CASPER

Astrophysics & Space Science Theory Group
Early Universe Cosmology & Strings Group
Gravity, Cosmology & Astroparticle Physics Group
Hypervelocity Impacts & Dusty Plasmas Lab
Space Science Lab

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INSIDE THIS ISSUE:

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New CASPER Theory Group

The Gravity, Cosmology, and Astroparticle Physics Group (GCAP), the newest of three theoretical groups within CASPER, was founded in the spring of 2006. The group currently consists of 12 members: Dr. Anzhong Wang (Physics), the head of the group; Dr. Qin (Tim) Sheng (Mathematics); Dr. Yumei Wu (Physics); Prof. Zhong-Heng Li, a visiting professor from Zhejing University of Technology; Dr. Yungui Gong, a Baylor postdoctoral research fellow; Dr. Rong-Gen Cai, a CASPER adjunct professor, from the Institute of Theoretical Physics, Chinese Academy of Science; Dr. N. O. Santos, a CASPER adjunct professor, from the Brazilian National Scientific Computation Lab; and five graduate students: Michael Devin, Preet Sharma, Andreas Tziolas, Rui Wu, and Qiang Wu. Research topics include string/brane inflation, current acceleration of the universe, the hierarchy and cosmological constant problems, and higher dimensional black holes, their thermodynamics and formation, gravitational collapse and critical phenomena.

GCAP members have also recently been working on defining observational constraints on the current acceleration of the universe, holographic dark energy models, and the thermodynamics of dark energy.

With recent developments in high technology, observational cosmology is entering a golden age. One of the most remarkable discoveries over the past decade is the realization that our universe is not only expanding, but accelerating. In Einstein's theory of general relativity, to account for such an acceleration, a new component to the matter fields of the universe is required; this is now known as dark energy. Recent astronomical observations indicate that our universe is flat and currently consists of approximately 70% dark energy, 25% dark matter, and 5% baryonic matter and radiation. One fundamental question that remains is the nature of dark energy. One method for studying this employs two orbifold 3-branes, models inspired by string/M-theory. The GCAP group has recently developed a mathematical formalism in the context of an accelerating universe and assuming the cyclic universe scenario. This approach also allows investigation of the hierarchy and cosmological constant problems subjects that are also of great interest.

Theories of gravity, including general relativity, also predict the existence of black holes and gravitational waves. Black holes, their thermodynamics and formation mechanisms from gravitational collapse have been a primary research topic over several decades. Recently, these studies have attracted further attention due to new gravitational wave detectors, such as LIGO (USA, 2002), GE600 (Germany & England, 2002), Virgo (Italy & France, 2002), and TAM300 (Japan,

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SOFIA at CASPER

As part of Baylor's recent acceptance into the Universities Space Research Association, the German Aerospace Center SOFIA secondary mirror team employed the CASPER HIDPL as its mirror inspection lab on October 25, 2006. The mirror had been in storage for over three years causing concern from the team as to its status. Inspection showed it to be in pristine shape and ready for final installation.

Under an agreement with NASA, DLR (the German Aerospace Center) supplied the telescope for the SOFIA observatory, as well as operation support, in exchange for observation time aboard the SOFIA.

The SOFIA telescope consists of a parabolic 2.7m primary mirror and a hyperbolic secondary mirror in a bent Cassegrain configuration with two Nasmyth foci, the nominal IR focus and an additional visible light focus for guiding. The secondary mirror is attached to a chopping mechanism providing chop amplitudes of up to ± 5 arcmin at chop frequencies between 0 and 20 Hz, programmable by either a user supplied analogue or TTL curve or by the telescope control electronics. A flat tertiary mirror reflects the IR beam into the infrared Nasmyth focus, 300mm behind the instrument flange. If the fully reflecting tertiary is replaced with a dichroic mirror, the transmitted optical light is reflected by a second tertiary 289.2mm behind the dichroic and sent to the visible Nasmyth focus. There it is fed into the Focal Plane Imager (FPI), an optical focal plane guiding camera system. Independent of the FPI there are two other imaging and guiding cameras available: the Wide Field Imager (WFI) and the Fine Field Imager (FFI). Both of these cameras are attached to the front ring of the telescope.

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SOFIA scientists and technicians examine the secondary mirror.

GCAP, SOFIA

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The secondary mirror is designed to minimize background noise during IR observations. As a result, both mirror stiffness and mass have been tightly controlled in order to allow for high frequency chopping rates. These requirements led the team to select Silcon Carbide for the mirror blank. Measured performance on the final mirror shows a mass of 1.97 kg, high stiffness with a first order resonant frequency of 1865 Hz and a measured optical surface accuracy of 39 nm rms, using Ion Beam Figuring.

SOFIA secondary mirror team at the HIDPL

Once operational, SOFIA will be the largest airborne observatory in the world, making observations impossible for even the largest and highest of ground-based telescopes. The SOFIA observatory is rapidly approaching flight test phase and has been designed to become the world's primary infrared observatory with a mission profile scheduled to last 20 years. In addition, SOFIA will provide an outstanding laboratory for developing and testing instrumentation and detector technology as well as a national education & public outreach facility for educators across the U.S. and Germany. The observatory is being developed and operated for NASA by a team of industry experts led by the Universities Space Research Association, which recently accepted Baylor as a member on first application due to research and education programs within CASPER.

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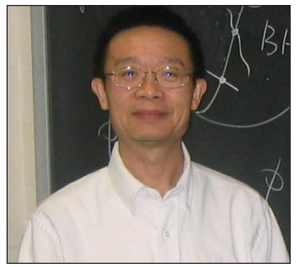
2001). The detection of gravitational waves and black holes requires a detailed understanding of the forms of gravitational waves, the sources that emit such waves, and the dynamical process of black hole formation. Due to the mathematical complexity of this problem, understanding of such phenomena is still limited and very advanced mathematical tools are needed.

GCAP Members

Dr. Anzhong Wang	Dr. Qin Sheng	Dr. Yumei Wu
Dr. Yungui Gong	Dr. Rong-Gen Cai	Prof. W. Huang
Dr. N. O. Santos	Prof. S.A. Chin	Prof. Zhong-Heng Li
Prof. C.Y. Chan	Michael Devin	Preet Sharma
Andreas Tziolas	Rui Wu	Qiang Wu
James Rogers	Preet Sharma	Lei Zhao
Brian Jain	Ryan Rios	Amy Webber

Personnel Updates
New CASPER Faculty and Staff



Dr. Qin (Tim) Sheng joins CASPER from Dayton, Ohio, where he taught at the University of Dayton before coming to Baylor as a Professor of Mathematics. He earned his PhD from the Department of Applied Mathematics and Theoretical Physics, University of Cambridge, England in 1990. His main research interests lie in solving singular partial differential equations via adaptive and/or splitting finite difference methods. Dr. Sheng is particularly interested in problems with important physical and/or practical applications, such as numerical black hole and relativity computations, electro-optics simulations, highly-oscillated integrations, and nonlinear differential equation problems used in quenching-combustion, solitary wave, singularly perturbation, fluid dynamics and finance processes. Dr. Sheng has published more than 60 peer-reviewed research articles, including book chapters.

Jorge A. Carmona Reyes was born in Veracruz, Ver, Mexico. He obtained his BS in physics from Southern Nazarene University in Oklahoma City, and his MS in physics from Baylor University, working for Dr. Truell Hyde. His research interests lie in hypervelocity impacts and complex plasma physics. He is now employed full time at the HIDPL. Jorge is also in charge of an ESL program at First Church of the Nazarene, where he and his wife lead a Spanish Bible study.

