

DEPARTMENT OF PHYSICS & ASTRONOMY
at
THE UNIVERSITY OF MISSOURI-ST. LOUIS

FACULTY RESEARCH
(Updated: July 31, 2007)

Here is a brief description of the research the faculty in Physics and Astronomy are involved in.

SONYA BAHAR

My research concerns neural synchronization in pathological processes and information processing, as well as general problems of collective dynamical behavior in biological systems. A major current area of study involves synchronization of neural firing during epileptic seizures. The role of synchronization in seizure development can be studied with computational models of coupled neurons or oscillators, and also with experimental imaging of epileptic events. I image seizure onset in the rodent neocortex using a combination of various techniques, including the intrinsic optical signal (a drop in light reflectance that correlates with an increase in electrophysiological activity), calcium sensitive dyes, and voltage sensitive dyes. A central problem is to investigate changes in spatiotemporal synchronization, and other measures of spatial organization, during the course of seizure onset, development, and offset, and to try to understand the underlying dynamics driving this process. Other projects involve MEG imaging of the human brain, in collaboration with clinicians at Saint Louis University Hospital, studies of synchronization among cerebellar neurons during eye movements, and synchronization in the crayfish photoreceptor/mechanoreceptor system.

Recent Publications

Bahar, S., M. Suh, A. Mehta and T. H. Schwartz. Intrinsic Optical Signal Imaging of Neocortical Epilepsy. In Bioimaging in Neurodegeneration. P. A. Broderick, D. N. Rahni, and E. H. Kolodny, eds. Humana Press, 2005.

Bahar, S., M. Suh and T. H. Schwartz. Multiwavelength Intrinsic Optical Signal Imaging of Acute Focal Seizures in Rat Neocortex. The "Epileptic Dip". Submitted to *Journal of Neuroscience*.

Suh, M., S. Bahar, A. D. Mehta and T. H. Schwartz. Temporal Dependence in Uncoupling of Blood Volume and Oxygenation during Interictal Epileptiform Events in Rat Neocortex. *Journal of Neuroscience* **25**(1):68-77, 2005.

Bahar, S. Burst-Enhanced Synchronization in an Array of Noisy Coupled Neurons. *Fluctuation and Noise Letters* **4**(1):L87-L96, 2004.

Bahar, S. Effect of Light on Stochastic Phase Synchronization in the Crayfish Caudal Photoreceptor. *Biological Cybernetics* **89**(3):200-213, 2003.

TA-PEI CHENG

My field is theoretical particle physics. For an introduction of the subject, see my co-authored books: "*Gauge Theory of Elementary Particle Physics*" (Oxford University Press, 1984) and "*Gauge Theory of Elementary Particle Physics: Problems and Solutions*" (Oxford, 2000). My collaborator, Professor L.F. Li of Carnegie Mellon University, and I have started writing another book on particle physics theory, tentatively entitled "*Terascale Particle Physics: The Standard Model and Beyond*".

In 2005 I completed the book: “*Relativity Gravitation & Cosmology: a Basic Introduction*” (Oxford Masters Series in Physics). This is an introduction to Einstein’s general theory of relativity for readers with an undergraduate math background, and includes much discussion of the exciting recent development in cosmology, issues like dark matter, dark energy, and the accelerating universe, etc.

BERNARD F. FELDMAN

My research interests are in physics education, in particular, in the development of new educational materials for introductory physics classes at the high school, college and university level that create excitement and enthusiasm about physics. Recent physics education papers include “What to say about the Tacoma Narrows Bridge to your introductory physics class,” [The Physics Teacher, 41, 92 (2003)], “A physicist’s view of the automobile engine,” [The Physics Teacher 42, 543 (2004)], “The Nimitz Freeway collapse,” [The Physics Teacher 42, 400 (2004)], “Hydrogen fuel cell automobiles,” [The Physics Teacher, 43, 492 (2005)], and “Origin of bird flight: A physics viewpoint,” [The Physics Teacher, 44, 351 (2006)]. I have also recently tried my hand at science policy issues with a talk and conference proceeding, titled “American Energy Policy and Alternatives to the Internal Combustion Engine,” published by the Advanced Policy Science Research Center at Toyo University (2005).

