2005 SUMMARY OF ENGINEERING RESEARCH

A Report of Activities during 2004

This .pdf is part of the larger 2005 Summary of Engineering Research, available on the Web at www.engr.uiuc.edu/research and on CD-ROM. The Summary of Engineering Research represents the extensive engineering research program conducted in 2004 at the University of Illinois at Urbana-Champaign. Detailed statistics about research in the College of Engineering are included in the Directory of Engineering and Engineering Technology Programs and Research, published by the American Society for Engineering Education, Washington, D.C.

How to Use the Summary of Engineering Research: Research projects are listed by title, followed by the names of the investigators and the sponsoring agencies. Projects are sorted by major topic areas. Project descriptions are brief. Additional information on each project may be obtained from the investigator in charge (denoted by an asterisk). Mailing addresses are provided on the introductory page.

How to Obtain Publications: Please consult academic and public libraries for the journal articles, papers, and books listed in this report. Information about technical reports is available from the Engineering Documents Center, Grainger Engineering Library Information Center, 1301 West Springfield Avenue, Urbana, IL 61801, USA. To search the center’s collection on the Internet, please visit the website at http://g118.grainger.uiuc.edu/engdoc/opent1.asp. Copies of theses can be found at the University of Illinois Library, www.library.uiuc.edu, or may be purchased from University Microfilms, 300 Zeeb Road, Ann Arbor, MI 48106, USA, www.umi.com.

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Tina M. Prow: Editor and Coordinator
Peggy Currid: Freelance Editor, Publications Sections
Jim Vattano: Graphic Designer
Thomas Habing: Research Programmer, Grainger Engineering Library Information Center
Bill Mischo: Engineering Librarian, Grainger Engineering Library Information Center

Please send queries and comments about the 2005 Summary of Engineering Research to the Engineering Communications Office, 303 Engineering Hall, MC-266, 1308 West Green Street, Urbana, IL 61801, USA, or email research@engr.uiuc.edu.
Research Organizations, Centers, and Laboratories

Advanced Materials Testing and Evaluation Laboratory

Peter Kurath, Director
p-kurath@uiuc.edu
204 Talbot Laboratory
104 South Wright Street, MC-262
Urbana, IL 61801
(217) 333-3751
www.mie.uiuc.edu/content/asp/research/laboratories/advanced_materials_testing_lab_amtel.asp

The Advanced Materials Testing and Evaluation Laboratory (AMTEL/M&IE) is a state-of-the-art facility for mechanical testing of coupon specimens to determine baseline engineering properties and more sophisticated biaxial testing. Equipment to test components and smaller structures has also been developed. AMTEL is supported by user fees from industrial and research contracts and supplemented by funds from the Department of Mechanical and Industrial Engineering.

Advanced Research in Information Security, Center for

Roy H. Campbell, Director
roy@cs.uiuc.edu
Thomas M. Siebel Center for Computer Science
201 North Goodwin Avenue, MC-258
Urbana, IL 61801
(217) 265-5225
www.caris.uiuc.edu

The Center for Advanced Research in Information Security (CARIS), a collaborative partnership between the University of Illinois and Argus, allows academic, government, and industrial institutions to team together. Its mission includes promoting and conducting research and development, promoting quality multidisciplinary education, increasing university and community awareness, and influencing appropriate and effective public policy in the areas of infrastructure and information system security.

To achieve these goals, CARIS is aggressively pursuing state and federal funding opportunities. Proposed research projects to date include the development and marketing of products that implement domain-based access controls that defend systems against attacks and halt the spread of viruses and worms. An additional project is targeted at the construction and deployment of a security infrastructure for integrated information security.

The University of Illinois is a National Security Agency Center of Academic Excellence for Information Assurance Education.

Advanced Transportation Research and Engineering Laboratory

Imad L. Al-Qadi, Director
alqadi@uiuc.edu
1611 Titan Drive
Rantoul, IL 61866
(217) 893-0705
http://cee.uiuc.edu/research/atrel

The Advanced Transportation Research and Engineering Laboratory (ATREL) is a unique and comprehensive transportation research, educational, and testing laboratory. ATREL is located on 47 acres on the former Chanute Air Force Base in Rantoul, Illinois. The facility includes approximately 60,000 square feet of laboratories, classroom, office space, a technical library, and computer facilities. The laboratory facilities provide for research studies in airport and highway pavements and materials, transportation systems, and railroad facilities.

Transportation programs at ATREL range from those in the basic research areas to full-scale testing and evaluation. The full-scale testing facilities can evaluate airport and highway pavements as well as railroad track systems. ATREL is served by an outstanding research and teaching faculty and an excellent support staff. It provides both undergraduate and graduate students with the opportunity to obtain the very best transportation research and engineering education offered in any university program.

ATREL has three major buildings, which provide considerable space for all types of transportation research. The main building is utilized for research relating to subgrade soils, aggregate base and railroad ballast materials, asphalt concrete and PCC materials, geosynthetics, and a multitude of other transportation systems. A second building provides the equipment needed for transportation research.
to handle and process the large quantities of materials needed in the test pavements. The Traffic Operations Laboratory building is dedicated to transportation operations, system simulation, and Intelligent Transportation Systems.

The large land area included at the ATREL complex is being utilized for the construction of a full-scale pavement testing facility. Through funding from the Illinois Department of Transportation and the State of Illinois, ATREL acquired an Accelerated Transportation Loading System (ATLaS) to evaluate a variety of transportation support systems. The facility has readily available data acquisition systems for collecting both static and dynamic data from instrumented pavement sections. A Sprung Structure has been built to house the ATLaS and protect the pavement section being tested from the elements.

ATREL conducts research for the Illinois Department of Transportation, Federal Highway Administration, Federal Aviation Administration, American Association of Railroads, National Cooperative Highway Research Program, Illinois Transportation Research Center, and other governmental and private agencies.

**Air Conditioning and Refrigeration Center**

Predrag S. Hrnjak and Anthony M. Jacobi, Co-Directors
acrcc@uiuc.edu
Department of Mechanical and Industrial Engineering
1206 West Green Street, MC-244
Urbana, IL 61801
(217) 333-3115
http://acrc.mie.uiuc.edu

The Air Conditioning and Refrigeration Center (ACRC), established by the National Science Foundation in 1988, conducts industry–university cooperative research on energy-efficient, environmentally sound technologies for human comfort, environment control, food preservation and transportation, and other applications. The ACRC provides a forum for industry and university researchers to coordinate research with long-term value. Graduate students and faculty members from across the College of Engineering pursue advanced study in acoustics, dynamics, control systems, design, materials, and the thermal sciences. The ACRC is an active collaboration between approximately 30 companies in industry and the university.