Richard Campbell joined the Mechanical Engineering Department of Baylor University in 2006 after 36 years of military aircraft operations, aircraft systems design and manufacturing experience in the defense industry. His previous research and design activities related to improving aircraft systems and protecting military aircraft from hostile threats. Originally from Dallas, Mr. Campbell was educated at the U. S. Naval Academy and completed his graduate work in Aeronautical Engineering at the Naval Postgraduate School in Monterey, California. In addition to teaching undergraduate engineering he also represents the Paul Meyer Observatory of Central Texas Astronomical Society (CTAS). He conducts experimental research on pulsating white dwarf stars and other photometric experiments, and conducts outreach for science education to local schools.

Dr. Lorin Matthews, tenure track bound

Dr. Lorin S. Matthews received her B.S and Ph.D. degrees in physics from Baylor University, Waco, Texas, in 1994 and 1998, respectively. After graduation, Dr. Matthews worked at Raytheon Aircraft Integration Systems where she was the Lead Vibroacoustics Engineer on NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) project. For the past several years, she has been working with CASPER as a Senior Research Scientist and lecturer in physics. As of fall 2006, she is an Assistant Professor within the physics department and a member of CASPER where her research interests include theoretical complex plasmas, ring system physics and protoplanetary coagulation.

Personnel Updates
Recent Graduates

Ben Dundee defended his master thesis, “Grand Unified Theories in Higher Dimensions: From the Heterotic String to Randall-Sundrum,” in August and graduated in December 2006. Congratulations!

Lei Zhao defended his master thesis, “Gravitational Collapse and Black Hole Formation in the Backgroud of Dark Energy,” in September and graduated in December 2006. Congratulations!

New Adjunct Faculty in CASPER

Dr. Rong-Gen Cai is one of the leading scientists in gravitation and cosmology in China, and has published more than 90 research articles in international refereed journals. His work examines the physics of black holes in four and higher dimensional space times and his papers on the current acceleration of the universe have been highly cited. Recently, Dr. Cai has been working on the holography of gravity, the relationship between Einstein’s equation and thermodynamics, inflation models in the early universe and the nature of dark energy.

Dr. N.O. Santos has been working on gravitational collapse and the formation of black holes for many years, and has published over 100 research articles. Currently, he is attempting to use strong gravitational fields to explain the production of jets ejected from active galactic nuclei and micro quasars. Dr. Santos is also interested in obtaining exact solutions of Einstein’s fields’ equations particularly ones that can produce gravitational waves. His seminal work on the junction conditions of a collapsing object remains the cornerstone of recent studies in gravitational collapse. Dr. Santos will be in residency in CASPER from April 15 to May 15, 2007.

Dr. Phillip Anz-Meador is an assoicate professor of physics at Embry-Riddle University. His areas of interest include orbital debris/micrometeoroid science, computer modeling, and remote sensing. Orbital debris and micrometeoroid-related activities include computer modeling of the debris environment, ground-based optical observations of the environment, and space surveillance/debris observation experiments. He has published more than 80 research articles.

SOFIA Director Featured Speaker at CASPER

Dr. Eric Becklin was recently the featured speaker at a joint CASPER / Physics colloquium. Dr. Becklin is the designated director for the SOFIA airborne observatory (scheduled to see first light in 2009), and has been the Chief Scientist for SOFIA since 1996. SOFIA (Stratospheric Observatory for Infrared Astronomy) will utilize a 2.5-meter infrared telescope installed in a Boeing 747-SP as an airborne observatory to study the universe in the infrared spectrum. Additionally, SOFIA will be a major factor in the development of observational techniques, new instrumentation and the education of young scientists and teachers in the discipline of infrared astronomy.

SOFIA at L3 hangar in Waco, Texas

NASA and the DLR, German Aerospace Center, worked together to create SOFIA, which will be the largest airborne observatory in the world, providing the capability to make observations impossible for even the largest and highest of ground-based telescopes. The observatory is being developed and operated for NASA by a team of industry experts led by the Universities Space Research Association and built at L3 systems in Waco immediately across the runway from the CASPER HIDPL.

Dr. Becklin, a PhD graduate of the California Institute of Technology, has more than 40 years of experience in the field of infrared astronomical observations and instrumentation. He has studied a variety of astronomical objects, primarily at infrared wavelengths, resulting in over 300 scientific papers of which he is either the author or co-author. Most recently he has worked extensively on observational problems related to dust debris clouds, the formation of solar systems and the search for low mass stars, brown dwarfs and extrasolar planets. He is also working on infrared observations of the massive black hole at the center of the galaxy. In addition to being the first director of the NASA Infrared Telescope Facility (IRTF) in Hawaii, he was also the principal investigator (PI) for two successful experiments which used the Kuiper Airborne Observatory during a total solar eclipse to measure the extent of the sun’s far infrared and submillimeter wave-lengths. Dr. Becklin also played a pivotal role in the development of infrared instrumentation for both the Hubble Space Telescope (NICMOS) and the Keck Observatory (NIRSPEC).

Photography courtesy of NASA/USRA

The Universities Space Research Association is a private, non-profit organization established by the National Academy of Sciences. This independent consortium, established in 1969, is comprised of 100 U.S. universities offering graduate programs in space sciences or aerospace engineering. USRA member institutions act together as a council providing research and program guidance to NASA, with NASA grants and contracts funding most USRA activities.

Additional information about the USRA can be found at www.usra.edu. Additional information concerning SOFIA can be found at www.sofia.usra.edu.

Selected Colloquium Speakers

Eric Becklin - SOFIA: Stratospheric Observatory for Infrared Astronomy

Abstract: The SOFIA project to develop and operate a 2.5-meter infrared telescope in a Boeing 747-SP is in the final stages of development. First science flights will begin in 2009, with the observatory designed to operate for over 20 years. Status of the development and technical issues were discussed along with the expected sensitivity, and first light science instruments. Also discussed were examples of the science to be carried out and opportunities for the science community to use SOFIA. On the science side, Dr. Becklin discussed recent high angular resolution results on the Galactic Center with Keck laser adaptive optics.

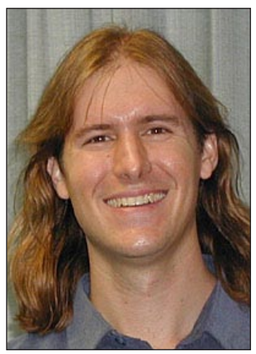
Eric E. Becklin, a PhD graduate of the California Institute of Technology, has more than 40 years of experience in the field of infrared astronomical observations and instrumentation. In addition to being the first Director of the NASA Infrared Telescope Facility (IRTF) in Hawaii, he was also the principal investigator (PI) for two successful experiments which used the Kuiper Airborne Observatory during a total solar eclipse to measure the extent of the sun's far infrared and submillimeter wave-lengths. He is currently the designated director for the SOFIA airborne observatory (scheduled to see first light in 2009), and has been the Chief Scientist for SOFIA since 1996.