RICARDO A. FLORES

My research interests are astrophysical cosmology and applications of quantum field theory to the physics of elementary particles. Cosmology is now a well established branch of science thanks in great part to the astounding diversification of Astronomy in the last three decades into observations covering a very broad range of the electromagnetic spectrum. It is also a very exciting field of research due to its inherent intellectual appeal, and the rapid progress allowed by a steady flow of observational data. I am currently working on analyses of large samples of dark matter halos from cosmological simulations to work out their expected properties in the concordance Cold Dark Matter cosmology with dark energy, which is currently favored by a large body of observational evidence. My most recent work has been on the systematics of the shape of DM halos (<http://xxx.lanl.gov/abs/astro-ph/0508497>), and comparisons to observations to test these predictions (<http://xxx.lanl.gov/abs/astro-ph/0508226>). Other relatively recent work has been on clusters of galaxies (see ApJ 532(2000)206 and ApJ 538(2000)92) and gravitational lensing (see ApJ 533(2000)194 and ApJ 535(2000)555). My work has been funded by the National Science Foundation, the University of Missouri System Research Board, and by Research Awards here at UM - St. Louis. Over the years, I have collaborated on a long-term basis with scientists from around the world to carry out my research. Most recently: Joel Primack @ UCSC (Santa Cruz, USA), and Hernan Quintana @ Universidad Catolica (Santiago, Chile).

PHILIP B. FRAUNDORF

Background and Approach: I’m interested in ways to examine nature on many scales, and how that impacts: (i) processes of interest to regional employers, as well as (ii) global problems in nanotechnology, complex system informatics, and astrobiology. *Methodology and Tools:* I use atomic resolution electron microscopes along with many other tools for our observing. From those observations, we use Bayesian inference to draw useful conclusions about the behavior of complex systems on various scales of space and time. *Examples of recent results:* I’ve been developing mathematical methods for measuring pico-meter scale strains in device and nanoparticle images (cf. <http://arxiv.org/abs/cond-mat/0403017>), for quantifying the visibility of lattice fringes as one tilts a nanostructure images (cf. *J Appl Phys* **98** (2005) 11430), and for tracking the effect of electronic media on the correlation-focus of individuals in communities (cf. <http://arxiv.org/abs/physics/0603068>). Recent results involve images of unlayered carbon atom sheets whose arrival in our solar system was concurrent with the carbon atoms in you, but which remain bonded to the sibling carbon atoms that made the trip across the galaxy with them from the red giant star in which they were born (cf. *Ap. J. Lett.* **578** (2002) L153). This “unlayered graphene” is unlike carbon familiar on earth, and may be very resistant to impurity diffusion judging

from images of isolated single heavy atoms in these specimens. It suggests the possibility of surface eruptions of carbon from deep within the interior of these cool bright stars. We also discovered a family of room-temperature intrusions into the surface of air-exposed silicon, which may prove to be allies as computer chip line-widths move into the nano-meter range (cf. *ECSS Lett.* **5** (2002) G83). *Significance and applications:* Methods development in collaboration with regional researchers has: (i) helped put graduates into jobs with employers MEMC Electronic Materials (St. Peters MO), Seagate (Minneapolis), Martin-Marietta (New Orleans), Mitsubishi Silicon America (Portland), and Motorola's Digital DNA Lab (now Freescale Semiconductor) in Mesa AZ, (ii) has given Missouri researchers their only local access to atomic resolution images for over a decade in a recently expanded center designed with that in mind, and (iii) has helped inspire and fund regional nanoalliance meetings in St. Louis, Kansas City, and Columbia MO. It has also given UM-StL researchers access to a wide range of interesting materials, and challenges in healthcare, energy, biology, engineering, and catalysis. Such materials include the "natural nanomaterials" mentioned above, which show that the world around is full of surprises that might be important to our quality of life in more ways than one.