**Airport Technology, Center of Excellence for**

David A. Lange, Director
dlange@uiuc.edu
1117 Newmark Civil Engineering Laboratory
205 North Mathews, MC-250
Urbana, IL 61801
(217) 333-7501
http://cee.uiuc.edu/research/ceat

The Center of Excellence for Airport Technology (CEAT) draws resources from the University of Illinois and several other universities to conduct basic, developmental, and applied research in airport technology. CEAT is sponsored by both the Federal Aviation Administration (FAA) and the O'Hare Modernization Program (OMP). The FAA is supporting research in pavement structural modeling, concrete fatigue studies, asphalt overlay design, base and subgrade material characterization, pavement response analysis, airport safety, and wildlife hazards. OMP is supporting research in subgrade stabilization, raw materials for concrete production, and concrete pavement behavior. In addition, the center has developed an outreach program that encompasses a Summer Minority Student Internship Program and a Minority Contractor Outreach Program in Chicago. Portions of the research and testing are performed at the Advanced Transportation Research and Engineering Laboratory (ATREL) in Rantoul, Illinois.

**Anderson Laboratory for Global Education in Engineering**

Bruce Vojak, Director
bvojak@uiuc.edu
306 Engineering Hall
1308 West Green Street
MC-266
Urbana, IL 61801
(217) -333-6057
www.engr.uiuc.edu/OCEE/anderlab

The Anderson Laboratory for Global Education in Engineering (Anderson Lab) supports the College of Engineering in the development of online graduate programs as well as effective, cost-efficient online teaching materials directed to K-12 audiences. The Anderson Lab developed a set of Atomic Force Microscope instruction modules for the Nano-CEMMS Center. A paper on “Magic Sand and the Hydrophobic Effect” is being converted into educational activities for
middle school students. These educational activities will be used in WaterCAMPWS summer camps. The Anderson Lab is currently working with the Physics Department and the College of Education on activities related to the 50th anniversary of the BCS Theory of Superconductivity developed at the University of Illinois. Interactive online materials for use by middle and high school students are being created. Additionally, the Anderson Lab will create a website on which to host these materials and work with middle and high school teachers in central Illinois to test the materials in summer camps before implementation in their classrooms.

Beckman Institute for Advanced Science and Technology

Pierre Wiltzius, Director
publications@beckman.uiuc.edu
405 North Mathews Avenue, MC-251
Urbana, IL 61801
(217) 244-1176
www.beckman.uiuc.edu

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign is the largest and most ambitious university-based multidisciplinary research facility in the United States. It was founded on the premise that reducing the barriers between traditional scientific and technological disciplines can yield research advances that more conventional approaches cannot.

The building was made possible by a $40 million gift—at the time, the largest ever presented to a public university—from University of Illinois alumnus Arnold O. Beckman, founder of Beckman Instruments, Inc., and his wife, Mabel M. Beckman. This gift was supplemented by $10 million from the State of Illinois, which also provides ongoing operating support for the facility. The research programs in the building are supported mainly by external funding from the federal government and from corporations and foundations.

Research performed at the Beckman Institute focuses on three broadly defined main research themes: biological intelligence, human–computer intelligent interaction, and molecular and electronic nanostructures.

The general goal of the biological intelligence main research theme is to develop understanding of intelligent systems by studying the diverse ways in which neurally based systems become capable of intelligent behavior and to use this knowledge, for example, to implement such processes in the design of intelligent devices. Within this research theme, programs extend from biochemical, molecular, and cellular-level studies of how neurons work, through integrative and computational neuroscience, to cognitive science, which seeks to understand how humans process sensory information and represent knowledge.

The general goal of the human–computer intelligent interaction main research theme is to improve the ways a human operator interacts with a computer by studying not only the input–output techniques but also the human factors. Within this research theme, programs range from artificial intelligence, robotics, computer vision, cognitive science, human perception, and performance to virtual reality environment experiments carried out in collaboration with the National Center for Supercomputing Applications.

The general goal of the molecular and electronic nanostructures main research theme is to develop a fundamental understanding of chemical and physical processes in molecular nanostructures, mesoscopic semiconductor-based systems, and macromolecular assemblies, with emphasis on future electronic or optoelectronic applications. Within this research theme, programs range from computational electronics and scanning tunneling microscopy, including lithography and fabrication of semiconductor nanostructures, and photonics, to efforts to synthesize and characterize new materials, including self-organized syntheses of inorganic, organic, and biochemical systems.

Twelve Beckman Institute research groups, composed of faculty and students from nearly three dozen University of Illinois departments as far ranging as psychology, computer science, and biochemistry, are investigating these and other areas. The building, with its more than 200 offices; specialized, state-of-the-art laboratories and other facilities; and meeting areas for conferences, workshops, and casual interactions, provides an ideal environment for fostering collaborative research.

Bio-Optoelectronic Sensor Systems, Center for

K. Y. Norman Cheng, Director
kycheng@uiuc.edu
150 Micro and Nanotechnology Laboratory
208 North Wright Street, MC-249
Urbana, IL 61801
(217) 333-6642
www.micro.uiuc.edu/ boss/Title.html

The Center for Bio-Optoelectronic Sensor Systems (BOSS) is part of the Defense Advanced Research Projects Agency (DARPA) university center program. The goal of the center is the development of integrated optoelectronic technologies, including materials, devices, integrated interferometers, optical microelectromechanical system
(MEMS) spectrometers, and heterogeneous integration that are critical to the realization of integrated and reconfigurable biological and biochemical sensor systems. Microspectrometer and interferometer-waveguide–based optoelectronic biosensor systems will be developed to improve the size, cost, sensitivity, and signature resolution of the fieldable sensors for detecting biological and chemical entities in the environment in real-time through on-chip optical measurements. The center will utilize compound semiconductor optoelectronic systems integrated with MEMS fabrication techniques, molecular biology methods, and information fusion algorithms to attain integrable and reconfigurable optoelectronic biosensor chips.

