University of Southern California

PHYSICS and ASTRONOMY

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FORMER DEAN NOMINATED

John Marburger III, past dean of the *College of Letters, Arts and Sciences* and currently head of Brookhaven National Laboratory, has been nominated by President Bush for the position of *White House Science Advisor*. In the 70's, Marburger was a professor of physics and electrical engineering at USC and served as Chairman of the Physics Department before becoming Dean of LAS. In 1980, Marburger became President of State University of New York, Stony Brook. Marburger's appointment is now before the U.S. Senate for approval. ✥

DEPARTMENT THANKS DONORS

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THEN AND NOW...

The First Forty Years

We've decided to chronicle our departments' history since the inception of the University of Southern California to the present day and share it with our alumni and friends in our bi-annual newsletters. No narrative has existed prior to this and we feel it's important to recognize those who have come before us in order for us to fully appreciate and understand where we are today and hope to go in the future.

This first installment looks at the years from 1879 to 1920. I've used many sources, among them the theses by Leslie F. Gay, Jr. and Samuel E. Gates, notes from Professor Arthur W. Nye, and the book "Southern California and its University" by Servin and Wilson. Any errors or misinterpretations contained within are mine alone.- Margo Burrows

The University of Southern California was founded as a Methodist college in 1879 and first opened its doors for students in 1880. Students could pursue a Bachelor of Arts or Bachelor of Science. The Scientific Course was laid out as follows:

FRESHMAN CLASS

First Term.
Mathematics - Plane Geometry.
Belles-Lettres - Composition and Rhetoric.
Natural Science - Mineralogy, Determinative.
Botany.
Second Term.
Mathematics - Solid Geometry.
Belles-Lettres - Composition and Rhetoric.
Natural Science - Botany.
Physical Science.
Third Term.
Mathematics - Plane Trigonometry.
History - Ridpath's United States History.
Natural Science - Botany.
Chemistry.

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SOPHOMORE CLASS

First Term.

Mathematics - Surveying and Navigation.
German - Woodbury's Practical Grammar.
Natural Science - Chemistry, Biology, Lectures.
History - Thalheimer's Ancient History.

Second Term.

Mathematics - Analytical Geometry.
History - Thalheimer's Mediaeval History.
Natural Science - Chemistry, Chemical Philosophy
German - Grammar and Reader.

Third Term.

Mathematics - Differential Calculus.
History - Thalheimer's Modern History.
Natural Science - Analytical Chemistry.
German - Select Reading.

JUNIOR CLASS

First Term.

Natural Science - Deschanel's or Silliman's Physics.
Belles-Lettres - English Literature.
Mathematics - Integral Calculus.
German - Goethe's Prose.
Inorganic Chemistry.

Second Term.

Natural Science - Deschanel's or Silliman's Physics.
Belles-Lettres - Logic.
Mathematics - Analytical Mechanics and Civil Engineering.
French - Grammar and Reader.
Organic Chemistry.

Third Term.

Belles-Lettres - Rhetoric.
Mathematics - Practical Mechanics and Nature of Mathematics.
French - Grammar and Reader.
Physics.

SENIOR CLASS

First Term.

Mental Philosophy.
Belles-Lettres - Political Economy.
Natural Science - Astronomy.
French - Select Readings.
Metallurgy.

Second Term.

Moral Philosophy - Gregory's Christian Ethics.
History - Guizot's History of Civilization.
Natural Science - Astronomy.
French - Select Readings.
Geology.

Third Term.

Moral Philosophy - Butler's Analogy.
Belles-Lettres- International Law.
Modern Languages - Conversation in German and French.
Geology.

In 1880, about 50 students registered for classes though very few of them were of collegiate rank so during that first year the work was confined almost entirely to special courses and the Preparatory Department. The President of the college, **Marion M. Bovard**, did the large part of the teaching. The tuition was $15 per term. The founders of the University stated: *"The University of Southern California was organized for a specific purpose and with a distinct object in view. The founders of this institution recognized the fact that man possesses a threefold nature, physical, intellectual, and moral. They were, further, insistent in the belief that each of these three departments of man's being should receive the proper amount of care and training in order to achieve the best results."*

In 1881, enrollment doubled to 100 and climbed steadily. By 1887, student registration was about 290 and tuition costs had increased to $30 per semester. High moral and religious standards were rigorously maintained.

In 1885, physics courses were offered under the auspice of the Department of Chemistry and Mathematics. By 1889, the department was Physics and Chemistry with Mathematics becoming a separate entity. The Mathematics Department taught the *General Astronomy* class throughout the time frame we are now looking at.

In 1887, Mr. **E. F. Spence**, a local banker, donated money to the University to help create the Spence Observatory on Mount Wilson. *(see story on page 6).*

Laird J. Stabler, M.S., Ph.C., assumed direction of the Physics and Chemistry Department in 1894. At that time, *"modern methods and progressive plans were introduced throughout. Science laboratories were fitted up, new apparatus and appliances purchased and the very best equipment installed for doing the highest grade of work."*

By 1897 USC had developed four physics courses. They were:

IX *Advanced Physics*: Mechanics, Sound and Light,
X *Advanced Physics*: Continuation of IX, including Heat, Magnetism and Electricity,
XI *Electricity and Magnetism*: Recitations and lectures, and
XII *Electrical Measurements*: Laboratory course with a study of general methods of testing and using electrical machinery.

