and Engineering, Professional and Applied Disciplines and Social Sciences.

Shak's winning poster description is: Thin films of Na are covered with 1/100 of a monolayer of Fe or Co. Then the impurities are covered with several atomic layers of Na. The magnetization of the films is measured by means of the anomalous Hall effect (AHE). The magnetization follows a Brillouin function with a magnetic moment of about 6 Bohr magnetons for Co on the surface and in the bulk of the Na. For the Fe impurities a magnetic moment of 6 Bohr magnetons is observed. These large moments suggests that 3d impurities polarize the conduction electrons of the Na similar to the giant moments in Pd. These results confirm our findings of giant moments of Co and Fe in the Cs.

Shak is a junior and has worked in Professor Bergmann's laboratory since 1998. His research group was one of the first to receive USC undergraduate research funding in 1999.

The Department of Physics and Astronomy congratulates Shak and wishes him continued success in his endeavors. ♦

ASTROPHYSICAL RESEARCH

DETAILED PROPERTIES OF SOLAR MATTER

The following is a summary of research being conducted by Professor Werner Däppen. Professor Däppen is working in collaboration with Alan Nayfonov, his postdoctoral research fellow and graduate students Zhigang Gong, Chia-Hsien Lin, and Ladislav Zejda. They are coordinating with several international research teams. The Department is extremely proud of Professor Däppen and his continuing research.

The interest in the physics of stellar matter is not merely motivated by astrophysics. It has turned out that one star - the Sun - is very special in two respects. First, the methods of helioseismology, *the art of interpreting the precisely measured solar five-minute oscillation frequencies*, allow us to infer conditions in the solar interior very accurately (in particular, sound speed and density). Second, in the solar convection zone, helioseismology presents an opportunity to isolate the question of the equation of state from opacity and nuclear reaction rates, since the stratification is essentially adiabatic and thus determined by thermodynamics. Thus the Sun has become an astrophysical laboratory to study subtle thermodynamic properties of a Coulomb system under conditions that cannot be achieved on Earth.

In stellar models, the equation of state and opacity are, together with nuclear reaction rates, the fundamental material properties. The structure of a star is a result of (i) a balance of forces, (ii) a balance between the energy loss at the stellar surface and energy generation in the core, and (iii) stationary energy transport between the core and the surface. The balance of forces, described as (*hydrostatic equilibrium*), results in a relation between the pressure gradient and the gravitational acceleration. The force of gravity is determined by the density distribution in the star: thus stellar modeling requires a relation between density and pressure through the specific properties of the matter. The temperature of the stellar interior is determined by the energy balance. In

much of the Sun, energy transport takes place through radiation and depends on absorption coefficients, obtained from atomic physics, which determine the *opacity* of stellar matter. It was also realized early on that the requirements of radiative transport could result in a temperature gradient so steep that a star would become convectively unstable: convection, *where hot elements of gas rise and then generally dominate the energy transport*. In the Sun this occurs in about the outer 30% of the radius. Due to the efficiency of convective energy transport, it generally requires a temperature gradient only slightly in excess of the adiabatic gradient, a thermodynamic quantity derived from the equation of state. Another consequence of the equation of state, adiabatic sound speed, plays the crucial role in helioseismology.

In the solar convection zone, helioseismology presents an opportunity to isolate the question of the equation of state from opacity and nuclear reaction rates, since the stratification is essentially adiabatic and thus determined by thermodynamics. Accurate analysis of the observations requires use of the full, non-asymptotic behavior of the oscillations. We now have astonishingly accurate results, for instance, sound speed from the solar surface down to the center. The results of these inversions can be used, in a simplifying spirit, as the (*data*) of helioseismology, disregarding how they were obtained from solar oscillation frequencies. The most important result of the helioseismic equation-of-state analyses was that it is essential to include the leading Coulomb correction to ideal-

gas thermodynamics. Under solar conditions, the size of the relative Coulomb pressure correction is largest in the outer part of the convection zone (about -8 percent) and it has another local maximum in the core (about -1 percent).