THOMAS F. GEORGE

Dr George is involved in theoretical research in several areas of laser/materials physics. One area involves molecular clusters, where excitation processes in fullerenes by ultrafast laser pulses are being investigated theoretically by numerically solving the Liouville equation for electron density matrices. Comparisons are then carried out with experiments in regard to the control of vibrational excitations. Another area is nonlinear optical processes, where a theory of quantum control of short-wavelength sum-frequency generation, which employs continuum states, has been developed. Nonlinear interference processes in a multi-level ladder-type quantum system are being considered, along with the coupling of several strong laser fields with adjacent bound-bound (discrete) and bound-free (continuous) transitions in the continuous wave regime, accounting for relaxation of coherence. Also, quantum switching and amplification without inversion controlled by two optical fields are being examined in connection with (1) solids doped by rare earths and (2) atomic and molecular vapors. A third area involves ultrafast laser-driven materials processing, where femtosecond laser pulses are used in a theoretical analysis of microprocessing of metals, semiconductors and dielectrics. Here, a two-temperature model (energy coupling between electronic and phonon subsystems), the role of Debye effects, and ballistic transport are being considered. Step melting of crystalline and amorphous lead foils due to irradiation by ultraviolet laser pulses are being examined experimentally by optical microscopy-densitometry and atomic force microscopy methods. A fourth area is nanomedicine, where nanophotothermolysis with pulsed lasers and absorbing nanoparticles (like gold nanospheres) attached to specific targets is being used for selective damage to cancer cells. Finally, there are two projects "just for fun." The first deals with asset volatility in the financial market, which is described by theories using statistical/thermodynamics. The second such project is the application of Newtonian mechanics to help resolve the controversy of two opposite theories explaining the origin of vertebrate flight: (i) running and leaping into flight ("ground-up theory") and (ii) gliding to flight ("tree-down theory").

Recent Publications (since 2007)

G. P. Zhang, T. F. George, L. Assoufid and G. A. Mansoori, "First-Principles Simulation of the Interaction between Adamantane and an Atomic Force Microscope Tip," *Physical Review B* **75**, 035413-1-7 (2007).

A. V. Zhukov, M. V. Paliy, O. M. Braun and T. F. George, "Two-Stage Melting in Tribological Systems," *Physics Letters A* **361**, 437-41 (2007).

R. R. Letfullin, V. P. Zharov, C. Joenathan and T. F. George, "Laser-Induced Thermal Explosion Mode for Selective Nano-Photothermolysis of Cancer Cells," in *Complex Dynamics and Fluctuations in Biomedical Photonics IV (Photonics West 2007: Biomedical Optics)*, edited by V. Tuchin, *Proceedings of the Society of Photo-Optical Instrumentation Engineers* **6436**, 64360I-1-5 (2007).

R. R. Letfullin and T. F. George, "Gas-Dispersed Active Medium for High-Energy HF/DF Laser Systems Based on a Photon-Branched Chain Reaction," in *High Energy/Average Power Lasers and Intense Beam Applications II (Photonics West 2007: Lasers and Applications in Science and Engineering)*, edited by S. J. Davis, M. C. Heaven and J. T. Schriempf, *Proceedings of the Society of Photo-Optical Instrumentation Engineers* **6454**, 64540P-1-12 (2007).

R. R. Letfullin and T. F. George, "Diffractive Lens for Matter-Wave Beams," in *Optical Components and Materials IV (Photonics West 2007: Integrated Optoelectronic Devices)*, edited by S. Jiang and M. J. Dignonnet, *Proceedings of the Society of Photo-Optical Instrumentation Engineers* **6469**, 64690N-1-12 (2007).

R. Letfullin, V. Zharov, C. Joenathan and T. George, "Nano-Photothermalolysis of Cancer Cells," *SPIE Newsroom (Society of Photo-Optical Instrumentation Engineers)* DOI: 10.1117/2.1200701.0634-1-2 (2007) – <http://newsroom.spie.org/x5983.xml>.

T. F. George, "Putting Knowledge to Work," *Horizons* (Winter 2007), pp. 19-20 (publication by RubinBrown LLP – <http://www.rubinbrown.com>).

G. P. Zhang and T. F. George, "Origin of Ellipticity Anomaly in Harmonic Generation in C₆₀," *Journal of the Optical Society of America B* **24**, 1150-4 (2007) [*Virtual Journal of Nanoscale Science & Technology* **15**, Issue **17** (April 30, 2007) – <http://www.vjnano.org>].