Cement Composite Materials, Center for

Leslie Struble
lstruble@uiuc.edu
2129 Newmark Laboratory
205 North Mathews Avenue, MC-250
Urbana, IL 61801
(217) 333-2544
www.cee.uiuc.edu/research/ccm

The Center for Cement Composite Materials (CCCM) is an interdisciplinary research center that develops knowledge to solve technical problems relating to portland cement and cement-based materials. The center identifies technical problems in the production and use of these materials, designs and carries out fundamental, science-based research to provide the knowledge required to solve these problems, and disseminates results of this research, both directly to center members and more broadly through open scientific literature, education, and the development of new standards. The center has research and analytical facilities available to university faculty and to industry. The center is closely affiliated with the Center for Advanced Cement-Based Materials (ACBM), which is headquartered at Northwestern University (www.acbm.northwestern.edu). ACBM was established in 1989 as a National Science Foundation Science and Technology Center, and since 2000 it has been a collaborative industrial research program with approximately 25 companies participating.

Complex Systems Research, Center for

Alfred W. Hubler, Director
a-hubler@uiuc.edu
4-129 Engineering Sciences Building
1110 West Springfield Avenue, MC-704
Urbana, IL 61801
(217) 244-5892
www.csr.uiuc.edu

The Center for Complex Systems Research (CCSR) is an interdisciplinary group of faculty members and graduate students administered through the Department of Physics. This group investigates a variety of complex dynamic processes occurring in biology, physics, chemistry, astronomy, and engineering. It considers not only specific dynamic problems but also the generic aspects of adaptive dynamic modeling and control that can be applied to any of the natural sciences or engineering. Major funding for the center is provided by a grant from the Office of Naval Research and the National Science Foundation.

Computational Electromagnetics and Electromagnetics Laboratory, Center for

Weng C. Chew, Director
w-chew@uiuc.edu
379 Everitt Laboratory
1406 West Green Street, MC-702
Urbana, IL 61801
(217) 333-7309
www.ccem.uiuc.edu

The Center for Computational Electromagnetics and Electromagnetics Laboratory (CCEML) performs leading-edge research in electromagnetic technology. Research areas include electromagnetic scattering and interaction, solving scattering problems of unprecedented sizes, antenna arrays, inverse scattering, high-speed digital circuits, electro-optics, remote and geophysical sensing, genetic algorithms, and bioengineering. Electromagnetics and antenna research in the laboratory has a long and distinguished history. Frequency-independent (log-periodic) antennas and corrugated horns were invented here in addition to uniform geometrical theory of diffraction, theory for random arrays, reflectors and lenses, and microstrip antennas. Some recent contributions are development of fast computational algorithms and analysis techniques, and reconfigurable antennas, as well as antennas for wireless and sensing applications.
Computational Science and Engineering

Michael T. Heath, Director
heath@uiuc.edu
2270 Digital Computer Laboratory
1304 West Springfield Avenue, MC-278
Urbana, IL 61801
(217) 333-0654
www.cse.uiuc.edu

Computational science and engineering (CSE) is inherently interdisciplinary, requiring expertise in advanced computing technology as well as in one or more applied disciplines. The purpose of the CSE program at the University of Illinois is to foster interdisciplinary, computationally oriented research among all fields of science and engineering and to prepare students to work effectively in such an environment.

Students electing the CSE option become proficient in computing technology, including numerical computation and the practical use of advanced computer architectures, as well as in one or more applied disciplines. Such proficiency is gained, in part, through courses that are specially designed to reduce the usual barriers to interdisciplinary work. Thesis research by CSE students is expected to be computationally oriented and actively advised by faculty members from multiple departments.

In addition to its educational programs, CSE is also the administrative home of several interdisciplinary research centers, including the Center for Simulation of Advanced Rockets (funded by the Department of Energy) and the Center for Process Simulation and Design (funded by the National Science Foundation). Websites for these centers are at www.csar.uiuc.edu and www.cse.uiuc.edu/cpsd, respectively.

Continuous Casting Consortium

Brian G. Thomas, Director
bgthomas@uiuc.edu
356 Mechanical Engineering Building
1206 West Green Street
MC-244
Urbana, IL 61801
(217) 333-6919
http://ccc.me.uiuc.edu

The Continuous Casting Consortium (CCC), created in 1991, consists of several companies in the steel industry that have been supporting research on the continuous casting of steel at the University of Illinois at Urbana-Champaign. The consortium encompasses a cooperative research effort to develop comprehensive mathematical models of continuous casting and related processes and to apply these models to improve fundamental understanding, to optimize the industrial processes, and to solve practical problems of interest to the participating members and to the steel industry in general. In addition to funding, the members provide plant data and direction to the research. Funding is augmented by grants from the National Science Foundation and other agencies.

Decision and Control Laboratory

Mark Spong, Director
mspong@uiuc.edu
149 Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
217-333-4281
http://black.csl.uiuc.edu/~dcl

Members of the Decision and Control Laboratory conduct research on a broad spectrum of topics covering systems, control, and decision-making, encompassing both theory and applications. The Decision and Control Laboratory is active in both the theory and application of feedback control. The group’s research has applications in robotics, intelligent control systems, discrete-event systems, semiconductor manufacturing, mathematical economics, aircraft flight control under icing conditions, and information technology. In information technology, the research group is pioneering some exciting work in controlling the traffic of communication packets on high-speed networks in both wired and wireless worlds, even exploring the control of objects at distant locations over networks.

Environmental Council

W. C. Sullivan, Director
www.environ.uiuc.edu

The Environmental Council strengthens environmental teaching, research, and engagement at the University of Illinois through partnerships with departments, colleges, programs, and the scientific surveys. Educational activities include the Environmental Fellows Program, an undergraduate minor that allows students to explore
environmental issues in an interdisciplinary way, and the Special Undergraduate Research on the Environment Program, which provides students with funding to conduct research on an environmental problem of their choice. At the graduate level, the Environmental Council supports four interdisciplinary programs: Ecology and Evolutionary Biology, Environmental and Resource Economics, Environmental Toxicology, and Human Dimensions of the Environment.

Annually the Environmental Council hosts Environmental Horizons, a conference showcasing the breadth and depth of environmental research and scholarship on campus. Other research and engagement activities have included providing funding to improve and update the environmental content of curriculum; sponsoring a grant writer’s workshop; facilitating submission of large, interdisciplinary grants; and distributing information to the environmental community on campus.