However, two very recent inversions have had further implications for the equation of state. First, the strong constraints from helioseismology has forced us to include *relativistic effects* of electrons. This is very surprising and illustrates the fantastic degree of accuracy of helioseismology. Temperature in the solar center is about 10^7 K, that is, kT is around 1keV. The relativistic effect on sound speed is manifested in the property that the adiabatic exponent is, respectively, $5/3$, $5/3$, and $4/3$ for a classical, a non-relativistic degenerate, and a fully-relativistic gas. Helioseismology has revealed the subtle lowering of the adiabatic exponent from $5/3$ towards $4/3$ due to the relativistic part of the electrons. Now, since the kinetic energy of the electrons in the solar center is small (1 keV) compared to their rest energy (511 keV), the lowering brought in by relativistic electrons is merely on the order of 10^{-3} .

Second, there are indications that in the outside 2% of the solar radius, the presence of excited states in hydrogen and helium is revealed. Again, this is a small, subtle effect, because under the prevailing circumstances, the majority of atoms and ions are in the ground state, and when they begin to be excited, normally they are ionized at the same time. Therefore, the correction due to the

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Astrophysical Research

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presence of excited states is small, again on the order of 10^{-3} , and therefore much smaller than the effect of screened Coulomb potentials. It speaks for the power of helioseismology as an astrophysical tool that such small physical effects can be studied.

Future work will concentrate, among other aspects, on the difficulties in interpreting the helioseismic results, in particular due to (i) the influence of turbulence on the structure and the acoustic modes, (ii) magnetic fields, and (iii) effects from the deviation from local thermodynamic equilibrium (LTE) in the solar atmosphere. Removing those uncertainties will enhance the reliability of our findings both in plasma physics (e.g. higher-order non-ideal effects) and solar physics (e.g. helium abundance of the Sun). ♦

SUPERIOR TEACHING RECOGNIZED

Graduate students **George Tikhonov** and **Jeff Nuttall** were honored for their teaching excellence in September 1999.

George Tikhonov received the *Outstanding Teaching Assistant* of the year honors. He is extremely self-motivated. In the fall of 1996, George was appointed the Head Teaching Assistant for the first semester of the Engineering Physics series (Physics 151). He has dedicated himself to teaching excellence since then. His enthusiasm and leadership inspires his students and they thrive under his tutelage. George is an instructor of the highest order and very deserving of the Outstanding Teaching Assistant award.

The award for *Most Improved Teaching Assistant* of the year was presented to Jeff Nuttall. Jeff has worked extremely

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THE CENTER FOR THEORETICAL PHYSICS

The **Center for Theoretical Physics** was created in order to provide a suitable environment for theoretical physicists to work together and share experiences and expertise. The center resulted from the perseverance and personal efforts of USC Provost **Lloyd Armstrong, Jr.** and Caltech President **David Baltimore**. They envisioned a place where physicists could share and exchange knowledge and pursue new developments. Others instrumental in the yearlong discussions that established the collaboration were **Larry Swanson**, Dean of Research at the USC College of Letters, Arts and Sciences, **Tom Tombrello**, Chair of Astronomy, Physics and Math at Caltech, **Tu-nan Chang**, Chair of Physics at USC and Caltech Provost **Steve Koonin**.

The joint effort officially took off with the scintillating symposium, *String Theory at the Millennium*, at Caltech in January 2000. There were nearly 300 theoretical physicists in attendance, the top in the field. Among the speakers were **Stephen Hawking** of Cambridge University; Nobel laureate **Murray Gell-Mann** of the Santa Fe Institute; **Ed Witten** of the Institute for Advanced Study (currently at Caltech); 1999 physics Nobel Prize winning physicist **Gerard 'tHooft** of the University of Utrecht; and one of the originators of string theory **John Schwarz** of Caltech. The attendees found the symposium extremely valuable and exhilarating.