R. Vajtai, B. Q. Wei, T. F. George and P. M. Ajayan, "Chemical Deposition of Organized Architectures of Carbon Nanotubes for Applications," in *Molecular Building Blocks for Nanotechnology: From Diamondoids to Nanoscale Materials and Applications*, edited by G. A. Mansoori, T. F. George, L. Assoufid and G. P. Zhang (Springer, New York), *Topics in Applied Physics* **109**, 188-211 (2007).

G. P. Zhang and T. F. George, "Theoretical Investigations in Retinal and Cubane," in *Molecular Building Blocks for Nanotechnology: From Diamondoids to Nanoscale Materials and Applications*, edited by G. A. Mansoori, T. F. George, L. Assoufid and G. P. Zhang (Springer, New York), *Topics in Applied Physics* **109**, 246-55 (2007).

L. Nánai, S. Szatmári, G. J. Taft and T. F. George, "On the Induction Period of Laser-Driven Thermochemical Processes," *International Journal of Theoretical Physics, Group Theory and Nonlinear Optics* **11**, 301-6 (2007).

S. Li, T. F. George, X. Sun and L. S. Chen, "Electric-Field-Induced Spin Accumulation in Polymer Light-Emitting Diodes" *Journal of Physical Chemistry B (Letters)* **111**, 6097-100 (2007).

A. V. Zhukov, M. Kolář and T. F. George, "Evolutions of Local Entanglement in a Non-Equilibrium 1D Critical Ising Chain," *Physics Letters A*, in press.

G. J. Taft, M. T. Newby, J. J. Hrebik, M. F. Onellion, T. F. George, D. Szentesi, S. Szatmári and L. Nánai, "Ultrafast Dynamic Reflectivity of Vanadium Pentoxide," *Journal of Materials Research*, in press.

Y. Yuan, T. F. George and S. Xin, "Origin of Symmetry Breaking and Confinement in Conducting Polymers with Ring Structures," *Communications in Theoretical Physics (Beijing, China)*, in press.

L. Braescu, T. F. George and S. Balint, "Evaluation and Control of the Dopant Distribution in a Nd:LiNbO₃ Fiber Grown from the Melt by the Edge-Defined Film-Fed Growth (EFG) Method," in *Photonic Fiber and Crystal Devices: Advances in Materials and Innovations in Device Applications (Optics and Photonics 2007)*, edited by R. Guo, S. S. Yin and F. T. S. Yu, *Proceedings of the Society of Photo-Optical Instrumentation Engineers* **6698**, in press.

L. Braescu, T. F. George and S. Balint, "Mass Transfer Analysis in the Case of a Nd:YVO₄ Cylindrical Bar Grown from the Melt by the Edge-Defined Film-Fed Growth (EFG) Method," in *Proceedings of the European Computing Conference* (World Scientific and Engineering Academy and Society Press, Athens, Greece, 2007), in press.

T. F. George, L. F. Braescu and S. Balint, "Mass and Heat Transport in Bridgman-Stockbarger and Edge-Defined Film-Fed Growth Systems," in *Springer Handbook of Crystal Growth, Defects and Characterization*, edited by G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Springer, Heidelberg, 2007), in press.

A. K. Popov, S. A. Myslivets, T. F. George and V. M. Shalaev, "Tailoring Transparency of Negative-Index Metamaterials with Parametric Amplification," *Proceedings of the First International Congress on Advanced Electromagnetic Materials in Microwaves and Optics* (Rome, Italy, 2007), in press.

G. A. Mansoori, T. F. George, G. P. Zhang and L. Assoufid, "Structure and Opto-Electronic Behavior of Diamondoids, with Applications as MEMS and at the Nanoscale Level," in *Nanotechnology Research Advances*, edited by F. Columbus (Nova Science Publishers, Hauppauge, New York, 2007), in press.

ERIKA L. GIBB

Star formation takes place in dark clouds of gas and dust, hidden from view by microscopic dust grains coated with ice. How this collection of gas and icy grains evolves physically and chemically during star formation and the formation of planetary systems is not currently understood. Dr. Gibb uses infrared spectroscopy to study the physics and chemistry of ice and gas in cold dark clouds, regions of star formation, disks around young stars, and comets in our own solar system. In particular, she studies the organic composition in these different environments with the goal of understanding the chemical evolution during star and planet formation. She is also interested in understanding how comets may have contributed to Earth's supply of water and organics, potentially a vital step in the origins of life on the early Earth.