Russell Hulse - An Astronomical Detective Story: The Discovery of the Binary Pulsar

Abstract: Among the many things we hope for in our lives is to have some opportunity for adventure, and to experience personal discoveries which lead us to a deeper knowledge of the fascinating world around us. For Dr. Hulse, this meant an interest in science from an early age, an interest which eventually led to the opportunity to make a rather special discovery and receive a Nobel Prize. But his recollection of the discovery which led to the prize is still most deeply that of a very personal adventure, one fraught with anxiety and frustration as well as triumph and understanding. This is the story of that adventure and the discovery which resulted from it.

Dr. Russell A. Hulse of Princeton University, the discoverer of the first binary pulsar and co-recipient of the 1993 Nobel Prize in Physics, is a principal research physicist at the U.S. Department of Energy's Princeton Plasma Physics Laboratory. Hulse won the Nobel Prize for the discovery of the first binary pulsar – a twin star system that provides a rare natural laboratory in which to test Albert Einstein's prediction that moving objects emit gravitational waves, as well as other aspects of his general theory of relativity. In 1977, Hulse changed fields from astrophysics to plasma physics and joined the Plasma Physics Laboratory at Princeton, where he has worked since.

Mark Lewis - Effects of Moons and Moonlets in Planetary Rings: Numerical Exploration of Cassini Discoveries in the A Ring



Abstract: Quickly approaching the end of its second year in orbit, the Cassini probe has already revolutionized our knowledge of the Saturnian system with stunning images and other measurements. This talk examined Cassini results related to small moons embedded in the rings, and compared them to large scale numerical simulations to help us understand their dynamics. The talk began with a quick look at the best understood embedded moon, Pan, and the gap it creates, the Encke gap. Moving down in size we next explored the Keeler gap and the features produced near its moon, Daphnis. We concluded with a look at some of the most recently released features of the rings, propeller shaped structures formed by embedded moons so small it's hard to say if they qualify as moons at all.

Mark Lewis graduated from Trinity University in 1996 with Honors in physics and computer science and then went immediately to the University of Colorado at Boulder to work on a Ph.D. in astrophysics. Along the way, he picked up Masters degrees in astrophysics and computer science. Dr. Lewis did his dissertation work with Glen Stewart at CU on gravitational wakes in rings and is now an assistant professor in the Department of Computer Science at Trinity.

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May 21, 1947 - August 11, 2006

instrumental in the overall design of CASPER's Physics Circus, a unique science outreach tool impacting literally thousands of middle and high school students. Jerry's was always willing to take what he had learned as his own plan unfolded and invest that into a bunch of squirming kids. He opened their eyes to all that a career in science could make available to them. The shouts of kids seeing a laser light show for the first time, their laughter at making their hair stand up at a Van de Graaf accelerator, and their screams of terror as the Tesla coil threw lightning (OK, so maybe that one *did* get a little out of hand…) are absolutely unforgettable.

Three. *The plan for one life never exists alone; it always enriches the plans of others.* Jerry's plan intersected my own in a life-changing way. Together we founded CASPER's experimental facility at TSTC, and my own research has never been the same. My life is richer for all that he brought to that partnership. One of the first things I did when we started down this path was listen to Jerry when he said that I needed to hire two of his students—Mike Cook and Jimmy Schmoke. He kept after me, telling me that they were two of the best he had seen in his time of teaching and that they were exactly what we needed at the lab to make things work. As usual, he was right and both Mike and Jimmy have, like Jerry, become far more to me than mere colleagues.

Once we got the lab up and running, I started taking everyone I had money for with me to research conferences. I must admit that traveling to a conference with Jerry—sometimes he would bring along John Simcik, which is another story entirely!—was both entertaining and an educational experience to say the least. During one trip to Sandia, I actually learned that you *can* use state funds to rent a convertible, but again—that's a different story. Any time there was a plasma conference anywhere in New Mexico, we had to eat at Sadie's and bring back green chilies. Along the way, Jerry made sure we visited Z-pinch so that he could brag on what his students were doing. And then there were always the bull sessions outside the hotel late into the night where we solved all the world's problems or worked on some experimental snag in the lab. *Working* on physics after you've been *listening* to physics all day at a conference might sound crazy but Jerry *loved* this stuff. My own life has changed in ways I cannot begin to describe because Jerry made the experience he'd gained from living out his own plan available as a resource for mine.

Four. *Some parts of the plan are more important than others.* In the past year, Jerry continued his work at TSTC and in the CASPER lab despite a grueling schedule of tests aimed at clearing him for a lung transplant. He spent increasing amounts of time in prayer and studying the Bible (I know for a fact that he read through the entire book multiple times, referring to the New Testament as "the good part") and I am as confident of this as I am of anything: Jerry Reay fully understood the importance of the Plan and was prepared for this day.

I can't bring this to a close without remarking on Jerry's unique ability to be grumpy and gruff (or at least that's what I'll call it here!), sometimes pretty dramatically. He was a perfectionist—demanding the best from his students and committing to the best from himself. Whether it was turning up at the lab in the middle of the night to fix a problem as soon as the solution occurred to him or reassembling the entire reference cell because he didn't think it was completely symmetric, Jerry was a perfectionist.

No matter the situation, Jerry had his own unique way for letting everyone know exactly how careful and accurate the work should be. It's amazing how many times a turbo pump (with ceramic bearings no less) can be 'ruined' by being accidentally turned on its side. More than one student was sent to me by Jerry to confess that they had just cost me a LOT of money because they didn't follow proper procedure in the lab.

This demand for excellence often translated itself into sheer terror for TSTC students as well as several of Baylor's graduate and postdoctoral fellows. In the classroom, students quickly learned they had better be ready to write when he hit the door and even more importantly that they had better learn to keep their mouths shut if they were blowing smoke. In the lab things moved to a new level, since Jerry *loved* to work one on one with students. His teaching would always include a story (for *any* situation….trust me!) about some related incident that occurred when he was at one of the national labs. One of my favorites was the story where Jerry waltzed into the cap bank shield chamber after a failed shot only to discover everything was still fully charged. He realized this when both his hair and beard stood straight out from his head (his hair was evidently much longer at the time!) at which point he carefully backed out of the room. The backing out of the room was the best part since Jerry always acted out his stories! I've used this incident when teaching E&M as an example and I'm sure I will continue to do so. My guess is that were we to go around this room, *everyone* would have a Jerry story to tell. I also feel certain we'll be telling them for a long time after today.

I will admit that Jerry softened a bit on OSHA issues toward the end. I suppose that rigging a bracket to hold your oxygen bottle so that you can continue to ride your motorcycle to work and then having to explain all of this to a cop does that to you.

And while no one could gripe quite as dramatically as Jerry, very few were better at bragging. He would do anything for his students (he bragged constantly on where they were and what they were accomplishing) and his colleagues. I can't think of Jerry without thinking of Jeremy and Julie, since he talked about them every time I saw him. He was as proud a father as I've ever known!

Jerry Reay will be profoundly missed. He was a TSTC faculty member whose contribution to the college's reputation cannot be overstated. He was a man whose life was spent on others—family, friends, colleagues and students. I am proud to have been his friend.

In Memoriam
Mr. Jerry Reay

Material taken from Dr. Truell Hyde's eulogy at Jerry Reay's funeral

Jerry Reay was born May 21, 1947, in Mount Vernon, Washington, and died Friday, August 11, in Waco, Texas. He is survived by his children, Julie Reay of Mart, Texas, and Jeremy Humphries of McKinney, Texas, as well as his grandson, Holden Humphreys of Denton, Texas. Jerry also leaves behind his sisters—Judy Lowry of Lorena, Texas; JoAnne Clark of Highland Village, Texas, and Jill Fowler of Fort Worth, Texas. He is also survived by his brother, Jim Reay, of Bullard, Texas.