In 1901, **William T. Randall** was Dean of the *College of Liberal Arts*. There were approximately 600 students enrolled at U.S.C. The tuition for attending was $31 per semester with an additional $4.00 for physics. Around 1902, Professor Stabler, head of the Department of Physics and Chemistry, took a leave of absence and **Frank I. Shepherd**, A.M. took over the duties of running the department.

The **Course Catalogue from 1902** gives the following description of the laboratory: *"The physical laboratory is arranged to accommodate forty students at one time. There is a good collection of apparatus of the best make for lecture demonstrations. It includes a new steropticon with special apparatus and slides for projection; equipment for*

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electrical study, voltmeters, ammeters, resistance coils, galvanometers, reading telescopes, induction coils, Crooke's tubes, etc.; spectroscopes, polariscopes, lenses, etc. for the study of light; thermometers, barometers and registering apparatus for meterology; air pumps, condensers and receivers for gases; as well as apparatus for the composition and resolution of forces."

In 1906, **George S. Beane**, A.B., B.Sc., Ph.D., was named Chair for the Department of Physics and Electrical Engineering. This combined department of physics and electrical engineering existed until 1919, at which time they were separated. The tuition had increased by this time to $35 per semester with $4 to $10 additional being charged to physics students. The **1906 Course Catalogue** give the following description of physics instruction and the classes offered:

> *Instruction in Physics is given by means of lecture, text and laboratory exercises. A good collection of lecture room apparatus is possessed by the department so that experimental demonstrations can be given of all important phenomena. There is also a good working Departmental library besides standard works in the General Library of the University.*
>
> *The courses provide instruction for those who desire to pursue the subject as pure science or for those who are looking forward to the engineering profession.*
>
> *Courses I, II, and III, are fundamental and prerequisite to all other courses. In these the student learns the use of standard instruments and becomes acquainted with methods. For students in engineering, courses in Photometry, Calibration of Instruments, Testing of Direct Current, Alternating and Polyphase Machinery.*
>
> *Every encouragement is given the students to carry on the work of investigation. The spirit of scientific enquiry is stimulated. In connection with laboratory work courses of reading are indicated.*

A - Course for Undergraduates

I. *Mechanics* - Lectures, Texts and Laboratory work.
II. *Heat, Sound and Light* - Presented as a continuation of Physics I.
III. *Electricity and Magnetism* - Lectures and Laboratory work in the theory and practice of Electrical measurements.

B- Primarily for Undergraduates but open to Graduates

IV. *Light* - Theoretical and Experimental. Lectures and reading from standard authors with much experimental work. A good working knowledge of mathematics is required.
V. *Heat and Thermodynamics* - An advanced course.
VI. *Electrical Measurements* - A practical course in which theory and methods of exact electrical determinations are studied including use of Ballistic Galvanometer, and condensers and the measurement of induced currents and permeability.
VII. *Measurements and Determination of Constants.*
VIII. *Direct Current Principles and Machinery* - The theory of Direct Current. Fundamental types of Direct Current Generators and Motors. Based on Sheldon's Dynamo Electrical Machinery.
IX. *Alternating Current Theory and Machinery.* - A careful consideration of principles involved in alternating current phenomena. General types of alternating generators and motors.
X *Dynamo Laboratory* - D.C. and A.C. apparatus, operation, efficiency, curve plotting, etc.

C - Primary for Graduates

XI. *Experimental Physics* - The exact determination of some of the important standard experiments.
XII. *General Physics* - Theoretical and practical study of some particular group of Phenomena or Laws. This will consist of a critical study of the Literature of the subject as well as experimental work.
XIII. *Thesis* - In all cases where Physics is pursued as a major subject for an advanced degree a thesis will be required. While this will be criticized primarily as to the subject matter it must also be commendable as a piece of literary work.

The Old College (also known as The College of Liberal Arts)

George S. Beane died unexpectedly on October 31, 1907. Instructor **Arthur W. Nye** was made temporary head until Professor **W. K. Bowker** took over in 1908.

In 1907, the physics department occupied the second floor of the south wing of the Old College (also known as the College of Liberal Arts Building. The Old College was among the first permanent buildings constructed on campus in 1887 - and the first to be torn down - in 1949. It stood about where the present day Taper Hall is located.)

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After the summer of 1907, the department moved to the central basement of Old College into rooms previously used by Chemistry. There it gradually expanded until considerable floor space was occupied. This was the location of the department until 1928, when the department moved to the then newly constructed Science Building (present day Science Hall).

Until 1910, there had been no great demand for graduate work. Now there was a definite need for the higher degrees. That spurred the University to formally organize a committee to set forth graduate requirements. Professor's **Arthur Nye** and **Laird Stabler**, both from the Physics Department, were on the council during the second year of its creation. The councils task was;

1) To give due prominence to graduate courses in the University.
2) To insure systematic and efficient administration of this higher work.
3) To provide separate instruction for graduate and upper division students.

To accomplish those goals, the Graduate Council was created. Their duties were very definitely formulated and announced as;

1) To fix conditions of admission to the Graduate department.
2) To provide courses of graduate instruction; to pass judgment upon graduate courses offered by the respective departments, no one of which shall become operative without their approval.
3) To pass upon the credentials of all candidates for degrees.
4) To establish and maintain requirements for graduate degrees.
5) To formulate regulations for the effective organization and administration of the Graduate department.