Recent Papers

Gibb, E., Van Brunt, K. A., Brittain, S. D., Rettig, T. W. "Warm HCN, C₂H₂, and CO in the Disk of GV Tau", *Astrophysical Journal*, 660, 1572, 2007.

Gibb, E., DiSanti, M. A., Magee-Sauer, K., Dello Russo, N., Bonev, B. P., Mumma, M. J. "The organic composition of C/2001 A2 (LINEAR)", *Icarus*, 188, 224, 2007.

Rettig, T., Brittain, S., Gibb, E., Simon, T., & Kulesa, C. "CO Emission and Absorption Toward V1647 Ori (McNeil's Nebula)", *Astrophysical Journal*, 626, 252, 2005.

Gibb, E., Rettig, T., Brittain, S., Haywood, R., Simon, T., Kulesa, C. "Upper Limit for CH₄ in the Protostellar Disk Tward HL Tau", *Astrophysical Journal Letters*, 610, 113, 2004.

Gibb, E. L., & Whittet, D. C. B. "Interstellar Ice: The ISO Legacy", *Astrophysical Journal Supplements*, 151, 35, 2004.

PETER H. HANDEL

Dr. Handel continues his research on the Quantum 1/f Effect which describes fundamental fluctuations in the physical cross-sections and process rates of Quantum Mechanics, important in most modern high-technology industrial applications, and at Governmental research labs. Support is available for Ph.D. studies in this field. On June 4-6, 2000, and in 2002 he organized together with A.L. Chung, and chaired the 8th and 9th van der Ziel Symposium on "Quantum 1/f Noise and Other Low-Frequency Fluctuations" at UMSL (Sponsored by ONR, AFOSR, ARO and NSF). Dr. Handel also solved the excess heat puzzle in electrolysis. He was an Invited speaker at ICNF'99, 2001, 2003, 2007 and at many recent conferences (he organized and chaired the 12th conference in this series in St. Louis in 1993), and also at several conferences in Europe this year. He served as a member of the "Ultra-low phase noise, high power, GaN HFET-based Generators" MURI at UC-Santa Barbara 2001-2006, and cooperates now ther with the MINE MURI. Finally, Dr. Handel continues his research

in the Quantum 1/f Theory and experiment with applications in nanotechnology (he has a Laboratory which is equipped for noise experiments), on his Polarization Catastrophe theory of Atmospheric Electricity, on variants of cold fusion, and on his Maser-Soliton Approach to Ball Lightning, which Dr. Handel has also been directing in Moscow. As the US representative and Executive Committee member in ICBL he organized together with A.L. Chung and chaired the International Symposium on Ball Lightning in 2001. See his web site at www.umsl.edu/~handel containing his General Quantum 1/f Bibliography with contributions from several dozens of other authors to this fundamental new field of science and technology, which he introduced in 1975. It is practically important in most high-tech fields of science and engineering, with many successful industrial applications.

P.H. Handel and A.G. Tournier, "Nanoscale Engineering for Reducing Phase Noise in Electronic Devices," invited paper, Proc. IEEE 93, 1784-1814 (2005).

P.H. Handel, A.G. Tournier and B. Henning: "Quantum 1/f Effect in Resonant Biochemical Piezoelectric and MEMS Sensors", IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 52, 1461-1467 (2005).

Adam G. Tournier and Peter H. Handel "Quantum 1/f Noise and Quantum 1/f Phase Noise Related to the Uncertainty Relations" Internatl. J. of Modern Physics B. World Scientific Publishing Co., Vol. **20**, Nos. 11-13, pp 1621-1628 (2006).

BOB L. HENSON

Currently, my activities in the Department are mostly in the areas of instruction at the graduate and undergraduate levels plus service in the curriculum area. This has been the typical for me. However, I am still active in theoretical research, but at a very reduced level of activity. My main scholarly activity now is writing a text on the topic of atmospheric physics at the senior-graduate level. I am approaching this by writing up and expanding my class notes for Physics 4354 (Atmospheric Physics), which I have taught several times over the past thirty years.