These are the facts but they do not begin to adequately embody Jerry Reay. Jerry was what is most often called a "free spirit" where the definition of this term is nebulous at best. As a result, to try and describe him even adequately is probably impossible, so I trust you'll be satisfied with a few personal observations on my part. I *can* guarantee you that Jerry is looking down on us right now and grinning at finding this affair being conducted by a physicist. To find 'cones' (as he so fondly called such folk…..at least I *think* it was fondly) speaking for him I'm sure is worth at least a grin.

So what can I say about Jerry?

Jerry was a believer. If you were around him much over the past few years, you know that he believed in *the Plan* (that's with a capital P). He trusted the Plan regardless of his circumstance. As his illness progressed, his response to any question concerning his health was almost always a smile and a comment along the line: "it's all in the plan—whatever His plan is, that's fine with me" or "it's all in the plan—we don't have to *see* the plan to know it's there." One reason his death caught so many of us off balance is that he became increasingly more at peace as his illness progressed. As such, although we are grieving a terrible loss, (and it is a *hard* loss to stomach!) we need to remember that today should also be a celebration—a celebration of Jerry's home-going and of the Plan that will continue to reap a harvest long after we leave this memorial service behind.

Jerry was competent. In a world increasingly occupied by people who pretend to be what they wish they were (you know the type, all hat … no cattle), Jerry Reay was the genuine article. When he told you he could do something, you could take it to the bank. His life's plan led him from naval service in Viet Nam to the laser electro-optics program at TSTC, after which he went on to work as a lead technician at national labs such as Los Alamos and Lawrence Livermore. These are two of the best research environments in the United States, which means they *are* the best in the world. Eventually, Jerry came back—thankfully for us—to TSTC, where he taught in the laser and semiconductor manufacturing programs for 19 years. Most recently, the Plan led him to me and my research within Baylor's Center for Astrophysics, Space Physics, & Engineering Research.

Jerry was my friend. Outside of my family I can count my true friends on one hand, so this part of the Plan on Jerry's life meant more to me than I can ever say.

So what can I say about this *Plan* that gave Jerry such comfort over the past year?

Jerry's students constantly tell tales of his lectures, so in that spirit…….

One. *The Plan always affects more than one man.*

Clearly, serving his country—first in the United States Navy, and later in the national labs—was a defining part of Jerry's character. Equally clearly, these years of experience prepared him for an outstanding career as a teacher. He was ***really*** a good teacher and I do not say this lightly. This statement is easy to prove by simply looking at the product he produced. Jerry's students hold positions in prominent labs all over the world. Obviously, the plan for Jerry's life had impact far beyond any one man. Consider where phones were ringing as news of his death spread: after his immediate family, the news spread rapidly, reaching an elite core of technicians and national research program directors currently at work in the nation's research labs; junior high and high school teachers who were mentored in CASPER's summer outreach programs; undergraduate and graduate students at TSTC, Baylor, and a host of other colleges across the country.

Two. *The Plan's impact will continue for years to come.* Jerry was part of the founding team for CASPER's HIDPL, a true experimental research *teaching* lab with a strong educational outreach component. The idea of a research lab where students actually collect the data and maintain the equipment is almost unheard of in the academy and yet Jerry pulled it off with alacrity. He was also

ZYVEX, CASPER Researchers Study High Velocity Impacts on Carbon Nano-Tube Tiles

One of the newest materials being tested as a possibility for shielding man-made structures in space and on earth is constructed from carbon nano-tubes.

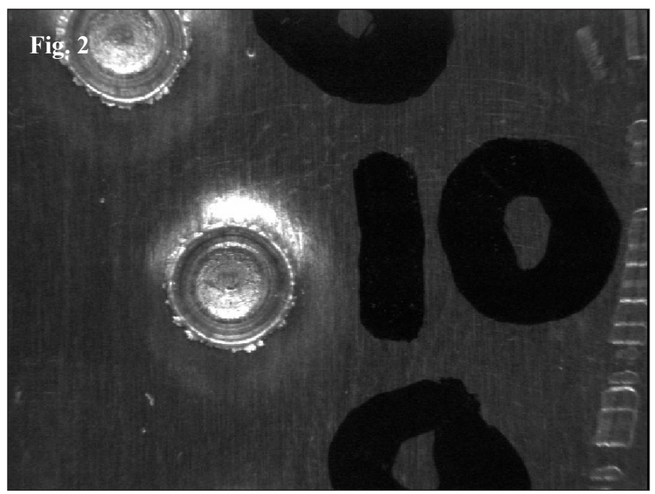
Recently, a Dallas-based company, Zyvex, contracted CASPER to test the advanced shielding capability of their fabricated carbon nano-tube material. Researchers at the HIDPL employed the one-stage Light Gas Gun (LGG) to test the shielding capabilities of tiles composed of four different laminated nano-tube combinations. For calibration purposes, a 3003-aluminum plate was also impacted for comparison with impact craters created on the various tiles.

Target tiles were clamped uniformly at each corner with a second impact plate placed 10 centimeters behind the primary. Laser fan detectors and PZT sensors were employed to measure impactor velocities both before and after impact.

The frame holding the target tile was also instrumented via an installed PZT. At the time of impact, the signal from the second laser fan can then be compared to that from the PZT, supplying a second coincident measurement for the speed of the projectile. The frame holding the target tile also secured the second witness plate mentioned above. A second PZT located on the frame was also used to detect the impactor penetration tile (if any) as well as measure the speed of the particle after penetration.

Figures 1 and 2 illustrate the mechanical response for a representative target tile (Fig. 1) and a 3003-aluminum plate (Fig. 2) for impacts taken under identical conditions. As can be seen, the nano-tube targets appear to resist impacts in a different manner than targets composed of standard materials. While additional data is still needed, it appears that these new materials may well provide new opportunities for advanced protective shielding.

Complete details can be found in *Low-Velocity Impacts on Targets Containing Embedded Carbon Nano-Tubes*, J.A. Carmona, M. Cook, J. Schmoke, J. Reay and Truell Hyde, Lunar and Planetary Science XXXVII, Lunar and Planetary Institute, Houston (CD-ROM), 2006.



Research Updates
Recent Publications

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Gravitational Collapse of a Massless Scalar Field and a Perfect Fluid with Self-Similarity in (2+1) Dimensions, F.I. Pereira, R. Chan and A. Wang, Inter. J. Mod. Phys. D15, pp. 131-152 (2006).

Improved Optimization of Soft Partition Weighted Sum Filters and Their Application to Image Restoration, Y. Lin, R. C. Hardie, Q. Sheng and M. Shao, Applied Optics, Vol. 45, pp. 2697-2706, 2006.

Kink Stability of Isothermal Spherical Self-Similar Flow Revisited, A. Wang and Y. Wu, Gen. Relativ. Grav., Vol. 38, pp. 623-1643, 2006.

Kuiper Binary Object Formation, R. Nazzario, K. Orr, C. Covington and T. Hyde, Accepted for publication in Advances in Space Research, 2007.

Low-Velocity Impacts on Targets Containing Embedded Carbon Nano-Tubes, J.A. Carmona, M. Cook, J. Schmoke, J. Reay and Truell Hyde, Lunar and Planetary Science XXXVII, Lunar and Planetary Institute, Houston (CD-ROM), 2006.