By 1914, the Physics Department offered the opportunity for an advanced degree. In addition to the bachelor's degree, a minimum of one year's graduate work, pursued in residence at the University, with a total of twenty-four units, including the thesis, was required of the candidates. The popularity of the Graduate department is attested to by the 248 students who received their degrees by 1920 from the College of Arts and Sciences.

The **First World War** took its toll at the University. Immediately after the United States entered the conflict in 1917, approximately 300 students left the classroom to enter the service. Others were deterred from enrolling. Operating costs were increased and tuition was raised to $50 per semester to help defray the University expenses. The next year conditions were even worse, for more than six hundred left the University due to the War. Prior to that, enrollment had shown a steady increase from 2,958 in 1913 up to 3,437 in early 1917.

The return to an era of peace was the signal for an era of unprecedented growth for the University in every field; enrollment, building, endowment, curriculum, and faculty. From 1918-1919, the increase in enrollment was slight, but beginning in 1920, the student body had grown at a rate of more than a thousand per year. In 1919, there were 4,375 students registered. Tuition was now $75 per semester, plus a five dollar diploma fee and ten dollars for physics courses.

The Physics Department, still under the charge of Professor Arthur Nye, had developed greatly from the original four classes first offered. From the **1919 - 1920 Course Catalogue**:

Lower Division Courses

1. *General Elementary Physics.*
2. & 3. *Mechanics.*
4. & 5. *Heat*
6. & 7. *Electricity.*
8. & 9. *Light.*
16. *Applied Electricity.*
17. *Physical Measurements.*

Upper Division Courses

105. *Electrical Measurements.* A laboratory course in which the theory and methods of exact electrical determination are taken up, including the determination of resistance by various methods, galvanometer constants, the measurement of current and electromotive force, insulation tests, hysteresis and permeability tests, the calibration of instruments, the use of condensers, the measurement of induction, etc.
106. *Heat.* Study of state changes, kinetic theory, radiation, and exact methods of experimental work.
107. *Physical Measurements.* To accompany course 106.
108a. *Physical Optics.* Study of theories of refraction and reflection, diffraction, interference, polarization, relativity, electron theory, etc.
108b. *Geometrical Optics.* Study of lenses, mirrors and prisms. Optical systems. Aberrations. Design of optical instruments, especially military instruments used in gun-fire control.
109. *Advanced Light Laboratory.* To accompany course 108.
110. *Sound.* General principles, theory of vowel sounds, construction of musical instruments, architectural acoustics.
111. *Physical Measurements.* To accompany course 110.
112. *Photometry and Illumination.* Lectures and recitations. A study is made of the physiological and physical phenomena of artificial illumination, methods of measurement, types of photometers, types of illuminants and their characteristics, reflectors, and the principles of interior and street illumination.
113. *Photometry.* A laboratory course to accompany course 112.
116. *Advanced Electricity.* A course dealing with certain modern theories and recent discoveries including vacuum tube phenomena.
206. *Teacher's Course.* Lectures and discussions of methods of presenting and teaching various parts of Physics and the equipment and management of the laboratory.

Major Work: Twenty-four hours in Physics and ten hours in Electrical Engineering or Civil Engineering.
Minor Work: Twelve units, including course 105.

The first forty years of our departments' history saw enormous growth and many changes. From the first small steps in the 1800's it grew in size and stature. Some areas of study have changed very little since that time, most notable is the fact that the basic foundations of physics have remained the same. Even more remarkable is that all this was all prior to the discovery of Quantum Mechanics. By 1920, the physics department had established itself as an excellent research facility and was attracting both quality students and faculty.

One of our more notable students from this time period was **Boris Podolsky**, a Russian who immigrated to the United States in 1913, who received his Bachelor of Science degree in 1918 and Master of Arts in 1926 from U.S.C. He went on to receive his Ph.D. in physics from Caltech in 1928. In 1935, the famous **Einstein-Podolsky-Rosen** paper entitled *"Can the Quantum Mechanical Description of Reality be Considered Complete?"* on gravitational waves was published. The EPR paradox was put forward to argue that quantum mechanics was not a complete theory but one that needed to be supplemented by additional values.

Today, we have 30 faculty members: 25 full professors, 3 associate professors and 2 assistant professors. Their backgrounds are extremely diverse. They came to U.S.C. from China, England, Russia, Germany, USA and Turkey and have studied and worked throughout the world. The depth and breadth of their collective knowledge is truly awesome.

The department currently supports research groups in six primary areas: Elementary Particle Physics, Astronomy, Space Sciences, Laser Physics, Atomic and Molecular Physics and Condensed Matter. In addition, faculty participate in two research units; the Center for Theoretical Physics and the Space Science Center.

The students majoring in physics also represent a cross section of the world. This year our freshman class consists of thirteen students; three majoring in Astronomy, one in Physics/Computer Science, three in Biophysics and six in Physics.

Our undergraduate program currently has 36 students enrolled. Along with the 13 Freshmen, there are nine Sophomores, four Juniors and ten Seniors. Nine are majoring in Astronomy, four in Physics/Computer Science, six in Biophysics and a total of 17 in Physics.