**Fluorescence Dynamics, Laboratory for**

Enrico Gratton, Director
egratton22@yahoo.com
William Mantulin, Co-Director
mantulin@uiuc.edu
Theodore Hazlett, Co-Director
thazlett@uiuc.edu
Loomis Laboratory
1110 West Green Street, MC-704
Urbana, IL 61801
(217) 244-5620
http://lfd.uiuc.edu

The Laboratory for Fluorescence Dynamics (LFD) at the University of Illinois at Urbana-Champaign was established in 1986 as a national research resource in biomedical fluorescence spectroscopy, supported by the National Institutes of Health and the University of Illinois at Urbana-Champaign. The aims of the center are to provide a state-of-the-art laboratory for time-resolved fluorescence measurements with technical assistance to visiting scientist/users and to design, test, and implement advances in the technology, especially in hardware, automation software, and applications to the biomedical arts.

**Grainger Center for Electric Machinery and Electromechanics**

Philip Krein, Director
krein@ece.uiuc.edu
341 Everitt Laboratory
1406 West Green Street, MC-702
Urbana, IL 61801
(217) 333-4732
http://machines.ece.uiuc.edu

The Grainger Center for Electric Machinery and Electromechanics (CEME) is dedicated to enhancing education, technology, understanding, and research activities in electrical energy, with emphasis on electric machinery. Major research thrusts include design of small inverter-fed induction machines, physics-based design for electromechanics, loss reduction across the whole range of electric machines, high-reliability energy supply designs for buildings and public facilities, research to develop new semiconductor materials for power applications and machines, and microelectromechanics. The center and the director’s chair are endowed by a gift from The Grainger Foundation Inc.

**Grainger Engineering Library Information Center**

William H. Mischo, Director
1301 West Springfield Avenue
MC-294
Urbana, IL 61801
(217) 333-3576
fax:(217) 244-7764
TDD: (217) 244-4580
www.library.uiuc.edu/grainger

The Grainger Engineering Library Information Center is a five-floor, 92,000 square-foot facility. The building can seat 1,200 patrons, can accommodate 350,000 volumes of library materials, and has the capability of supporting 1,000 networked computer connections. The Grainger Library provides a focal point for the College of Engineering faculty, students, and staff by making available group study rooms, individual study carrels, faculty and scholar studies, and conference and seminar rooms. It also provides state-of-the-art computing and information technologies to assist students in research and instruction and to provide patrons access to information resources held locally and available on the Internet.
The Grainger Library contains a two-story Main Reading Gallery, which can seat 1,254 people, and two smaller, two-story pavilion reading galleries, which can each accommodate approximately 60 people. The galleries are also used for special events and dinners. In addition, the facility contains three large seminar rooms (seating 30 to 50 people) and four smaller conference rooms.

Grainger Library computing facilities include two computer and multimedia labs with 80 high-end engineering workstations, which are used for CAD, numerical analysis and modeling, and software development; a digital imaging lab housing the Digital Library Initiative Projects, which provides access to 62,000 full-text journal articles; an information retrieval laboratory for visitors and researchers utilizing Grainger and campus resources; and two instructional services labs, which serve as high-tech classrooms for information literacy instruction and presentations.

Throughout the building, public-use terminals provide access to a statewide online catalog, Compendex, INSPEC, Aerospace Database, National Technical Information Service (NTIS), 1,000 full-text journals, and a wealth of local information resources.

The public terminals utilize an intelligent Web-based user interface and serve as the primary access mechanism for the statewide online catalog containing approximately 10 million holdings; a variety of periodical index databases, which provide access to 10 million articles, journals, magazines, and conference proceedings; Grainger journal information on received issues and linked tables of holdings; Engineering Documents Center publications; FAQs; and hard-to-find references. A “Help Getting Started” module is available to guide library users to information resources.

The Grainger Library contains 260,000 volumes of journals, books, reports, standards, theses, conference proceedings, and other materials. Holdings include 1,100 ongoing journal subscriptions and a large number of continually received conference and series publications.

The Grainger Library has become a popular place for students and faculty members to meet and interact. The workstation computing and information retrieval capabilities of Grainger are heavily utilized. More than 1.5 million people used the building during 2000.

The Grainger Library Information Center is dedicated to providing tools to assist people in their pursuit of knowledge and to serve as a showcase for the applications of information technologies. The Grainger Library home page provides access to Grainger resources.

The Grainger Library Information Center opened to the public in March 1994. A $22 million multifunctional facility, Grainger Library was primarily funded by a gift of $18.7 million from The Grainger Foundation Inc., which is headquartered in Skokie, Illinois. An additional $11 million of state and gift funds was expended on the project for the rerouting of steam, electrical, and telecommunications lines; the demolition of several buildings; and the construction of the new Engineering Quad (which had been under consideration since at least 1926). The Grainger Library is named after William Wallace Grainger, a 1919 graduate of the University of Illinois College of Engineering. A bas-relief of William Wallace Grainger is in the first floor lobby of the Grainger Library.

High-Performance Computing Laboratories

Robert D. Skeel and David A. Padua, Co-Chairs
padua@a.cs.uiuc.edu

Digital Computer Laboratory
1304 West Springfield Avenue, MC-258
Urbana, IL 61801
(217) 333-2727, (217) 333-4223
http://hpc.cs.uiuc.edu

This is an umbrella group of laboratories in the Department of Computer Science involving more than a dozen faculty members who are collaborating on a variety of funded research projects in high-performance computing. Current efforts are in the areas of parallel computer architecture design, parallelizing compilers, concurrent programming languages, run-time software for parallel I/O and computation, and software and algorithms for applications such as rockets and molecular simulation. This work is facilitated by access to large-scale parallelism through affiliations with campus research centers, including the National Center for Supercomputing Applications and the Center for Simulation of Advanced Rockets.

Hyper-Uniform Nanophotonic Technologies for Ultra-Fast Optoelectronic Systems, Center of

K. Y. Norman Cheng, Director
kycheng@uiuc.edu
150 Micro and Nanotechnology Laboratory
208 North Wright Street, MC-249
Urbana, IL 61801
(217) 333-6642
www.micro.uiuc.edu/mbc/HUNT_Webpage/index.html

The Center of Hyper-Uniform Nanophotonic Technologies for Ultra-Fast Optoelectronic Systems (HUNT Center) is part of the Defense Advanced Research Projects Agency.
The mission of the HUNT Center is the development of critical technologies including hyper-uniform nanophotonic fabrication, high-performance quantum dot vertical-cavity surface-emitting lasers, and ultra-fast light-emitting transistor-based lasers for the realization of ultra-fast (≥ 100 Gb/s) optoelectronic interconnect systems. The center’s goal of demonstrating such ultra-fast optoelectronic interconnect systems requires the ability to design, fabricate, and integrate ultra-high-speed light sources with detector and driver circuits. The HUNT Center’s research programs will address the challenges by embracing a newly invented ultra-fast semiconductor laser structure, the light-emitting transistor (LET), and through development of hyper-uniform nanophotonic fabrication methods and novel quantum dot micro-cavity laser technologies. The three-port operation of the LET offers a revolutionary solution to the laser speed barrier problem as well as novel integrated circuit functions.