Notes on the Diamond-α Dynamic Derivative on Time Scales, J. W. Rogers, Jr. and Q. Sheng, J. Math. Anal. Appl., Vol. 326, pp. 228-241, 2007.

Numerical Study of Structural Phase Transitions in a Vertically Confined Plasma Crystal, Ke Qiao and Truell Hyde, Advances in Space Research, Vol. 38, No. 11, pp. 2571-2574, 2006.

Observable/Hidden Broken Symmetry for Symmetric Boundary Conditions, B. Dundee, J. Perkins, and G. Cleaver, Int. Jour. Mod. Phys. A21, pp. 3367-3386, 2006.

Observational Constraints on the Acceleration of the Universe, Y.G. Gong and A. Wang, Phys. Rev. D73, 083506, 2006.

On Curvature Coupling and Quintessence Fine-Tuning, Y.G. Gong, A. Wang, and Y.Z. Zhang, Europhys. Lett. Vol. 74, pp. 930-936, 2006.

Relationship Between the DC Bias and the Debye Length in a Complex Plasma, Jie Kong, Jorge C. Reyes, James Creel and Truell W. Hyde, Accepted for publication in IEEE Transactions on Plasma Science, 2007.

Self-Similar Collapse of Perfect Fluid with Plane Symmetry, G. Benesh and A. Wang, Gen. Relativ. Grav. Vol. 38, pp. 345-364, 2006.

Shoch Structure in Viscoelasticity of Relaxation Type, Yumei Wu and I-shih Liu, Nonlinear Analysis, Vol. 65, pp.785-794, 2006.

Structural Phase Transitions of Three-Dimensional Shielded Coulomb Clusters (Finite Yukawa System) Ke Qiao, Matthew Benesh and Truell W. Hyde, Accepted for publication in IEEE Transactions on Plasma Science, 2007.

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Boundary Data Smoothness for Solutions of Nonlocal Boundary Value Problems for Second Order Ordinary Differential Equations, J. Ehrke, J. Henderson, C. Kunkel and Q. Sheng, Submitted for publication in J. Math. Anal. Appl, 2007.

Homothetic Self-Similar Solutions of Three-Dimensional Brans-Dicke Gravity, G. Benesh and A. Wang, Submitted for publication in Gen. Relativ. Grav., 2006.

Hybrid Approximations Via Second Order Combined Dynamic Derivatives on Time Scales, Q. Sheng, Submitted for publication in J. Functional Anal. Approx. Theory, 2007.

Hybrid Approximations Via Second Order Crossed Dynamic Derivatives with the ◊-Derivative, Q. Sheng, Submitted for publication in Nonlinear Anal., Series B, 2007.

Notes on the Diamond-Alpha Dynamic Derivative on Time Scales, J. W. Rogers, Jr. and Q. Sheng, Submitted for publication in J. Math. Anal. Appl, 2007.

See Publications, pg. 8

Spiral Science Curriculum

Edith Davis, CASPER doctoral student in the School of Education, department of Curriculum and Instruction, recently completed a three month intervention study at Parkdale Elementary that investigated the effectiveness of teaching an experimental Spiral Science Curriculum (SSC) to 5th grade students.

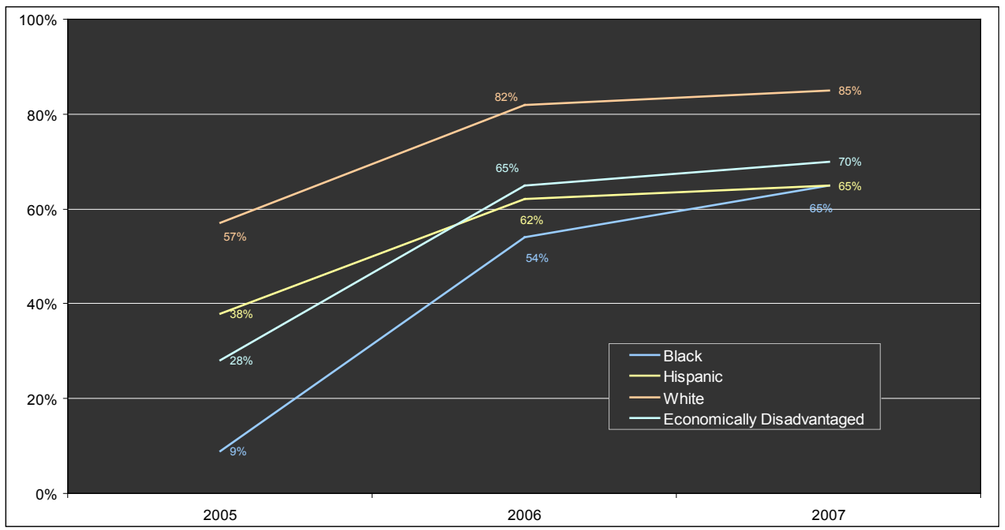
The basic concept of a spiral curriculum is one in which there is an iterative revisiting of topics or themes throughout the course. A spiral curriculum is not simply a repetition of a topic taught; it requires a deeper understanding of the course material, with each encounter of course matter building on the previous topic. This provides for increased competence of students.

The study involved teaching linear and spiral science curriculum to 5th grade students. In addition to the linear and spiral science classroom instruction, the study included surveys of school administrators, teachers, and parents to gather information about the current science curriculum, school demographic information, students' academic and behavioral attributes, and the students' academic progress.

The results from the intervention showed a statistically significant increase in TAKS achievement for those students being taught using the spiral science curriculum.

TAKS passing rates

	2005	2006
BLACKS	9%	54%
HISPANICS	38%	62%
WHITES	57%	82%



The 2007 percentages are goal percentages set by Parkdale Elementary. Edith's work is reflected in the 2005-2006 statistics

CASPER Outreach

Baylor, CASPER Awarded $11.8 Million Grant for GEAR UP Waco

Material taken in part from a story by Lori Fogleman, director of media relations, Baylor University

The U.S. Department of Education announced in July 2006 that Baylor University was awarded an $11.3 million, six-year grant to fund GEAR UP Waco (Gaining Early Awareness and Readiness for Undergraduate Programs), an established partnership between Baylor, Texas State Technical College-Waco, Making Connections with Youth Count Inc., City of Waco Academy for Educational Development, and the Waco Independent School District that prepares at-risk students academically and socially for college.

Baylor was the only university in Texas to receive GEAR UP funding. Its $11.3 million grant, or $1.89 million per year, was the second largest award in the state, behind only the funding received by the Texas Education Agency. The Baylor grant also was the second largest award given nationally to a U.S. university, just behind Washington State University which received $1.9 million per year in GEAR UP funding.

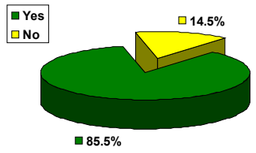
"The GEAR UP Waco partnership has made considerable strides over the past seven years to become a community catalyst for educational change and a leader in college access and awareness both locally and nationally," said Dr. Truell Hyde, vice provost for research at Baylor and the principal investigator for the GEAR UP Waco grant. "When we applied this year, we took the project components that worked well and proposed that we move them toward self-sufficiency. We also greatly strengthened STEM Education - Science, Technology, Engineering and Math."