JACOB J. LEVENTHAL

Current effort is directed toward writing an introductory textbook in quantum mechanics. This book is intended to be a prequel to: *Topics in Atomic Physics*, Springer, New York, by C. E. Burkhardt and J. J. Leventhal (ISBN: 0387257489,2005).

JINGYUE (JIMMY) LIU

Dr. Liu is involved in nanoscience and nanotechnology research with a focus on fundamental understanding of nanoscale systems and the commercial applications of these nanoscale systems. One area concerns the understanding and development of nanocatalysts with desirable properties. The development of better nanostructured catalysts can have profound impact on energy production, better usage of resources, reduction of pollutants and emissions control, etc. To understand the synthesis-structure-performance relationships of nanocatalysts it is critical to understand the surface and interface properties of the nanoparticles, which are the main components of a nanostructured catalysts, and how they evolve during the catalytic reactions. Atomic resolution imaging, nanospectroscopy and microdiffraction techniques, coupled with other surface analysis techniques, are used to characterize the nature of nanostructured heterogeneous catalysts. The fundamental insights gained via the study of nanocatalysts can be equally applied to other nanoscale systems. A closely related research area is the study of the physical, chemical and structural properties of monometallic, bimetallic and multimetallic nanoparticles and the application of these nanoparticle systems to catalysis and nanobiotechnology. Another research area concerns the application of nanoparticles or other nanoscale systems to understanding the nature of biological systems. For example, the use of functionalized quantum dots to label the sub-cellular components in a biological system or the use of nanoparticle systems as high-sensitivity

biological detectors and sensors. Another area concerns the development and application of ultra-high resolution imaging, atomic resolution spectroscopy, diffraction (e.g., small angle X-ray scattering and XRD techniques) and in situ techniques (e.g., atomic resolution environmental TEM, etc.) to characterizing nanoscale systems, especially nanostructured catalysts.

Recent Publications

Peng Li, Jingyue Liu, Nabin Nag and Peter A Crozier. In situ synthesis and characterization of Ru promoted Co/Al₂O₃ Fischer-Tropsch catalysts. *APPLIED CATALYSIS A-GENERAL* **307** (2): 212-221, 2006

Peng Li, Jingyue Liu, Nabin Nag and Peter A Crozier. Dynamic nucleation and growth of Ni nanoparticles on high-surface area titania. *SURFACE SCIENCE* **600** (3): 693-702, 2006

Jingyue Liu. Scanning transmission electron microscopy and its application to the study of nanoparticles and nanoparticle systems. *JOURNAL OF ELECTRON MICROSCOPY* **54** (3): 251-278, 2005

Xiaoyan Zhong, Jing Zhu and Jingyue Liu. Study of the interfacial structure of a Pt/□-Al₂O₃ model catalyst under high-temperature hydrogen reduction. *JOURNAL OF CATALYSIS* **236** (1): 9-13, 2005

John A Venables and Jingyue Liu. High spatial resolution studies of surfaces and small particles using electron beam techniques. *JOURNAL OF ELECTRON SPECTROSCOPY AND RELATED PHENOMENA* **143** (2-3): 205-218, 2005

Jingyue Liu. Advanced electron microscopy characterization of nanostructured heterogeneous catalysts *MICROSCOPY AND MICROANALYSIS* **10** (1): 55-76, 2004

ERIC MAJZOUB

The research focus in our group is on the study and design of new materials for energy storage and conversion, as well as sensing technologies. We perform our research using the tools of condensed matter physics for the characterization and modeling of bulk and nano-crystalline materials. We employ a combined experimental and computational approach, utilizing first-principles techniques to understand the electronic, mechanical, and thermodynamic properties of the materials we study.