The Center for Theoretical Physics offices are located on the first floor of *Kaprielian Hall* on the USC campus. It's taken some time to structure the physical layout in order to maximize meeting and office space, but the attractive offices are now fully functional. The faculty and staff of the Center hosted an open house reception the beginning of March, which was well attended by both USC and Caltech faculty.

The Center hosts day-long workshops twice a week; Wednesday's at the Center on the campus at USC and Friday's at Caltech. The morning is generally given to discussion and interaction among the physicists followed by an invited lecturer on specific aspects of the theory. Recent visitors have included; **Ashoke Sen**, speaking on the K theory, **Edward Witten**, whose talk focused on the K theory and its connection to branes in string theory and **Michael Green** discussing String scattering in the bulk and on the brane.

String theory has been much in the news over the past several months. The *Los Angeles Times* ran two front page articles in November on string theory. The first on November 16, 1999, discussed space-time and string theory, on which USC's own Elementary Particle Physics group works, and refers to the *'Two Times Physics'* work of Professor **Itzhak Bars**, who is now acting director of the Caltech-USC Center for Theoretical Physics. The follow-up article on November 17, 1999, interviewed John Schwarz from Caltech, who is the deputy acting director of the Center.

According to string theory, the most basic ingredients in the universe are no longer point-like particles, the familiar electrons and quarks. Instead, they are unimaginably small vibrating strings of some unknown fundamental stuff. String theory suggests that different configurations of strings produce different harmonic chords. The vibrating string gives rise to the particles, and the way the string vibrates determines each particle's properties. This all takes place in a convoluted landscape of eleven-dimensional space.

Certain approaches to string theory dispense with the notion of space-time completely. Yet, they seem to produce the same set of results as string theories with normal space and time. To some theorists, this strongly suggests that space and time are superfluous. Space and time as fundamental concepts may be about to disappear altogether.

"Our goal is to turn Los Angeles into a center for theoretical physics," said acting director Itzhak Bars. For more information on the Center for Theoretical Physics, please visit the web site at <http://physics.usc.edu/~citusc>. ♦

THE PHYSICS AND ASTRONOMY DEPARTMENT REACHES OUT**CALIFORNIA STATE
SCIENCE FAIR**

The **California States Science Fair** is the final science fair of the academic year for students throughout the State in grades 6 – 12 and is hosted by the **California Science Center**. It began in 1952 and was the first of its kind west of the Mississippi River. The Fair began with 237 student participants and has grown to hosting nearly 1,000 young scientists. This year's Fair was held on May 22 and May 23 on the floor of the Sports Arena in Los Angeles.

Professor **Chris Gould** has been involved with the California State Science Fair for 20 years in a variety of positions. He finds it an excellent way to promote general sciences to children throughout California. "The overall impression of the Fair is that the participants are all science 'geeks', which is just not the case. Only a small minority of the students will ever turn science into a career," he stated. He went on to describe some of the sophisticated projects he has seen and contrasted today's exhibits with years past. Forty years ago, a presentation could consist simply of labeled rocks. The projects today can involve complicated equations and computer graphics. A student project from a year or two ago demonstrated how the use of snake venom could be used to treat hypertension.

The Fair started with 57 judges, among which three were Nobel Prize winners. This year, there was approximately 350 judges, working with a panel of fellow judges, in deciding the top projects in one subject category for each age division. Throughout the years, Professor Gould has helped develop judging guidelines, and this year he will once again be applying his knowledge in viewing the student's projects, "Every time I can help inspire one kid to explore physics, I feel rewarded," Professor Gould said. Judges are selected from UCLA, Cal State and various business and industries. Throughout the years many alumni have given their time as judges and many in our Department have also been involved including Professors **Stephan Haas, Gene Bickers, Hans Bozler** and **Vitaly Kresin**.

For more information, please see the California Science Fair web page at <http://www.usc.edu/CSSE>. ♦

SUPERIOR TEACHING

CONTINUED FROM PAGE 8

hard to learn to present the material in such a way that engages the students. He has become a superior instructor and strong leader.