Since 1999, the GEAR UP Waco grant partnership has supported the CASPER Physics Circus. The Physics Circus is one of less than a handful of mechanisms proven to impact the growing need for science, math, engineering and technical students. The project employs state of the art education research, bringing students into a learning environment strongly coupled with a research setting. According to surveys of participating students within the WISD after the event, 87.7% plan to take physics in high school and 21.3% plan to major in science in college. The Physics Circus also provides secondary students with the opportunity to encounter the hard sciences as well as interact with NASA researchers and resources. The goals of the Physics Circus are to introduce students to a STEM career path and to bring students into a research environment that provides an outlet for immediate application of knowledge.

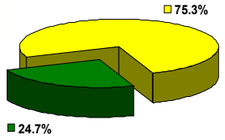
The Physics Circus consists of three parts: (1) a fully developed theatre production on a custom-designed stage, including a laser light show, integrated acting, and multimedia; (2) hands-on research; and (3) a contest requiring the application of various scientific and technical principles. These three primary Physics Circus activities are designed to provide increasing complexity during each successive year of the project.

In addition, the Physics Circus provides curriculum modules developed through projects funded by the NSF and Department of Education. New curriculum modules and discovery kits will build on existing modules to provide students with a solid understanding of the emerging field of nanotechnology and be built around currently funded CASPER research grants, providing leveraged impact. All modules will be designed to enhance Career & Technology Education (CATE) as well as traditional science classes with additional modules planned for easy integration. Finally, all curriculum modules will be integrated into a single, spiral-based curriculum package and tested across various age groups and demographics.

The following graphs are based on the original cohort students in GEAR UP Waco.



(left) 85.5% of students say they plan on attending college. The national average is under 50%. (right) Of the students who said they plan on attending college, 24.7% say they also plan on attending graduate school.



Research Updates
Recent Presentations

"Accelerating Universe from M-theory," A. Wang, presented at the String Conference 2006, Satellite Workshop: Gravitation and Cosmology. Shanghai, China, June 12-14, 2006.

"*Accelerating Universe in Randall-Sundrum Models of Two 3 branes,"* A. Wang, presented at the International Conference on Physics Education and Frontier Research, Taipei, China, June 27-30, 2006.

"A Note on exponential splitting in adaptive and hybrid computations," Q. Sheng, presented at the Castellón Conference on Geometric Integration, Sept. 18-22, 2006.

"Before the Big Bang: String Theory, God, and the Origin of the Universe," Gerald Cleaver, presented at Christ College Symposium, Valparaiso University, Valparaiso, Indiana Jan. 19, 2006.

"Before the Big Bang: String Theory, God, & the Origin of the Universe," Gerald Cleaver, presented at the Metanexus, June 5, 2006.

"Black Holes, Hawking's Information Loss and Resolution: A Layman's Introduction," A. Wang, presented at CASPER Seminar, Baylor University, Feb. 10, 2006.

"Black Holes, Hawking's Information Loss and Resolution," A. Wang, presented at the Physics Department, Zhanjiang Normal University, Zhanjiang, China, July 6, 2006.

"*CASPER, Dusty (Colloidal) Plasmas and Undergraduate Research*," Truell Hyde, invited speaker at the University of Texas at Dallas (2006).

"Charged Grains and the Dynamics of Saturn's F Ring," L. Matthews and Truell Hyde, presented at the American Physical Society Meeting, Dallas, Texas (2006).

"*Construction of a PZT Sensor Network for Detecting Impacts*," J.A. Carmona, M. Cook, J. Schmoke, J. Reay, L. Matthews, T.W. Hyde, presented at the Lunar and Planetary Science Conference, Houston Texas, March 2006.

"Cosmic Dust Bunnies and Laboratory Dust Crystals: An introduction to complex plasma research," Lorin Matthews, presented at the Physics and Astronomy Department Seminar, Trinity University, San Antonio, Texas, March 7, 2006.

"Cosmic Dust Bunnies and Laboratory Dust Crystals: A layman's introduction to complex plasma research," Lorin Matthews, presented at CASPER Seminar, Friday, March 3, 2006.

"Current Acceleration of the Universe, the Cosmological Constant, and Cyclic Universe Scenario," A. Wang, presented at CASPER Seminar, Baylor University, Sept. 8, 2006.

"Direct Mapping of the Potential Well in a GEC Reference Cell Using a S-100 Nano-Manipulator," J.A. Carmona, M. Cook, J.Schmoke, J. Reay and T.W. Hyde, presented at the Eleventh Workshop on the Physics of Dusty Plasmas, Williamsburg, Virginia (2006).

"Dust Crystal Structure Transitions Caused by an Externally Applied DC Bias," J. Kong, T.W. Hyde, K. Qiao, L. Matthews, J. Reyes, J. Schmoke and M. Cook, presented at the Eleventh Workshop on the Physics of Dusty Plasmas, Williamsburg, Virginia (2006).

"Dynamics of Charged Grains in Saturn's F Ring," Lorin Matthews, presented at the April meeting of the American Physics Society, Dallas, Texas April 22, 2006.

"Exponential splitting on time scales and applications," Q. Sheng, presented at the 6th International Conference on Computational and Mathematical Methods in Science and Engineering (International Congress of Mathematicians 2006 Satellite Conference), Madrid, Spain, Sept. 21-23, 2006.

"External DC Biases in Complex Plasmas," T.W. Hyde, K.Qiao, J. Kong, L. Matthews, J. Reay, M. Cook and J. Schmoke, presented at the 48th Annual Meeting of the Division of Plasma Physics (American Physical Society), Philadelphia, PA (2006).

"Formation of Cosmic Dust Bunnies," L. Matthews, R. Hayes, M. Freed and T.W. Hyde, presented at the Eleventh Workshop on the Physics of Dusty Plasmas, Williamsburg, Virginia, June 29, 2006.

"*From an exponential function to parallel/splitting computations,"* Q. Sheng, presented at the Mathematics Colloquium, Austin Community College, Nov. 17, 2006.

"From the Sheng-Suzuki Theorem to Beyond," Q. Sheng, presented at the CASPER Seminar, Baylor University, Feb. 17, 2006.

"Further Investigations into the Formation Mechanism for Kuiper Belt Binaries," Ray Nazzario and Truell Hyde, presented at the April American Physical Society Meeting, Dallas, Texas (2006).

"General Scaling Solution," Y.-G. Gong, presented at the String Conference 2006, Satellite Workshop: Gravitation and Cosmology. Shanghai, China, June 12-14, 2006.

"*Instabilities within Complex Plasmas*," B. Smith, J. Kong, L. Matthews, T.W. Hyde, presented at the IEEE International Conference on Plamsa Science, Monterey, California (2006).

"Low-Velocity Impacts on Targets Containing Embedded Carbon Nano-Tubes," J.A. Carmona, M. Cook, J. Schmoke, J. Reay and T. Hyde, presented at the Thirty Seventh Lunar and Planetary Science Conference, Lunar and Planetary Institute, Johnson Space Center, Houston, Texas (2006).

"Nonlinear Dynamics and Critical Phenomena at the Threshold of Black Hole Formation," A. Wang, presented to the Mathematics Department, Baylor University, March 30, 2006.

"Nonstandard semi-implicit shooting methods for second order singular ODE boundary value problems," Q. Sheng, presented at the Joint AMS-MAA-SIAM Annual Meeting, San Antonio, Texas, Jan. 15, 2006.