Currently, our primary research area is hydrogen storage. Materials of current interest for hydrogen storage applications include complex anionic hydrides such as the class of materials known as alanates and borohydrides. Examples include NaAlH₄, LiAlH₄, Ca(BH₄)₂, and LiBH₄. These materials are generally wide gap insulators, and are very different in their material properties from interstitial metal hydrides. In a classic interstitial hydride, the metal alloy composition remains the same before and after hydrogenation. For example, the compound LaNi₅ reversibly absorbs hydrogen to become LaNi₅H₆. In contrast, the complex hydrides undergo decomposition reactions. NaAlH₄ ultimately decomposes into Na and Al. Important stoichiometric compounds in the system include Na₃AlH₆, and NaH. It is interesting to note that Na and Al are immiscible, even in the melt. The compound NaAlH₄ exists as an ionic molecular solid, with AlH₄⁻ anions bound with polar covalent Al-H bonds. Likewise, Na₃AlH₆, is composed of AlH₆³⁻ anions, charge balanced by three Na⁺ cations. *In-situ* single crystal Raman scattering studies have shown that the AlH₄⁻ anions are stable up to the melt in NaAlH₄ (see ref. 4 below), limiting the explanations of enhanced sorption kinetics through transition-metal "doping" procedures commonly used for this compound. Our group studies the structure, lattice dynamics, and thermodynamic properties of these materials to develop higher hydrogen capacities and better hydrogen sorption kinetics. We have also developed a Monte Carlo global optimization technique, using basin-hopping and potential energy smoothing, which can predict ground state crystal structures and structures close to the ground state in many of the complex anionic hydrides. This approach allows us to search the space of materials difficult to access experimentally, and to search for new potential hydrogen storage materials.

Selected Publications

Crystal structure, Raman spectroscopy, and ab initio calculations of a new alkali alanate K_2LiAlH_6 , E. Ronnebro, E.H. Majzoub, J. Phys. Chem. B, 110, 25686, 2006.

Location and energy of interstitial hydrogen in the 1 / 1 approximant W-TiZrNi of the icosahedral TiZrNi quasicrystal: Rietveld refinement of x-ray and neutron diffraction data and density-functional calculations, R.G. Hennig, E.H. Majzoub, K.F. Kelton, Phys. Rev. B, 73, 184205, 2006.

^{27}Al and 1H MAS NMR and ^{27}Al Multiple Quantum Studies of Ti-doped $NaAlH_4$, J.L. Herberg, R.S. Maxwell, E.H. Majzoub, J. Al. Comp., 417, 39-44, 2006.

Lattice dynamics of $NaAlH_4$ from high-temperature single-crystal Raman scattering and ab initio calculations: Evidence of highly stable AlH_4 anions, E.H. Majzoub, V. Ozolins, K.F. McCarty, Phys. Rev. B, 71, 024118, 2005.

XRD and NMR investigation of Ti-compound formation in solution-doping of sodium aluminum hydrides: Solubility of Ti in $NaAlH_4$ crystals grown in THF, E.H. Majzoub, J.L. Herberg, R. Stumpf, S. Spangler, R.S. Maxwell, J. Al. Comp., 394, 265-270, 2005.

Electronic structure and Rietveld refinement parameters of Ti-doped sodium alanates, V. Ozolins, E.H. Majzoub, T.J. Udovic, J. Al. Comp., 375, 1-10, 2004.

FRANK E. MOSS

The overall objective of this research is to study the role of noise, or random processes, and low dimensional processes, for example, chaos, on nonlinear dynamical systems. The emphasis is on biological sensory systems where individual neurons or networks of coupled neurons are the nonlinear system of interest. Our studies are both experimental, using preparations taken from the mechanosensory system of the crayfish and the electrosensory system of the paddlefish, and theoretical/numerical. Recent collaborative research has moved some aspects of this research toward applications in medical science. Complex motions of zooplankton swarms and dynamical theories that describe them are also of interest. More recently, we have performed experiments and helped in the development of theory on optimal feeding strategies of zooplankton in collaboration with a group at Humboldt University in Berlin, Germany. Our research is carried out within the interdisciplinary Center for Neurodynamics. Faculty and students from the Departments of Physics and Astronomy and Biology carry out research within the Center.

Ricardo Garcia, Frank Moss, Ai Nihongi, J. Rudi Strickler, Sebastian Göller, Udo Erdmann, Lutz Schimansky-Geier, Igor M. Sokolov, Optimal foraging by zooplankton within patches: the case of *Daphnia* species. *Math. Biosci.* 207 (2007) 165-188..