We applaud the excellence of our accomplished teaching assistants and look forward to working with them throughout their tenure. On behalf of the department and the students, a heartfelt thank you to both George and Jeff. ♦

**PHYSICS LABS FOR
STUDENTS IN HIGH SCHOOL**

The **USC Physics Labs for Students in High School (PhLaSH)** is a summer physics lab program designed specifically for high school students to experience the fun and challenge of doing hands-on science in a university lab setting.

The program was conceived in 1999, when a high school student telephoned Professor **Gerd Bergmann**, asking if there was any possible way she could work in his lab. Professor Bergmann and **Ty Buxman**, Director of Undergraduate Affairs, discussed possible ways to present interested high school students with the opportunity to gain hands-on lab experience and pursue their interest in physics. They designed the pilot program that ran for two weeks, including six lab sessions and no formal reports or grading. They wanted to make the student contact with USC Department of Physics and Astronomy as stimulating and non-threatening as possible. They sent out flyers to various local high schools promoting the program and received twice as many applicants as there were spots available.

Professor Bergmann taught the class of 12 students with four of his undergraduates assisting. Every student received personalized instruction. Professor Bergmann arranged different presentations every day for the students and also gave a short lecture at the end of each class. The time commitment was tremendous but, he feels, extremely worthwhile. The group of students was mixed, with some being far more advanced in their knowledge of physics. Professor Bergmann attributes this to the students coming from different high schools with varying levels of physics instruction. "Patience was the most difficult thing for many of the students to master," he said, smiling. "They have not yet learned that many experiments take time, the results are not instantaneous."

The student comments on the program demonstrate how successful it actually was. They include: "The program has certainly helped me decide which areas of education I will focus on in the future. In short, the PhLaSH program is unparalleled; and you can't beat the price!" "The PhLaSH program was a great experience for me. Thank you for giving me the opportunity to be a part of it. I hope that the program continues to grow, so that other high school students will have this great opportunity."

On the whole, Professor Bergmann and the Department are very happy with the results of the pilot program and are looking for ways to continue and expand it. ♦



Thank you to the following alumni for your show of support and interest. Your response is encouraging and appreciated by the Faculty and Staff of the USC Department of Physics and Astronomy.

BING AI

PH.D. PHYSICS '95, has been working on patent prosecution at the national intellectual property law firm of Fish & Richardson P.C. since '96. He is a registered patent agent and is studying for his Jurist Doctor degree at the University of San Diego. He and his wife have two boys.

JACK AVRIN

M.S. PHYSICS '51, worked as a defense/aerospace engineer for forty years, working primarily in areas related to information acquisition and processing. Upon retirement, he has developed a unique, geometrical model of the elementary particles which appears to explain many of the basic tenets of physics. His current research is focusing on a dynamic theory to fit the model to known phenomenology.

PHILIPPE DE LOREILHE

B.S. PHYSICS '82, B.S.

ASTRONOMY '82, changed his name upon marriage and becoming a U.S. citizen to **Philip de Louraille**. He began his career at the Chevron Oil Field Research Center in La Habra, California as a geophysics programmer/researcher. He has changed fields and now works in computer and network security management. Since '98, he has been Head of Information for eBay, Inc.

J. KIRK DICKENS

B.A. PHYSICS '55, M.A. PHYSICS '62, PH.D. PHYSICS '63,

retired from Oak Ridge Laboratory after 32 years of full-time research. Since '96 he has been a research professor of Physics at the University of Tennessee, continuing part-time research at the Oak Ridge National Laboratory. He participated in measurements of the small neutron-capture cross section by the isotope

7-Li, a measurement having astrophysical implications (see Phys. Rev. C 54, 383 [1996]), which received the Lockheed-Martin Energy Research Corp. Technical Achievement award for '96. More recently his group succeeded in measuring the cold-neutron-capture cross section by the isotop 208-Pb, the smallest neutron-capture cross section so far measured.