See Presentations, pg. 8

Research Updates
Recent Publications/Presentations

Publications, continued from pg. 6

On Geometrical Interpretation of Non-Abelian D- and F-Flat Direction Constraints, G. Cleaver, D.V. Nanopoulos, J. Perkins, and J.W. Walker. Submitted for publication in Nuclear Physics B, 2007.

On the Nth Mode Numerical Solutions of a Second Order Boundary Value Problem on Semi-Infinite Domain, Q. Sheng and J. W. Haus, Submitted for publication in Communications on Applied Nonlinear Anal, 2007.

Phase Transitions in a Two-Component Dusty Plasma, B. Smith, C. Boesse, T. Hyde, L. Matthews, J. Reay, M. Cook, J. Schmoke, Submitted for publication in Advances in Space Research, 2007.

Randall-Sundrum and Flipped SU(5), B. Dundee and G. Cleaver. Submitted for publication in Physical Review D.

Stringent Phenomenological Investigation into Heterotic String Optical Unification, J. Perkins, B. Dundee, R. Obousy, S. Hatten, E. Kasper, M. Robinson, C. Sloan, K. Stone, and G. Cleaver. Submitted for publication in Physical Review D, 2007.

Thermodynamical Properties of the Universe with Dark Energy, Y. Gong, B. Wang, and A. Wang, Submitted for publication in Journal of Cosmology and Astroparticle Physics (JCAP), 2007.

Presentations, continued from pg. 7

"*Numerical stability and convergence of the adaptive splitting methods for certain singular reaction-diffusion equations*," Q. Sheng, presented at the SIAM Annual Meeting, Boston, Massachusetts, July 2006.

"Ricci Tensors and Scalars for Half-Flat Manifolds," Gerald Cleaver, presented at the Symposium on Particles, Strings and Cosmology (PASCOS), Ohio State University, Sep. 11, 2006.

"*Status of the Heterotic String Optical Unification Investigation*," Gerald Cleaver, presented at the American Physics Society, April 26, 2006.

"String Cosmology of 11-Dimensional Spacetime," Gerald Cleaver, presented to the Physics Department, Valparaiso University, Valparaiso, Indiana, Jan. 20, 2006.

"Structural Phases in Box_Tree Simulations of 3D Screened Coulomb Clusters," Ke Qiao and T.W. Hyde, presented at the Eleventh Workshop on the Physics of Dusty Plasmas, Williamsburg, Virginia (2006).

"Structural Phases in Complex Plasmas," T.W. Hyde, K. Qiao, J. Kong, L. Matthews, J. Reay, M. Cook and J. Schmoke, presented at the April American Physical Society Meeting, Dallas, Texas (2006).

"The Cosmological Constant and Cyclic Universe," A. Wang, presented at Elementary Particle Physics, Physics Department, Baylor University, Oct. 18, 2006.

"The Stringy Universe," Gerald Cleaver, presented at the Woodway Rotary Club, Woodway, Texas, Jan. 24, 2006.

"The Relationship Between the DC Bias and Debye Length in a Complex Plasma," James Creel, Jie Kong and T.W. Hyde, presented at the TSF06 Meeting of the American Physical Society, UTA, Texas (2006).

"*What Happened to Pluto?*," T. Hyde, presented at CASPER Seminar, October 6, 2006.

Physics Circus T-Shirts On Sale

Don't be without a Physics Circus T-Shirt! The CASPER office has a limited number of T-Shirts left on sale. Sizes run from S-XXL.
Call 254-710-3763 for more information or visit
www.baylor.edu/physicscircus

CASPER Summers

Thirteen students and two teachers participated in the 13th annual National Science Foundation (NSF) Research Experience for Undergraduates (REU) and Research Experience for Teachers (RET), hosted by CASPER and Baylor's physics department, from June to August 2006.

During the eight-week program, students experienced and participated in theoretical and experimental projects with Baylor faculty. This past summer, teachers also worked with Edith Davis, a School of Education doctoral student, and in the lab conducting research projects, as well as developing classroom content to be incorporated into their own classes.

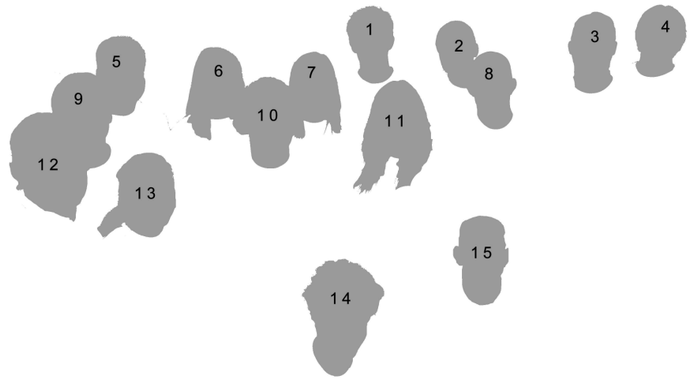
In between research projects, students, teachers and Baylor faculty gathered for Wednesday Lunch Bunch Seminars and weekly Friday updates. During the Lunch Bunch Seminars, faculty gave brief physics-related presentations, such as, "Why Does the Sun Shine?," and "The Physics of Baseball," and "Calculation of Orbital Parameters for Space Navigation." During the Friday updates, each participant presented to faculty on their research experience with this time also dedicated to assisting the students with educational resources. Students were given tips on literature searches, writing papers, preparing posters, creating Power Point presentations, and applying to graduate school.

To conclude the program, each participant prepared a poster, gave a 12 minute presentation, and wrote a paper detailing their research and results. Most of the students submitted their papers for online publication in the *Journal of Young Investigators*. Several of the REU students also had their papers accepted to the *IEEE Transactions on Plasma Science*.

CASPER, NSF and Baylor University would like to thank Drs. Truell Hyde, Lorin Matthews, Ken Park, Walter Wilcox, Dwight Russell, Mr. Dick Campbell, and Mrs. Edith Davis for their participation in the 2006 NSF Research Experience for Undergraduates and Research Experience for Teachers.

For information on the 2007 NSF REU and RET program, please visit the CASPER web site at http://www.baylor.edu/casper/index.php?id=20536

1. Alex Price
2. Michael Freed
3. Justin Janak
4. Dennis Oubre
5. Matthew Benesh
6. Hallie Graves
7. Sarah Smith
8. James Creel
9. Patrick Wilkerson
10. Josh Qualls
11. Ksenia Terekhova
12. Gary Shetler
13. Jessica Norcia
14. Ryan Hayes
15. Jason Caravalho



CASPER Summers
REU, RET

(above) REU and RET Members visited the Paul and Jane Meyer Observatory, located in Clifton, Texas, this past summer for a "Star Watch" party. (above right) As dusk settles in, the telescope dome opens up. Three REU members, Sarah Smith, Hallie Graves and Michael Freed, wait for the sun to set to start the "Star Watch" party. (right) Members of CASPER and REU fellows gather this summer near the Meyer Observatory.

USRA Visits CASPER

As a result of Baylor's admission to the Universities Space Research Association, one of USRA's top administrators recently visited Baylor.