The graduate program continues to grow. We have 66 active graduate students working towards their advanced degrees. The dedication and drive of these individuals in tremendous. They work with the various groups and their contributions to the work each group is doing are extremely valuable. In addition, many are also teaching assistants and are developing into exceptional instructors.

While tuition has increased somewhat from the original $15 per term in 1880, and the campus has changed its look many times throughout the years, the same proud spirit that created the University of Southern California remains strong. The Department of Physics and Astronomy was organized by professionals of the highest caliber - to Laird Stabler, Frank Shepherd, George Beane, Arthur Nye and W.K. Bowker - thank you for your dedication and passion that helped to build such a substantial and respected department. ❖

SHIN-TSON WU

A Story of Success

My Life at USC

I came to the USC Physics Department in 1977 from Taiwan. I really appreciated the high quality education and vigorous research programs offered by USC faculty. Today, after 20 years, I still remember Dr. **Nodvik's** Math, Dr. **Chang's** Quantum Mechanics, Dr. **Thompson's** E&M, Dr. **DeShazer's** Quantum Electronics, and Dr. **Steier's** Fiber Optics classes. Each professor has his own style and characteristics. I learned from them how to be a great teacher. In 1981, I obtained my Ph.D. under Prof. **Michael Bass's** supervision. At that time, he was the director of the Center for Laser Studies, and Prof. **Elsa Garmire** was the Associate Director. I learned from them how to be a first class researcher.

My Life at Hughes Research Laboratories

Being an international student, I needed to obtain my permanent residency in order to legally work in this country. Therefore, I spent slightly more than a year in a small company located in San Fernando Valley to fix my visa. In 1983, I joined *Hughes Research Laboratories* in Malibu, California. In the 1980's, Hughes was a leading R&D Lab in lasers, electro-optics, and microelectronics. In particular, Malibu is an inspiring place. This Lab has edified numerous outstanding scientists and engineers. At Hughes, I devoted my entire career in liquid crystal studies, ranging from molecular designs, optical and electro-optic properties, to direct view and projection display devices and systems.

My Life at School of Optics, UCF

After having worked with Hughes Research Laboratories for 18 years, I joined the School of Optics, *University of Central Florida (UCF)* as a Provost Research Enhancement Professor (PREP) in July, 2001. This year, UCF has 36,000 students enrolled. It is forecasted to become one of

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USC's BOVARD BROKERED MOUNT WILSON'S FIRST TELESCOPE

Reprinted courtesy of USC News Service. First appeared in the USC Chronicle 8/27/01 issue.

by Bob Calverley

Mount Wilson, spectacularly perched over the Los Angeles basin high above Pasadena, has a rich astronomical history.

In the 1880s, scientists noticed that most of the time the San Gabriel Mountains, and Mount Wilson, had the astronomically desirable qualities of a clear sky and stable night air.

In 1889 USC President Marian Bovard ordered the glass for a 40-inch refracting telescope to be paid for with a $50,000 gift from a local banker. Bovard hoped that USC would soon operate the world's largest telescope and share a site on Mount Wilson where Harvard would also establish an observatory.

Harvard astronomers installed a 13-inch refracting telescope on the mountain only to suffer through the winter of 1889-90, one of the severest on record. At the same time, the Southern California economy foundered and the gift to pay for USC's telescope did not materialize.

The glass for the telescope, however, had already been ground. George Ellery Hale, a young, unknown Chicago astronomer, heard about the glass and persuaded the University of Chicago and streetcar magnate Charles Yerkes to back him. The telescope ended up at Lake Geneva, Wis., where Hale be came the first director of the Yerkes Observatory.

Mount Wilson soon captivated Hale. He ended up building the world's largest telescope three more times and two of them, the 60-inch and 100-inch reflectors, are still in use on Mount Wilson.

In 1908, Hale built the 60-foot tower that USC operates today, and in the first year of its operation discovered the sun's magnetic field. In the early 1960s, Robert Leighton, a Cal tech physicist, used the facility to show that the sun vibrates with a predominant period of five minutes. The sun's surface appears roiling and disorganized, like boiling water, but Leighton determined that waves periodically pulsed out to a peak and then collapsed back into the interior.

"These were the two key discoveries made at the 60-foot tower," said Ed Rhodes, professor of physics and astronomy who is in charge of the facility today. "In the late'70's, I learned that the tower was only being used for about 40 minutes a day and was able to secure it for this project" (studying solar oscillation patterns).

The tower is actually a large coelostat, which is a device with flat mirrors that reflect sunlight through a stationary lens to form images. Before Hale, coelo stats were much smaller and usually rigged temporarily for studying solar eclipses.

Hale, who wanted to study the sun, was frustrated that only relatively small instruments could be attached to the moveable ends of telescopes. He wanted to use large spectrographs to spread the spectrum of sunlight wider so he could make a more detailed study.

"There's a 30-foot working spectrograph underneath this tower," said Rhodes. "When it was built, this was the world's premier tool for solar research. We still find that much of the old original equipment works better than the newer stuff."

While there are almost 300 clear days per year in which Rhodes can study the sun, the top of Mount Wilson - slightly more than a mile above sea level - can still be subject to the rain, snow and cold that drove Harvard away.

Using data collected from a tower on Mount Wilson, Ed Rhodes, professor of physics and astronomy, studies the waves that wrack the sun.