U. Erdmann, W. Ebeling, L. Schimansky-Geier, A. Ordemann, and F. Moss; Active Brownian and Random Walk Theories of the Motions of Zooplankton: Application to Experiments with Swarms of *Daphnia*. Preprint at <http://arXiv.org/abs/q-bio.PE/0404018>

F. Moss, L. M. Ward, and W. G. Sannita, "Stochastic resonance and sensory information processing: A tutorial and review of application." *Clinical Neurophysiol.* Vol 115/2 pp 267-281 (2004).

A. Neiman, X. Pei, D. R. Russell, W. Wojtenek, L. A. Wilkens, H. A. Braun, M. Huber, K. Voigt
"Synchronization of the electrosensitive noisy cells in the paddlefish", *Phys. Rev. Lett.* 82, 660-663 (1999)

"Use of behavioral stochastic resonance by paddlefish for feeding" *Nature*, 402, 219-223 (1999) (D. Russell, L. Wilkens)

WILFRED H. SORRELL

Main research focus is theoretical astrophysics. Previous research work was focused on models for interstellar solid particles with a special emphasis on the physical and chemical properties of graphitic solid particles producing the interstellar ultraviolet absorption band at wavelength 2175 Angstrom. The research work was published and appears in a peer-review journal as (Sorrell 1990. *Monthly Notices Royal Astronomical Society*, 243,570). Other research works on the chemical properties of hydrogenated amorphous carbon solids in diffuse interstellar clouds appear as (Sorrell 1991. *Monthly Notices Royal Astronomical Society*, 248,439), and dust grain processing in the Orion Nebula (Sorrell 1992, *Monthly Notices Royal Astronomical Society*,255,594). Research work on the interstellar dust grain alignment problem (Sorrell 1994. *Monthly Notices Royal Astronomical Society*,268,40),(Sorrell 1995. *Monthly Notices Royal Astronomical Society*, 273, 169-200). Research work on the issue about a massive black hole at the center of the Milky-Way galaxy appears in the Bad-Honnef Conference on Cosmic Jets, July 3-7, 1995. Recent research focused on the Origin of Life problem appears in (Sorrell 2001. *Astrophysical Journal Letters*, L129-L132). Recent research work on the nature of the T-Tauri binary system appears in (Sorrell 2002. *Monthly Notices Royal Astronomical Society*, 334, 705-712). Current research is focused on cosmological models for the universe that have nothing to do with the big-bang. The cosmological models I am now constructing are based upon my idea that says the Big Bang is a comic myth.

BRUCE A. WILKING

Using infrared wavelength imaging and spectroscopy, I study the earliest stages in the formation of low mass stars and substellar objects. Near-infrared spectroscopy of young stellar objects (YSOs) in the nearby Corona Australis, Rho Ophiuchi, and NGC 1333 molecular clouds has been obtained with the 4-m telescope at Cerro Tololo Interamerican Observatory in Chile, the 3-m Infrared Telescope Facility in Hawaii, and the Keck 10-m telescope in Hawaii. These data are being analyzed to derive the ages and masses of invisible YSOs and to identify young brown dwarf stars (<http://www.umsl.edu/~wilkingb/>). The goal of this research is to determine the distribution of masses for YSOs in each star-forming region and to investigate whether significant differences exist. It is possible to trace any differences in the mass distributions directly to the physical conditions of the molecular gas and provide basic constraints to theories for the formation of stars. A paper describing the discovery of young brown dwarf stars in the NGC 1333 cloud and an analysis of the cluster mass function appeared in the *The Astronomical Journal* in 2004 (v127, pp.1131-1146). A follow-up study using the NICMOS infrared camera on the Hubble Space Telescope that reveals a possible lack of young objects below 20 Jupiter masses appeared in *The Astronomical Journal* in 2007 (v133, pp.1321-1330). We have also undertaken an optical spectroscopic study of the surface population of the Rho Ophiuchi and Serpens molecular clouds using the multi-object spectrograph HYDRA at the WIYN 3.5 meter telescope. The first results of this study for the Rho Ophiuchi cloud, which allow us to trace the star formation history of the region, appeared in *The Astronomical Journal* in 2005 (v 130, pp. 1733-1751).