Dr. H.D. Jirdeh (Director of University Relations) was the first to officially visit Baylor after its admission to the USRA. He toured CASPER's theoretical, experimental, educational and engineering facilities and met with CASPER faculty, staff and students. Dr. Jirdeh received his doctorate in Mechanical Engineering in 1988 from the State University of New York, Buffalo. His primary research interest is in thermal systems and space technologies. Prior to joining USRA, Dr. Jirdeh was on the faculty at Vanderbilt University in the Department of Mechanical Engineering. As the Director of University Relations for the USRA, he is working with Baylor to develop mechanisms allowing the university to cooperate effectively with other USRA members, the government, and other organizations to further space science and technology, while also promoting education in these areas. One example of a USRA educational outreach project is the scale model of the Solar System on the National Mall in Washington, DC. This exhibition provides a one to 10-billion scale model of the Solar System designed to convey the distances between the Sun and its planets and the relative sizes of these bodies.

Research Updates
Recent Proposals and Awards

PIRE: International Center for Advanced Materials Processing (I-CAMP)
Submitted in Response to a NSF Program Announcement (January, 2007)
• Pending •

Meeting Industries' Critical Workforce Needs
Submitted in Response to a Texas Workforce Commission Program Announcement for the Aerospace and Defense Cluster (December, 2006)
• Pending •

Sexus Equipment Grant Proposal
Equipment grant proposal to Sexus Inc - September, 2006
• $4600 •

21st Century Learning Community
Submitted in Response to a MCYC Program Announcement (August, 2006)
• $23,800 •

Summer Undergraduate Research Experience
Submitted in Response to a NSF REU Program Announcement (August, 2006)
• $515,000 - 3 years •

GearUp Central Texas
Submitted in Response to a Department of Education Announcement of Opportunity (March, 2006)
• $11,360,124 - 6 years •

Phase Transitions in Complex Plasmas
Submitted in Response to a Department of Labor Program Announcement (February, 2006)
• $72,000 •

Quick Shot: An Imaging Diagnostic Tool for Hypervelocity Flight Path Reconstruction
SBIR Phase One Proposal Investigation, Submitted in Collaboration with Start Vision Technologies, Inc. to an Arnold Air Force Base Program Announcement (January, 2006)
• $20,000 •

Impact Testing on Carbon Nano-Tube Surfaces
Submitted in Response to a Zyvex Program Announcement (November, 2005)
• $4500 •

Gear Up Waco: Making College a Reality
Congressional Cost Up Award (July, 2005)
• $497,000 •

NSF Photonics Center of Excellence Proposal
Submitted in Response to a NSF Program Announcement (April/October, 2005)
• $50,000 •

Summer Undergraduate Research Experience
Submitted in Response to a NSF REU Program Announcement (September, 2003)

Selected CASPER Colloquium Speakers

Dr. Carlos Lousto - Department of Physics and Astronomy and Center for Gravitational Wave Astronomy, The University of Texas at Brownsville

Abstract: We have used our new technique for fully numerical evolutions of orbiting black-hole binaries without excision to model the last orbit and merger of an equal-mass black-hole system. For the chosen configuration we track the trajectories of the individual apparent horizons and find that the binary completed approximately one and a third orbits before forming a common horizon. Upon calculating the complete gravitational radiation waveform, horizon mass, and spin, we find that the binary radiated 3.2% of its mass and 24% of its angular momentum. The plunge part of the waveform is remarkably similar to the waveform from the previously studied `ISCO' configuration. We anticipate that the plunge waveform, when starting from quasicircular orbits, has a generic shape that is essentially independent of the initial separation of the binary.

"Who Wants to be a Scientist?"

The 6th annual Physics Circus takes center stage with "waves"

Q: What is a wave?

A: A wave is a traveling disturbance.

Q: Define a Transverse Wave.

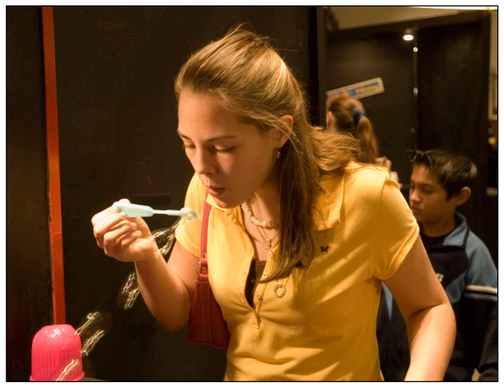
A: A Transverse Wave is a wave in which the disturbance producing the wave moves perpendicularly (side to side or up and down) to the direction of propagation.

Q: What is the best technique for teaching students physics?

A: The best technique for teaching students physics and science is in an exiting and fun environment where students are taught the information through demonstrations and hands-on experiences.

That's what the Physics Circus excels at doing.

The sixth annual Physics Circus educated and entertained more than 1780 students, including 20 pre-K students, and 75 teachers and parents, at the Mayborn Museum Complex Feb. 20 – March 3, 2006.



The theme, "Physics of Waves", aimed at educating students about waves. A flashlight, radio, balloons, musical instruments, a slinky and more, were used to help explain wave characteristics. Students learned the difference between standing, light, sound, electromagnetic, compressional, longitudinal, transverse and torsional waves, and how and where these waves are found in everyday life.

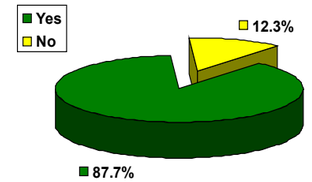
As always, this topic was approached in an unusual manner. Participants were invited to play the game of, "Who Wants to be a Scientist?", a combination of *Wheel of Fortune* and *Who Wants to be a Millionaire*, making the educational process different and entertaining for the students. The game show host, Dr. Einsteina (Sherry O'Connor), and her assistant, Ms. Cindy Can Do (Margaret Holmes) demonstrated different physics phenomena and students were invited on stage to participate in the show for a unique hands-on experience. Holding true to the game show spirit, the Circus came complete with a big wheel to spin and three life-lines for each participant.

A variety of interesting contests kept students excited, providing them opportunities to play such physics classics like "Twinkle, Twinkle Little Star" using Palm Pipes®, cylinder pipes of varied lengths open at each end. When these pipes are struck on one end, they produce sounds of varying pitch (wavelength) with the longest pipe producing the lowest pitch and the shortest pipe producing the highest pitch.

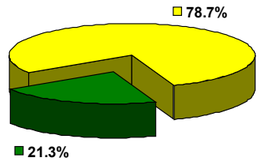
Using a white light projector and a glass prism, Dr. Einsteina also showed Cindy Can Do how light can be bent producing the colors of the rainbow. To fill in the physics behind these demonstrations, Dr. Einsteina invited her friend Jorge Carmona-Reyes, the traveling physics expert, to demonstrate how white light is created. Carmona-Reyes used a white light projector to project primary colors, red, blue, and green, onto the wall, showing students how yellow, purple, and white can be produced by overlapping the primary colors in the correct sequence.

The Physics Circus is a CASPER and GEAR UP Waco initiative and is funded by the Department of Education, CASPER and Baylor University. This year's Physics Circus is scheduled for March 12–16, 19-23 and 26-30. For more information, please visit www.baylor.edu/physicscircus.

The graphs below are based on voluntary information provided by students who attended the 2006 Physics Circus.



(above) 87.7% of students say they plan on taking physics in high school. (below) In addition, 21.3% said they plan on majoring in science in college.



The Physics Circus is held at Baylor's Mayborn Museum Complex. Kindergartners through high school students from private, home school and various Independent School Districts attended the show. More than 1780 students and 75 parents and teachers were educated and entertained by the engaging presentation of physics demonstrations. Information about the Physics Circus was contributed by Brenda Suggs.

Brenda Suggs