WAYNE 'SAM' DODDS

B.S. PHYSICS '74, joined the United States Air Force upon graduation and flew F-4's for 12 years. He then went to Northrop Grumman Corporation to work on the B-2 project. In '98 he moved to Boeing North America to work on the NMD program. Throughout most of his career, he has been involved with training operators. He enjoys golf and scuba diving when he finds the time.

STEPHEN DUCHARME

M.A. PHYSICS '82, PH.D. PHYSICS '86, joined the faculty in the Department of Physics and Astronomy at the University of Nebraska-Lincoln in '91, where he directs research on ferroelectric and photorefractive materials, and teaches a variety of physics courses. His group, working in collaboration with researchers from the Russian Academy of Sciences, has made several notable breakthroughs in studies of ultrathin films of polyvinylidene fluoride copolymers, crystalline polymers similar to Teflon. The films have potential application in nonvolatile random access memories, infrared imaging, ultrasound, sonar, and high-energy capacitors. If you'd like further information on Professor Ducharme, surf to <http://physics.unl.edu/directory/ducharme/ducharme.html>.

EDWARD R. 'NED' FLOYD M.S. PHYSICS '65, PH.D. PHYSICS '71, is now retired but recently published an article, "Which Casuality? Differences between Trajectory and Copenhagen Analyses of an Impulsive Perturbation", Int. J. Mod. Phys. A 14 (7), 1111-1124 (1999) quant-ph/9708026.

AMY FREDERICKS

B.S. ASTRONOMY '96, is currently a research assistant at Goddard Space Flight Center looking at X-ray data on Eta Carinae. She received her Masters from the University of Maryland Astronomy Department in December 1999.

CLINT D. HARPER

M.A. PHYSICS '73, PH.D. PHYSICS '76, has been a professor of physics and astronomy at Moorpark College in Ventura County since 1977. In '92, he was selected faculty member of the year by the students and he received the college's first Distinguished Faculty Chair in '96. He is also a member (third term) of the Moorpark City Council and former mayor of the city. He loves sailing and has a Cal 27 sloop ("Jolly Mon"). If any USC alumni like sailing, he's always looking for a crew!

XIAO-ZHOU HUANG

M.A. PHYSICS '87, PH.D. PHYSICS '91, after 3 years at Los Alamos National Laboratory doing research in condensed matter, he decided to change his career to finance and moved to New York City working for Citibank credit card division. While there, he introduced parallel computing technology and developed a bankruptcy model that generated 3 million dollars a year. He then moved to J.P. Morgan as a vice president in fixed income research. Currently, he is a proprietary stock trader at a hedge fund using datamining and risk management tech-

niques to find out and utilize predictive factors in seemingly chaotic stock price movement and writing computer programs to execute buy/sell orders automatically.

JIEN-PING 'J.P.' JIANG
PH.D. PHYSICS '90, is currently working at QED, making diode pumped solid state lasers and doing research on spectroscopy (Raman and near infrared).

MYRON A. MANN
M.A. PHYSICS '64, taught for 30 plus years at L.A. Valley College, until his retirement. He is still teaching, at the college as well as in high schools. He also is the Southern California coordinator of the Two-Year College Physics Project under the auspices of the American Association of Physics Teachers.

SHANNON McCONNELL
B.S. ASTRONOMY '89, is currently working as the Education Outreach Coordinator for NASA's Cassini Mission to Saturn. She lives in Pasadena, CA with her husband and son and when not traveling, working or playing with her son, she works as a member of the Pasadena Tournament of Roses.

JOHN MOORE
B.S. PHYSICS '67, is a program manager for AverStar, Inc., an Information Technology company. He supports the maintenance and development of mission critical software laboratories for the US Navy in the Southern California area. His outside interests include amateur radio and astronomy.

PHILIP J. MOORE
M.A. PHYSICS '87, worked in the defense industry for ten years before deciding he'd rather spend his days performing music. So he's now a freelance musician and is living a nice life.