Image Laboratory: Multimedia Signal Processing, Analysis, and Visualization

Thomas Huang, Director
huang@ifp.uiuc.edu
Beckman Institute
405 North Mathews Avenue, MC-251
Urbana, IL 61801
(217) 244-1638
www.beckman.uiuc.edu/research/hciilab.html

The Image Lab was established under two National Science Foundation Research Infrastructure grants and carries out basic research in a wide spectrum of topics in multimedia (especially image/video and audio) signal processing, analysis, and visualization. Research activities include image databases content and similarity-based retrieval and the use of relevance feedback to adapt the system to the user; video databases (creation of table of contents and semantic index); multimodal human–computer interface (speech- and gesture-based interface in virtual environments using computer lip-reading to enhance audio speech recognition), combining eye tracking and speech in display control; image and video compression; computerized imaging (computer tomography, magnetic resonance imaging, and synthetic aperture radar); and parallel algorithms and architectures for multimedia signal processing. More than 10 faculty members and 50 graduate and undergraduate students are affiliated with the laboratory.

Information Trust Institute

William H. Sanders, Director
info@ctns.uiuc.edu
Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
(217) 333-0345
www.ctns.uiuc.edu

The Information Trust Institute (ITI) provides national leadership combining research and education with industrial outreach in trustworthy and secure information systems. ITI brings together over 40 faculty, many senior and graduate student researchers, and industry partners to conduct foundational and applied research to enable the creation of critical applications and cyber infrastructures. In doing so, ITI is creating computer systems, software, and networks that society can depend on to be trustworthy; that is, secure, dependable (reliable and available), correct, safe, private, and survivable. Instead of concentrating on narrow and focused technical solutions, ITI aims to create a new paradigm for designing trustworthy systems from the ground up and validating systems that are intended to be trustworthy.

Integrated Microsystems, Illinois Center for

Naresh R. Shanbhag, Director
shanbhag@uiuc.edu
Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
(217) 244-0041
www.icims.csl.uiuc.edu

The Illinois Center for Integrated Microsystems (iCIMS) facilitates collaborative research in the design of integrated microsystems, including integrated circuits or chips, devices, system-on-a-chip (SOC), and structures. The center has 9 faculty and 40-plus graduate students working on various aspects of microsystem design. Specific projects include the design of high-speed chip-to-chip links, radio frequency CMOS circuits, reliability issues in chips, low-power/high-performance very large scale integrated (VLSI) circuits for broadband communications, and computer-aided design of SOCs. Center activities are funded through industry, the National Science Foundation, the Defense Advanced Research Projects Agency, and the Semiconductor Research Corporation. The center has an industrial outreach program whereby industry can participate in center activities by
funding research on specific topics of interest, by sending engineers to work with center faculty and students, and by providing summer internships to students in the center.

Machine Tool Systems Research, Center for

Shiv G. Kapoor, Director
gkapoor@uiuc.edu
158 Mechanical Engineering Building
1206 West Green Street, MC-244
Urbana, IL 61801
(217) 333-3432
http://mtamri.me.uiuc.edu/cmtsr.home

The Center for Machine Tool Systems Research (CMSTR) is an industry-driven center of excellence in manufacturing research to foster collaborative research initiatives between the university and industry represented by both large and small companies. CMSTR builds upon the strengths of the University of Illinois in areas of manufacturing research and education. Particular areas of attention include agile/flexible machining and machine tool systems, concurrent engineering as it applies to better understanding and utilizing machining process capability upstream during product engineering, machining process development and innovation, and machine-tool planning and control.

Through industrial memberships and participation, the center focuses its attention on leveraging the investments of the industrial memberships as well as its own resources to improve manufacturing competitiveness in the world economy. The center conducts collaborative research projects with its member companies, educates students in the problems and issues of manufacturing, and provides a broader access for its members to the laboratories and programs of the University of Illinois. A member company pays an annual fee and can designate that one-half of the funds contributed be applied to research of specific interest to that company. The results of the research from company-designated projects are available on an exclusive basis to the company. The remaining funds from each member company are employed collectively to support center-designated projects. The results of these projects are shared by all member companies.

Manufacturing Research Center

Shiv G. Kapoor, Director
gkapoor@uiuc.edu
158 Mechanical Engineering Building
1206 West Green Street, MC-244
Urbana, IL 61801
(217) 333-3432
http://mtamri.me.uiuc.edu/cmtsr.home.html

The Manufacturing Research Center focuses its attention on leveraging the investments of industrial memberships and its own resources to improve manufacturing competitiveness in the world economy. Particular areas of focus include agile/flexible machining and machine tool systems; concurrent engineering as it applies to better understanding and utilizing machining process capability upstream during product engineering; machining process development and innovation; and machine-tool planning and control.

The center conducts collaborative research projects with its member companies, educates students in the problems and issues of manufacturing, and provides a broader access for its members to the laboratories and programs of the University of Illinois. A member company pays an annual fee and can designate that one-half of the funds contributed be applied to research of specific interest to that company. The results of the research from company-designated projects are available on an exclusive basis to the company. The remaining funds from each member company are employed collectively to support center-designated projects. The results of these projects are shared by all member companies.

Materials Computation Center

Duane Johnson, Director
mcc@uiuc.edu
295 Engineering Sciences Building
1101 West Springfield Avenue, MC-233
Urbana, IL 61801
(217) 333-3324
www.mcc.uiuc.edu

The Materials Computation Center (MCC) at the Frederick Seitz Materials Research Laboratory (FS-MRL) provides an intellectual and interactive environment for researchers to support world-class, multidisciplinary educational experience and research across traditional boundaries in computational materials science. The MCC involves over 10 departments and programs (e.g., Materials Science and Engineering, Physics, Chemistry, and Computer Science)
and is actively supported by the College of Engineering and by the FS-MRL, as well as direct corporate interactions. The MCC promotes networking of researchers and students locally and worldwide, sponsors summer schools on current topics (e.g., computational biophysics and interface and nanoscience), and facilitates creation of useful tools and algorithms for research and education. In addition, the MCC hosts a Web-based, shared-resource software archive that contains codes fostering research and education. All interested parties are invited to contribute to the Software Archive on the Web. Research areas evolve but include computer science applications to, and scalable, parallel modeling of, multiscale problems, O(N) algorithms, complex systems, computational biophysics, and classical/quantum simulations. The center also directly supports broader interactions such as the Division of Computational Physics at the American Physics Society, and the National Research Experience for Undergraduates.