"When I first came here in 1968 we sometimes wore heated flight suits," Rhodes said. "Milton Humason [an astronomer with no formal training who started at Mount Wilson as a janitor] was famous for the fur coats he wore."

The 60-foot tower was not state-of-the-art for long. Almost immediately after discovering the sun's magnetic field, Hale began work on an adjacent 150-foot tower that is today operated by UCLA. In 1931, Albert Einstein visited the 150-foot tower where the solar astronomers were involved in an unsuccessful attempt to gather evidence to support his theory of general relativity.

"They were trying to measure the red shift caused by the gravitational field of the sun," said Rhodes. The theory, since proven, holds that a light beam from a distant star would bend as it passed through the strong gravitational field of the sun. "There are so many other motions in the

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JOHN A. RUSSELL, ASTRONOMER

Prepared by Gibson Reaves - Professor of Astronomy, Emeritus

John A. Russell, Professor of Astronomy, Emeritus, founder of the USC Department of Astronomy and pioneer meteor spectroscopist, died 2001 November 2. He was 88 years old. Dr. Russell joined the USC faculty in 1946, was chair of Astronomy until 1968, and was Associate Dean of Sciences and Mathematics from 1959 until 1968. In the late 1950's, with an astronomy faculty of only two, USC had the largest undergraduate enrollment in astronomy of any university west of the Mississippi. In 1962, Dr. Russell won the USC Associates' Award for Excellence in Teaching. Earlier, in 1957, he was the USC Faculty Research Lecturer - later called the USC Associates' Award for Excellence in Research. He is one of the very few USC faculty members who have won both such awards. In 1978, when he turned 65, he reluctantly retired from teaching, but continued active in his research.

In 1946, astronomy was very different from what it is today: the Palomar 200-inch (5-m) reflector was not yet in operation; images were recorded on photographic plates, not CCDs; photoelectric photometry was in its infancy, and computers as we know them today did not exist, not even IBM cards. No xerox; no artificial satellites; no space probes. Most fundamental: There was little if any money available for astronomical research. Therefore, as one eminent scientist put it, when you have no money, then you have to think. Dr. Russell thought. With his strong background in stellar spectroscopy, Russell selected the then quite unexplored field of meteor spectroscopy.

Russell's first observations were made using a small 30 degree dense-flint prism mounted ahead of an f/5.6 Kodak, focal length 130mm yielding a dispersion of 468 Angstroms per mm between Hδ and Hγ. At this time, three types of meteor spectra had been recognized. Since there are also three kinds of meteorites - and thus supposedly three kinds of meteoroids - it was reasonable to speculate that each kind of meteoroid produced each kind of spectrum. One of Russell's earliest spectrograms showed, on one Perseid meteor trail, all three kinds of spectra along its length. This was the first concrete evidence that the speculation was wrong: that the spectrum of a meteor depended more on the altitude and velocity of the meteoroid that produced it, and the state of the Earth's atmosphere at that altitude, than the character or composition of the meteoroid that produced it.

Dr. Russell continued his research on meteor spectra for over 30 years, with increasingly better equipment and with increasingly refined results. He was especially concerned with the erratic appearance in his spectra of the forbidden green line of neutral oxygen [OI] at 5577 Angstroms. These studies and others led him to conclude that there are indeed some physical properties of meteoroids that are reflected in their spectra - the density and friability of the meteoroid. Dr. Russell made many more fundamental contributions to meteoritics than there is space to mention here.

Astronomers, like other scientists, are sometimes asked to testify in court as expert witnesses, and John Russell was no exception. By making a careful analysis of the position of the shadows in a photograph of a young man, Russell was able to determine the time the photograph was taken to an accuracy of two seconds - at which time the young man in the photograph had been accused of raping a girl at some distance from the site of the photograph, and thereby established the innocence of the accused young man. Some time later, the true rapist confessed. The techniques of analyses used in sciences often have quite unexpected - and gratifying - applications.

John Russell loved his work, his research, teaching and his students. He was the epitome of a gentleman and a scholar. All of us who were his students and colleagues were indeed fortunate to have been associated with *"such and so great an ornament of human nature."* ❖

Here Comes the Sun: USC Astronomers on Mount Wilson Shed Light on Solar Waves

Reprinted courtesy of USC News Service. First appeared in the USC Chronicle 8/27/01 issue.

by Bob Calverley

The sun rises on Mount Wilson to reveal a clear, cobalt-blue sky over thick clouds blanketing the Los Angeles Basin below.

On top of the 60-foot tower operated by USC astronomers, two mirrors begin tracking the sun to bounce its image through a filter containing magnetized sodium vapor onto a million-pixel digital camera at the bottom of the tower.

The sodium gas absorbs a specific wavelength of the light, the same stark yellowish hue of urban streetlights. The magnetic field splits the light into two images, one shifted very slightly toward the blue end of the visible spectrum, and the other toward the red.

"Each blue-shifted image is sensitive to the parts of the sun that are coming toward and going away from us in a slightly different manner than is each red-shifted one," said Ed Rhodes, professor of physics and astronomy. A computer combines the two images into a single picture, called a dopplergram, that gives a clear view of the rising and falling areas of the sun's surface.

"The sun's surface looks like a big pot of boiling water. Everywhere you look, you see evidence of the convection below," said Rhodes, a helioseismologist who studies the waves that wrack the sun. "The sun is oscillating, or vibrating, in as many as a million different modes, and we are trying to measure all of those modes."