FERNANDO MORINIGO
B.S. PHYSICS '57, became Chief Corporate Scientist at Aura Systems, Inc. of El Segundo, CA in '92 after retiring from Hughes Aircraft Company, and after

a 28 year teaching career in the California State University system. In the past seven years, he has been granted 12 U.S. patents for various electromechanical devices. Several thousand mobile power devices with the trade name AuraGen, based on one of his patents, have been installed in commercial and military vehicles to date.

YIU 'MIKE' NGAN
M.A. PHYSICS '74, PH.D. PHYSICS '76, is now a senior systems engineer at Gencorp, a technology based aerospace company located in Azusa, CA. Since '96, after earning certification as a corporate Six Sigma Black Belt, he has led a major process and quality improvement effort on a 'smart munitions' production program, in which advanced statistical methods were used successfully to improve product yields and reduce manufacturing cycle time. Mike and his wife recently celebrated their 25th wedding anniversary and live in San Gabriel, California with their daughter.

ROSHAN L. SHARMA
M.S. PHYSICS '55, is an Adjunct Professor in the Electrical Engineering Department at SMU in Dallas, Texas and is keenly following developments in the fields of unified field theory with emphasis on string theory.

MARK W. SINCELL
B.S. PHYSICS '86, spent a year in Arizona making the transition from astrophysics research to science writing. He then moved to Houston, Texas with his wife who is teaching at Rice University. He currently covers astronomy, space science and physics issues for *Science Magazine*, the *Discovery Channel*, *Astronomy Magazine* and *Earth and Sky Radio*.

RAYMOND R. SINGH
B.S. PHYSICS '95, is currently an application developer for the Equity Derivatives Group at JP Morgan in New York. He is involved with a variety of tactical, trading and pricing applications for

futures, options and equity swaps risk management.

HOWARD SPITZER
M.A. PHYSICS '67, PH.D. PHYSICS '73, has been at TRW for the past 15 years, working in the field of satellite radiation survivability. He is also a Planning Commissioner for the City of Cerritos, California.

GEORGE STROBEL
PH.D. PHYSICS '65, is now studying whether 2 dimensional numerical simulations of rough capsule surface implosions are adequate or whether 3 dimensional simulations are required. He is an Associate Professor in the Physics Department at the University of Georgia in Athens, Georgia.

SHIN-TSON WU
PH.D., PHYSICS '81, has received the Y2K SID Special Recognition Award from the Society for Information Display. The award citation reads, "For the invention and commercialization of mixed mode twisted-nematic structure reflective liquid crystal displays". The award was formally presented to Dr. Wu on May 16, 2000 at the SID annual meeting.

WAYNE WEIMIN YU
M.A. PHYSICS '86, is the President of a high tech engineering company in Tustin, CA. Recent products include WebMux, a web server load balancer and high availability product, and WebSpray, a web server testing tool.

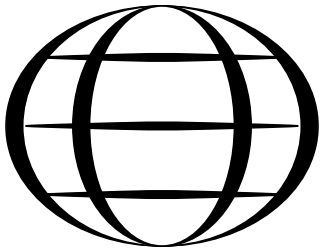
Physics Phollies

What did the girl atom say
to the boy atom?

I've had enough of you.
I'm splittin'.

ADDRESS CORRECTION REQUESTED

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Visit USC Physics and Astronomy
on the Internet at:

<http://physics.usc.edu/>.

We would also like to invite our
Alumni to visit:

<http://physics.usc.edu/Alumni/>.

The USC Department of Physics and Astronomy would very much like to hear from you.

Please send us news items, updates, etc. for the Fall newsletter and notify us of any change of address via e-mail at physicsalumni@usc.edu or send your news via US mail to: Margo Burrows, USC Physics and Astronomy, 920 W. 37th Place, SSC 300, Los Angeles, CA 90089-0484.

If you know of an alumni we may have lost track of, please let Margo know.

We look forward to receiving your information and greatly appreciate your help in keeping our records as up-to-date as possible.

PHYSICS *and* **A**STRONOMY
University of Southern California

Spring 2000