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Microanalysis of Materials, Center for

Ivan Petrov, Director
petrov@uiuc.edu
2015 Frederick Seitz Materials Research Laboratory
104 South Goodwin Avenue, MC-230
Urbana, IL 61801
(217) 333-8396
http://cmm.mrl.uiuc.edu

The Center for Microanalysis of Materials (CMM) at the Frederick Seitz Materials Research Laboratory is a Department of Energy National User Center that provides advanced instrumentation for the characterization of a wide range of advanced materials over the full range of scales from the atomic to the macroscopic. The CMM is an integrated facility containing the full array of modern nanostructural and nanochemical analysis techniques including electron microscopy (SEM, TEM, STEMs, high-pressure environmental cell TEM, high-temperature LEEM, focused ion beam microscopy, scanning probe microscopy, variable-temperature STM), surface microanalysis (SIMS, TOF-SIMS, AES, XPS, imaging XPS, electrochemical XPS), x-ray scattering in all modes, and ion-beam spectroscopies (RBS, channeling and NRA).

The center is staffed with experts in each technique who teach researchers so they can operate the instruments to conduct their own measurements. Licensed users have 24-hour access to the instruments. The CMM staff also provide guidance, consultation, and collaboration in the microanalysis of materials. Projects are selected on their scientific merit, and there are no user fees for nonproprietary research. Approximately 30 companies use the center.

Mid-America Earthquake Center

Amr Elnashai, Director
aelnash@uiuc.edu
1241 Newmark Laboratory
205 North Mathews Avenue, MC-250
Urbana, IL 61801
(217) 244-6302
http://mae.ce.uiuc.edu

The Mid-America Earthquake (MAE) Center is a National Science Foundation Engineering Research Center. The focus of the center is on assessment and mitigation of the effects of earthquakes on a regional level, including physical damage and consequential social and economic impact. Toward this end, the center has developed, articulated, and is applying to testbed regions in the Midwest a new framework for earthquake loss modeling referred to as consequence-based earthquake engineering, or CBE. The CBE framework guides the center in developing and executing its goals and objectives in research, education, and outreach. The geographical focus of the center is mid-America, where low-probability/high-consequence earthquakes have been recorded. The MAE Center consists of a consortium of eight core institutions, with the University of Illinois at Urbana-Champaign as the lead institution. Its program comprises more than 40 projects and supports more than 50 graduate and undergraduate students. For further information on the large research, education, and outreach program run by the Mid-America Earthquake Center, explore http://mae.cee.uiuc.edu.

Motorola Center for Communications

Ravi K. Iyer, Director
rkiyer@uiuc.edu
202 Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
(217) 333-2510
www.csl.uiuc.edu/mcc

The technical scope of the Motorola Center for Communications spans the full range of technologies related to communications. It reflects the tremendous
depth and breadth of strength in relevant disciplines in the College of Engineering at the University of Illinois at Urbana-Champaign and at Motorola. A central focus of the program is the support over several years of approximately 22 research projects conducted by Motorola-sponsored graduate research assistants with faculty advisors in the center and close contact with leading Motorola engineers. The current technical emphasis falls into the areas of wireless communication, multimedia (video, speech, and data) signal processing, Internet-driven technologies, communications networking, and mobile computing.

Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems, Center for

Placid Ferreira, Director
pferreir@uiuc.edu
2134 Mechanical Engineering Laboratory
105 South Mathews Avenue, MC-244
Urbana, IL 61801
(217) 265-0093
www.nano-cemms.uiuc.edu

The Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS) was established in 2003 as a National Science Foundation Nanoscale Science and Engineering Center. A partnership of the University of Illinois, the California Institute of Technology, and North Carolina Agricultural and Technological State University, Nano-CEMMS’ mission is to develop a viable manufacturing technology and science base for fabricating ultrahigh-density, complex nanostructures. Specifically, Nano-CEMMS research focuses on micro-nano fluidic networks, processing sensing and control, manufacturing systems, and applications to organic optoelectronic and combinatorial chemistry.

Power Affiliates Program

Peter Sauer, Director
sauer@ece.uiuc.edu
337 Everitt Laboratory
1406 West Green Street, MC-702
Urbana, IL 61801
(217) 333-0394
http://power.ece.uiuc.edu

The Power Affiliates Program consists of industrial members who provide funding and industrial interaction for the power and energy systems area in the Department of Electrical and Computer Engineering. The program currently has 11 industrial members and holds an annual review meeting every May. The objectives of the program are to bring focus to the power and energy systems area; provide financial assistance to students studying electric power engineering; and increase university–industrial interaction at all levels of education and research in electric power engineering.

Power Systems Engineering Research Center

Peter Sauer, Site Director
sauer@ece.uiuc.edu
337 Everitt Laboratory
1406 West Green Street, MC-702
Urbana, IL 61801
(217) 333-0394
www.pserc.wisc.edu

The Power Systems Engineering Research Center (PSERC) is a Multi-University National Science Foundation Industry/University Cooperative Research Center comprising 13 universities, including the University of Illinois at Urbana-Champaign. PSERC receives industrial funding from about 35 industrial members. The funds are used to perform research into the technical issues of electric power system restructuring. Each industrial member is represented on the Industrial Advisory Board, which meets twice per year to review activities and make decisions about project funding.