Every minute of every clear day, from half an hour after sunrise to half an hour before sunset, the camera methodically records another set of images. Although the process is largely automated, the equipment has to be turned on,

Ed Rhodes and his crew pose at the USC tower, flanked by UCLA's 150-foot tower and the 100-inch telescope. From left are graduate student Perry Rose, senior Jon Estay, Rhodes, junior Bill Rudnisky and Andy Grubb, an observer-data analyst.

monitored and turned off every day. Two under graduate astronomy students, Jon Estay, a senior, and Bill Rudnisky, a junior, are key members of the astronomy team that also includes observers Andy Grubb, Shawn Irish and graduate student Perry Rose.

"We give the undergrads a lot of responsibility. They've had to learn quickly how to operate the equipment and do the data reduction," Rhodes said.

Each day, the data from 700 or 800 pairs of high-resolution images are stored on digital audiotape cassettes. Each year, there are 200 to 300 clear days in which this can be done.

Rose, the physics graduate student, calculates that the project has generated about 7 terabytes of data since it began in 1984. A terabyte is a thousand gigabytes. A new personal computer today might come equipped with a 10-gigabyte hard drive to store data, so it would take 700 such computers just to store the project's data.

Their data is first processed by Sun workstations at the tower, but it takes computers with fast parallel processors at USC and a Cray supercomputer at the Jet Propulsion Laboratory to do the real analysis.

"The dopplergrams show oscillations similar to the motion of earthquake waves," Rhodes said. The waves are compression waves or acoustical waves that reflect off of boundaries caused by pressure and temperature differences within the sun. "It is like the sound that resonates in an organ pipe except that the waves in the sun are large. It wouldn't be audible to people."

Each of these resonating waves represents another oscillation mode. Rhodes said that from the ground he can detect about 700 oscillations and from space, 3,000 or more oscillations. Rhodes is also a guest investigator for NASA's Solar and Heliospheric Observatory (SOHO), a spacecraft parked in an orbit that keeps it directly between the Earth and the sun as the Earth orbits the sun.

Space observations are not subject to atmospheric interference and can be continuous because there is no night in space. But Rhodes said NASA can't afford to maintain the high-resolution tracking of the satellite necessary to gather data for more than two or three months per year.

"So we fill in gaps with ground-based data," he said. "We are able to synchronize with SOHO so that we can capture images at exactly the same moments from both the satellite and the tower."

Rhodes' goal is to have data for a complete solar cycle, which is 11 years. Unraveling the complex solar oscillation patterns will someday enable astronomers to predict where and when sun spots will occur and how that will affect the Earth.

But back on Earth in the first gathering gloom of sunset, Rhodes is concerned with more earthly matters. He's demonstrating the "Mount Wilson salute," frantically waving his hands around his head in a futile effort to disperse a horde of deer flies.

"You thought astronomers only worked at night?" he said. ✥

Ed Rhodes, professor of physics and astronomy, stands at the base of USC's 60-foot research tower on Mount Wilson. Rhodes uses the tower to study solar waves.

FIRST TELESCOPE

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sun that the sun turned out not to be the best star test to use." In fact, the gravitational red shift was not observed until 1954 using the light from a white dwarf star.

Using Mount Wilson's 100-inch telescope, Caltech astronomer Edwin Hubble showed that the universe is expanding, a discovery that Stephen Hawking described in his recent USC lecture as the greatest scientific achievement of the 20th century.

In the beginning, astronomical equipment was hauled up Mount Wilson by mules. Today, you can visit the Mount Wilson Observatory by following the Angeles Crest Highway north of La Canada Flintridge for 14 miles to Red Box Road. Turn right and go another 5 miles to the observatory gate. The observatory has walking tours on weekends, picnic facilities and a visitor's center. More information is available at http://www.mtwilson.edu/. ✥

Success

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the U.S. top ten universities in next 5 years. In parallel, UCF is striving to enhance its research programs. Therefore, the provost office initiated the PREP program to attract well established scholars to UCF. I am honored to be the first PREP professor in optics. We are de-lighted to welcome Prof. **Emil Wolf**, a distinguished professor in optics, to join our School of Optics beginning in the fall semester of 2002.

As electronics is for the 20th century, photonics is for the 21st century. The School of Optics at UCF was established in 1998 to bring together diverse disciplines into a cohesive program in optical science and engineering. The School of Optics has grown into an internationally recognized institute with 25 full time faculty members, 7 adjunct professors, ~25 research scientists and 100 graduate students with research activities covering all aspects of optics, photonics, and lasers. It is housed in a state-of-the-art 82,000 sq. ft. building dedicated to optics research and education. About 3/4 of our faculty members have received more than one society fellowship and 2/3 have received prestigious awards. As of this date, our faculty members have published and/or edited more than 18 books.

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Success

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The School of Optics offers interdisciplinary graduate programs leading to M.S. and Ph.D. degrees in Optics. Interdisciplinary research topics range from classical optics to quantum optics to materials science including materials characterization, non-linear optics, laser plasma, spectroscopy, diffractive optics, diode lasers, ultrafast phenomena, laser propagation, imaging science, 2D and 3D display materials and devices, fiber-optic communications, optoelectronics, optical waveguides, and detector technology.

A good friend from Cal Tech told me; "we are second class professors as long as we don't get a Nobel Prize". At UCF, we don't have a Nobel Laureate yet. So, we are working very hard towards that goal.

My Research Group at UCF

I am actively building up my research group. When completed, my group will have 6 post doctorates and half a dozen graduate students. My research at UCF is focused in three areas: *1.)* Optical phased arrays for optical communications, *2.)* Nano liquid crystal materials and devices, and *3.)* Next generation liquid crystal displays. I will give a brief flavor on each topic.

Optical Phased Arrays for Optical Communications

Optical phased array (OPA) is a versatile technology independently developed by Raytheon and Hughes scientists. Fig. 1 illustrates the operation principles of an OPA device where nematic liquid crystal is used as electro-optic media. By applying proper voltages to different pixels across the liquid crystal layer, a phase grating is generated. This phase grating will deflect the incoming laser beam to a wide angle with high energy efficiency. Its applications range from free space laser communications, electronic lens, adaptive optics for wavefront corrections, to fiber-optic network switching for telecommunications. Currently, this program is funded by DARPA.

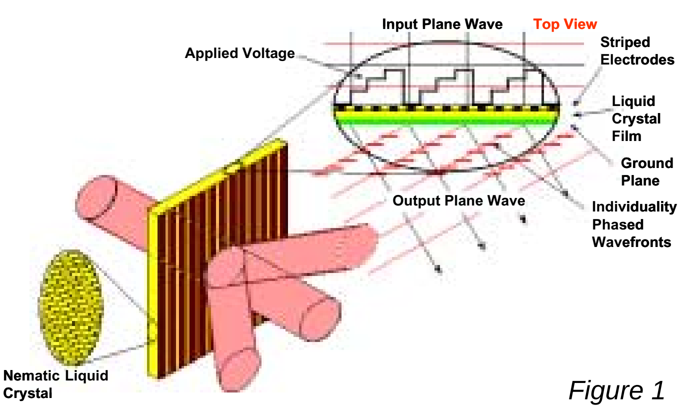

Figure 1

Device structure and operation principles of optical phased arrays

Nano Liquid Crystal Materials and Devices

Nematic liquid crystals are rod-like compounds about 2nm long and 0.5nm wide. How to design such nano-scale liquid crystal compounds with proper phase transition temperatures and desirable physical properties is a challenging task. For display applications, such as laptop and desktop computer monitors, low birefringence and low viscosity polar compounds are preferred. On the other hand, for telecom application at near infrared, high birefringence is desperately needed. Currently, this project is funded by AFOSR.

Molecular designs and syntheses need close collaboration between physicists and organic chemists. To develop new liquid crystal materials, I have assembled an international molecular engineering team. The collaborators include Professors **L. R. Dalton** (USC), **R. Darbrowski** (Poland), **B. M. Fung** (U. Oklahoma) **C. S. Hsu** (Taiwan), **S. Marder** (U. Arizona), and **M. Neubert**, **L. C. Chien**, **R. Twieg** and **A. Seed** from Kent State University.

Next Generation Displays

The world-wide market for information display is around $50B a year. Thin-film-transistor liquid crystal display has become mainstream flat panel technology. Some competitive technologies, such as organic light emitting diode (OLED) and polymer LED are emerging. However, these new technologies still suffer from insufficient lifetime owing to direct current effect on organic compounds.

My group is developing next generation display concepts and devices. We concentrate on electronic papers, low power reflective display for mobile communications, virtual projection display for mobile internet, large screen projection displays for HDTV and electronic cinema.

Honors and Awards

I am just an ordinary person. Dr. **John Nodvik** and Dr. **Tu-Nan Chang** can be my witnesses. In 1980, I unexpectedly received an Outstanding Student award from the USC Graduate School. Although the scholarship was only $200, the strong encouragement truly motivated me. Later, some major awards I received include a prestigious *SID* (Society for Information Display) *Fellow Award* in 2001, *SID Special Recognition Award* in 2000, *ERSO* (Taiwan) *Special Achievement Award* in 1997, *OSA* (Optical Society of America) *Fellow* in 1993, *Hughes Team Achievement Award* in 1991, and *Hughes Annual Outstanding Paper Award* in 1991.

SID Fellow is particularly difficult to get. Each year, SID honors only 4-5 fellows worldwide. Based on the global display activities, usually Asia (Japan) gets two, Europe gets one and America gets one. Amazingly, I am the only U.S. delegate for the year 2001 award.

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CLASSNOTES

1960's

JAMES P. CAMPBELL

M.A. Physics '65, completed his Ph.D. in EE at the ripe old age of forty and spent the next 27 years with the final of his three employers, the non-profit Aerospace Corp. He had the privilege of being connected with a major new national satellite system from its conception through years of successful operation. Through it all, he was supported and guided by his loving wife, Doris and their six daughters. He retired as General Manager of Aerospace's Imaging Programs Division in March 1998. Now with seven granddaughters and (surprise!) four grandsons, he is taking advantage of the opportunity to travel both in the in U.S. and abroad. James took up skiing a few years ago and so he and his family spend time at a condo in Ludlow, VT, while continuing to reside in rural Loudoun County, VA.

WILLIAM CARTER

B.S. Physics '65, after many years of work as a petroleum engineer, he is currently programming, building and marketing robot machinery for the movie industry.