Reliable and High-Performance Computing, Center for

Ravi K. Iyer and Janak H. Patel, Co-Directors
255 Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
(217) 333-2510 (Iyer); (217) 333-6201 (Patel)
www.crhc.uiuc.edu

The Center for Reliable and High-Performance Computing (CRHC) focuses on integrating research in the areas of reliable computing, high-performance architectures, dependability, security, testing, distributed and network computing, and optical and wireless networking. Research funding for the center comes from both industry and government. The center includes 25 faculty members and senior research staff and more than 100 graduate research assistants.
Silicon Nanoelectronics and Quantum Computers, Center for

John Tucker, Director
jrtucker@uiuc.edu
266 Engineering Sciences Building
1101 West Springfield Avenue, MC-233
Urbana, IL 61801
(217) 333-4810

The Center for Silicon Nanoelectronics and Quantum Computers is committed to developing a process for patterning atom-scale devices and growing them into the silicon crystal lattice. That capability will be used to explore new possibilities for computation based on the quantum states of individual electrons. An important part of this effort will be to integrate atom-scale electronics with conventional metal-oxide semiconductor (MOS) transistors on the same chip in order to explore a wide range of possibilities including single-electron circuits, quantum cellular automata, neural networks, and quantum computers. The center is currently funded by the Defense Advanced Research Projects Agency (DARPA) and, more recently, by the National Science Foundation's Nanoscale Interdisciplinary Research Teams (NSF NIRT) program. Faculty and staff are drawn from the University of Illinois, Utah State University, University of California at Berkeley, Yale University, and Lawrence Berkeley National Laboratory.

Simulation of Advanced Rockets, Center for

Michael T. Heath, Director
heath@uiuc.edu
2270 Digital Computing Laboratory
1304 West Springfield Avenue, MC-278
Urbana, IL 61801
(217) 333-3247
www.csar.uiuc.edu

The technical goal of the Center for Simulation of Advanced Rockets (CSAR) is the detailed, three-dimensional, integrated, whole-system simulation of solid propellant rockets. The center seeks to understand the performance of solid propellant rockets under normal and abnormal (accident) conditions. Meeting this daunting challenge requires a multidisciplinary team of engineers, physical scientists, and computer scientists to develop and implement the necessary mathematical models, algorithms, and software to build a virtual rocket. In addition, enormous computational capacity is required to perform the resulting simulated launch scenarios, frequently employing thousands of processors. CSAR is one of five university-based research centers funded by the U.S. Department of Energy as part of the National Nuclear Security Administration Advanced Simulation and Computing Program. The center includes 30 faculty members from 8 departments, 35 graduate students, and 25 research scientists, programmers, and postdoctoral research associates.

Space Sciences & Remote Sensing Laboratories

Erhan Kudeki
erhan@uiuc.edu
Gary Swenson
swenson1@uiuc.edu
313 Coordinated Science Laboratory
1308 West Main Street, MC-228
Urbana, IL 61801
(217) 333-9705

Faculty and students in these interdisciplinary research laboratories are engaged in a wide variety of studies of the Earth’s atmosphere and near-space environment. This work involves the design, construction, and operation of novel remote sensing instruments as well as the analysis of measurements conducted at major international facilities from the high Arctic to the South Pole. Much of the work focuses on environmental issues, including global atmospheric change. Radar, lidar, and satellite techniques are employed to probe the atmosphere from the surface to altitudes well into the thermosphere. Faculty members include Erhan Kudeki of the Aeronomy Laboratory; Chester Gardner and Gary Swenson of the Electro-Optic Systems Laboratory (http://conrad.ece.uiuc.edu/); and Stephen Franke of the Wave Propagation Laboratory. Funding for this work is provided by the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Defense. Annual research expenditures exceed $750,000.
The Illinois State Geological Survey (ISGS), a division of the state’s Department of Natural Resources, is one of the largest of the 51 state and territorial geological surveys. Since 1905, when it was first organized by legislative mandate, the ISGS has been assisting citizens, industries, and government agencies by supplying the geological information they need to protect the environment and help the state’s economy grow. The ISGS works closely with other offices and divisions of the Department of Natural Resources and with universities across the state to bring multidisciplinary research to bear on the problems and opportunities confronting the citizens of Illinois.

Activities of the ISGS fall into five major categories: mapping and modeling the geology of the glacial sediments and bedrock of the state in three dimensions; locating and characterizing groundwater aquifers to help develop new water supplies and protect them from contamination; locating the state’s energy and industrial mineral deposits and characterizing their physical and chemical properties to help producers develop them in environmentally sensitive and efficient ways; locating the causes and assessing the risks of geological hazards such as earthquakes, mine subsidence, and chemical spills; and distributing geological information to the public in a wide range of forms.

Following are a few examples of recent engineering-related research activities:

**Mapping and Modeling**
The ISGS is committed to mapping the geology of Illinois in detailed, 1:24,000-scale quadrangles from land surface into the bedrock. Emphasis is placed on providing understandable maps and models that show the three-dimensional (3-D) geology in as much detail as possible and that address critical water and mineral resource, economic development, and Earth hazard issues. Current mapping areas include the middle Illinois River valley, East St. Louis metropolitan area, Kane County, Kendall County, and portions of Lake County (Antioch and Fox Lake Quadrangles). The Lake County mapping is being conducted in association with the Central Great Lakes State Geologic Mapping Coalition, which includes the ISGS and state geological surveys from Ohio, Indiana, and Michigan and the U.S. Geological Survey. Coalition geologists are working together to test various mapping techniques, assess the results of geophysical methods for determining subsurface geology in complex glacial deposits, and discuss standard geological mapping procedures and modeling techniques of the 3-D geology in the four central Great Lakes states.

The benefits of geological mapping were recently discussed in a rigorous economic study done by the ISGS of the Kentucky geologic mapping program conducted in the 1960s and 1970s, where the entire state was mapped at a detailed scale. Based on responses to a questionnaire mailed to more than 200 professional users of Kentucky’s geologic maps, the economists used mathematical relationships derived from the theory of public goods and drawn from the literature on the value of information to show that the geologic maps provided economic benefits to consultants and other professional users that exceeded the costs of producing the maps by at least 25 times.

**Locating and Characterizing Groundwater Aquifers**
Illinois-American Water Corporation, which draws millions of gallons of drinking water from the Mahomet Aquifer to distribute to users in Urbana-Champaign and surrounding communities, recently asked the ISGS to assist them in determining the cause of progressive reductions in the specific capacities of some of their wells. Tests performed on samples of the aquifer, the groundwater, and suspended solids in the water revealed that iron-oxidizing bacteria, calcite precipitated by de-gassing of carbon dioxide from the water, and other mineral matter particles displaced and entrained by large-volume pumping are concentrating on the well screens and probably in the adjacent gravel pack surrounding the well annuli.