GEORGE STROBEL

PH.D. Physics '65, is working on trying to explain the spin crisis of the nucleon, where the quark contribution found is only a small fraction of the nucleon spin. The three quark model of a spin up nucleon has two spin up quarks and one spin down quark. A Dirac equation approach shows if the lower component of the quark wave functions is about 18% of the normalization, that the axial charge can be reproduced. Spin dependant forces between quarks are a way of reproducing the 0.58 quark contribution to the nucleon spin. The spin up quarks experience 75% S=1 interactions, while the spin down quark sees 50% S=1, and 50% S=0. The Delta nucleon mass difference suggests that spin dependent forces between quarks are present in amounts consistent with that needed to explain the spin data.

1970's

MARK GIAMPAPA

B.S. Astronomy '76, is the Deputy Director of the *National Solar Observatory.* The *National Science Foundation* has committed six million dollars toward a four year Design & Development study by the National Solar Observatory for the Advanced Technology Solar Telescope (ATST). At an envisaged aperture of 4 meters, the ATST in combination with adaptive optics is expected to yield unprecedented observations of the Sun at the highest resolutions that can be attained from the ground in the visible and the infrared. This will enable the study of the magnetic fine structure of the Sun, its origins and evolution, and its important role in the solar cycle.

1980's

PHILIP DE LOURAILLE

B.S. Astronomy '76, is the Principal Information Security Architect at *eBay, Inc.* Lately, he has been working on a special internal project - the goal is to immediately detect the intrinsic network characteristics of any Distributed Denial of Service (DDoS) attack on a TCP/IP network such that the attack may be blocked within a few minutes of its launch with minimal impact to the normal network traffic. The secondary goal of the project is to then traceback to the attack launchers. Previously, he had been working on another special internal project the goal of which was to detect all TCP/IP network intrusions at multi-gigabit per second bandwidth and block a selected set of these intrusions from reaching their intended targets. That project is now fully in place.

BRYAN FRANCES

M.A. Physics '89, discovered while attending USC, that he loved logic and philosophy even more than physics. So he quit physics, studied mathematical logic and philosophy at the University of Minnesota, got his Ph.D. in philosophy there. He is now a lecturer (equivalent of Associate Professor) in the School of Philosophy at the University of Leeds in England. While at the U of Minnesota, he married (taking his new wife's surname - he used to be Bryan Stewart) and had two children.

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Welcome to our 2001 Graduates

Ricardo Betancourt-Benitez
B.A. Physics

Lindsey Bruesch
B.S. Physics

Jiang-Rong Cao
M.A. Physics

Linda M. Carpenter
B.S. Physics

Noel A. Dunn
B.S. Physics

Jeanna Emmons
B.S. Physics

Zhigang Gong
Ph.D. Physics

Vitaly Kasperovich
Ph.D. Physics

Sanggeon Lee
Ph.D. Physics

William I-Te Liou
B.S. Biophysics

Andrey Mikhalchuk
Ph.D. Physics

Zufar Mulyukov
Ph.D. Physics

Ertan Salik
Ph.D. Physics

Ricky Sethi
M.S. Physics for Business

Yalew Tamrat
M.A. Physics

Stefan Wessel
Ph.D. Physics

Guolin Yang
Ph.D. Physics

Success

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My Books

Publishing a valuable book has long been my dream as a scientist and educator. I am especially thankful that I have published two books so far. My first book, entitled *"Optics and Nonlinear Optics of Liquid Crystals"*, coauthored with Prof. **I. C. Khoo** of Penn State University was published by World Scientific in 1993. The second book entitled *"Reflective Liquid Crystal Displays"*, coauthored with Prof. **D. K. Yang** of Kent State University was published by Wiley-SID in 2001. Writing a book is a painful but exciting experience. During the writing process, I needed to not only compile my own materials, but also collect, screen and analyze related materials that other experts published. My second book was published in time for the annual SID conference at San Jose. My book publisher asked me to stand near the booth to autograph for the buyers. That is truly exciting and rewarding!

My Gratitude to My Teachers

I would like to take this opportunity to thank my teachers for equipping me, no matter if they are still with USC or not. You are like a candle burning yourself to lighten your students. Your labor is not in vain. To my fellow graduate students, your future is bright. Let the Trojan spirit pass on to the future generations. ❖

EXCEPTIONAL TEACHING ASSISTANTS RECOGNIZED

We would like to congratulate all of our graduate teaching assistants. Once again, they've done an outstanding job. The work they perform is essential to our department and their skill and dedication is very much appreciated. Two of our teaching assistants were recently honored.

Jeffrey Nuttall was selected as the *Outstanding Teaching Assistant* of the year. Jeff's work has been exemplary and he is most deserving of this honor.

The *Most Improved Teaching Assistant* was awarded to **Kristian Kennaway**. This past year, Kris has made great strides in improving his teaching skills and communication with his students.

Congratulations and thanks to Jeff and Kris for their superior performance. ❖

CLASSNOTES

1990's

JIEN-PING JIANG
Ph.D. Physics '90, currently works in a small laser company doing solid state lasers and optical testing equipment. His new projects include high speed polymer modulator for telecom applications, airborne pathogen detectors and optics fiber sensors.

USC DEPARTMENT OF PHYSICS AND ASTRONOMY

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