Through funding from a National Science Foundation grant received in cooperation with several academic departments at the University of Illinois at Urbana-Champaign, a fully automated flow-through, compound-specific, isotope ratio mass spectrometer integrated with a gas chromatograph, elemental analyzer, and carbonate unit is now in use. The instrument’s greater sensitivity, automated sample preparation and analysis, and broad analytical capabilities are opening new avenues for teaching and research, especially in groundwater geochemistry.

**Locating and Characterizing Energy and Industrial Mineral Deposits**
To help prepare Illinois to better handle and dispose of carbon dioxide from coal combustion and other sources, the ISGS is leading the Midwest Regional Sequestration Partnership, funded by the U.S. Department of Energy, to assess and demonstrate methods for geological
sequestration of carbon dioxide in deep saline aquifers, coal seams, and spent oil reservoirs. To enhance the marketability of Illinois’ high-sulfur coal deposits and to meet the need for future mandates to reduce mercury emissions, ISGS and University of Illinois engineers and graduate students are investigating activated carbon materials made from coal, corn silage wastes, and other carbon materials as replacements for more expensive materials used in a variety of pollution-control and industrial process applications. Pilot-scale tests of the ability of some of these carbon materials to capture mercury from flue gases of coal-fired power plants were recently completed at Abbott Power Plant. The ISGS also is working with industry to pilot processes to increase the use of coal-combustion fly ash in making standard construction bricks and autoclaved aerated concrete. Bricks containing 50- to 70-weight percent fly ash mixed with standard clay have been formed successfully, fired, and shown to be as strong or stronger than standard bricks.

**Locating and Assessing the Risks of Geological Hazards**

To assist the Illinois Department of Transportation with infrastructure construction and improvement projects, the ISGS completes preliminary environmental assessments for property owned or to be acquired by IDOT. The reports present IDOT officials with information regarding environmental or geological issues that may impact IDOT projects, including contaminated soils, wetlands, and other potential hazards.

**Distributing Geological Information**

The ISGS continually adds new data files to its Geographic Information System, one of the largest and most comprehensive in the country. Many files are now available over the Internet through Illinois’ Natural Resources Geospatial Data Clearinghouse, part of the National Spatial Data Infrastructure.

**Supercomputing Applications, National Center for**

Thom H. Dunning, Jr., Director  
Danny Powell, Executive Director  
NCSA Building  
1205 West Clark Street, MC-476  
Urbana, IL 61801  
(217) 244-0072  
www.ncsa.uiuc.edu

The National Center for Supercomputing Applications (NCSA), one of the five original centers in the National Science Foundation’s Supercomputer Centers Program, opened its doors in January 1986. NCSA earned and maintains an international reputation in high-performance computing and networking, scientific visualization, data analysis, and innovative software development.

Today, NCSA’s overriding mission is to partner with diverse research communities to create the cyberinfrastructure that makes possible new scientific discoveries. Its specialty is shaping the most cutting-edge computers into working systems complete with software applications and tools for visualization, data mining and analysis, and collaboration. NCSA offers more than 40 teraflops of total computing power to the national research community—the most computing power in an open, university-based setting. The center also operates an Innovative Systems Laboratory (ISL) that provides early access to, and evaluation of, future generations of computing systems, hardware, and software. The ISL focuses on architectures that promise to significantly decrease the cost of computational scientific and engineering applications or to greatly extend the range of these applications.

NCSA is a key partner in the National Science Foundation’s TeraGrid project, a $100-million effort to offer researchers remote access to some of fastest unclassified supercomputers as well as an unparalleled array of visualization tools, application software, sensors and instruments, and mass storage devices. NCSA also leads the effort to develop a secure national cyberinfrastructure through the National Center for Advanced Secure Systems Research, a project funded by the Office of Naval Research.

The center leaves its mark through the development of networking, visualization, storage, data management, data mining, and collaboration software as well. The prime example of this influence is NCSA Mosaic™, which was the first graphical Web browser widely available to the general public. NCSA visualizations, meanwhile, have been a part of productions by the likes of PBS’s NOVA and the Discovery Channel. Through its Private Sector Program, top researchers from Fortune 500 companies explore the newest hardware and software, virtual prototyping, visualization, networking, and data mining to help U.S. industries maintain a competitive edge in the global economy.

Major support for NCSA is provided by the National Science Foundation. Additional funding comes from the state of Illinois, industrial partners, and other federal agencies.
Technology Entrepreneur Center

Andrew Singer, Director
singer@ifp.uiuc.edu
Department of General Engineering
313 Ceramics
105 South Goodwin Avenue
Urbana, IL 61801
(217) 244-3124
www.ge.uiuc.edu/tec

The Technology Entrepreneur Center (TEC) was created in 1999 to enhance the existing engineering curriculum, produce publishable research, and engage the College’s vast pool of faculty and alumni supportive of entrepreneurship. TEC’s 11 courses and co-curricular activities expose students to the complex concepts inherent in the simultaneous processes of technology innovation and market adoption. TEC also offers on-site and online certificate programs for education and professional development. Although affiliated with the Department of General Engineering, the center is interdisciplinary, having affiliated faculty members from other departments and colleges. TEC faculty members have produced an impressive body of collaborative research and publications in both theoretical and applied disciplines.

WaterCAMPWS—Advanced Materials for Purification of Water with Systems, Center of

Brian M. Pianfetti, Managing Director
watercampus@uiuc.edu
3253 Digital Computer Laboratory
205 North Mathews Avenue, MC-250
Urbana, IL 61801
(217) 333-2633
www.watercampws.uiuc.edu

The WaterCAMPWS (Center of Advanced Materials for Purification of Water with Systems) is a National Science Foundation Science and Technology Center that involves scientists, engineers, and other personnel principally from the University of Illinois at Urbana Champaign.

Theoretical Astrophysics, Center for

Frederick Lamb, Director
fkl@uiuc.edu
237B Loomis Laboratory
1110 West Green Street, MC-704
Urbana, IL 61801
(217) 333-6363
www.physics.uiuc.edu/Research/CTA

The Center for Theoretical Astrophysics works on outstanding problems in theoretical astrophysics, general relativity, and cosmology. The center’s research is highly interdisciplinary, requiring knowledge of many different areas of physics and astronomy—high-energy processes, radiation hydrodynamics, atomic physics, plasma physics, magnetofluid dynamics, general relativity, and condensed matter physics—to interpret data successfully and to model the astronomical objects and phenomena being studied. Members of the center, who work with collaborators worldwide, include faculty from the Departments of Physics and Astronomy and members of the National Center for Supercomputing Applications.