April 2010

2010 Unused Research Projects for ACTS Teachers

For more information click the Research Divisions page

MSD Materials Science Division

1. Superconducting Detectors for Cosmology
   Our Universe has expanded ever since the Big Bang, and this continuous stretching of space has both diluted and cooled the particles permeating it. As the universe has cooled, particles have combined into progressively more complex structures. Around 1 GeV, quarks combined to form protons and neutrons. Around 1 MeV, when the cosmic temperature was comparable to the core temperature of a star, some of the protons and neutrons combined via fusion reactions into light elements like helium, deuterium and lithium. Approximately 400,000 years after the Big Bang, the leftover protons combined with electrons to form electrically neutral hydrogen atoms and, consequently, generated a background of photons that has come to be known as the cosmic microwave background (CMB). This period of time is known as the Last Scattering because neutral hydrogen gas is sufficiently transparent to photons. As a result, the CMB is a remnant of the early Universe. Its existence is one of the cornerstones of the current Hot Big Bang model; its spectrum, temperature anisotropy, and polarization carry information about the fundamental properties of the Universe. The goal of the project is to develop superconducting transition edge detector array for precision measurement of the polarization anisotropy of the CMB radiation with the 10-meter South Pole Telescope (SPT) built by the University of Chicago and collaborators.

2. Atomic Force Microscopy
   Understanding the structural organization and distribution of proteins in biological cells is of fundamental importance in biomedical research. The use of conventional fluorescent microscopy for this purpose is limited due to its relatively low spatial resolution compared to the size of a single protein molecule. Atomic force microscopy (AFM), on the other hand, allows one to achieve single-protein resolution by scanning the cell surface using a specialized ligand-coated AFM tip. However, because this method relies on short-range interactions, it is limited to the detection of binding sites that are directly accessible to the AFM tip. We propose to explore a method based on magnetic (long-range) interactions to study binding of biofunctionalized superparamagnetic nanoparticles to the cancer cells. Considering its high spatial resolution and ability to "see" magnetically labeled proteins at a distance of up to 150 nm, this approach could be applied for investigating the dynamics of individual proteins on the cell membrane, as well as to understand the process of the nanoparticles uptake by the cell.

DIS Infrastructure Assurance Center.
This project will apply science and analytical tools to help solve homeland security problems involving research dependency and interdependency failures of key critical infrastructure outages (e.g., Northeast Power Outage, natural disasters). Conduct open source research on critical infrastructure facilities (e.g., stadiums, large office buildings, substations, telecommunication hotels). IAC group can accommodate multiple teachers. No previous homeland security experience necessary. Skills needed are good research skills and basic MS Office proficiency.

MCS Scientific Computing

Computation plays an increasingly important role in many sciences, complementing and in some cases, replacing traditional experiment-based methods. Scientific computing involves the creation of mathematical models and numerical solution techniques, which are then applied to numerous scientific or engineering problems. Depending on the problem being solved, large-scale parallel computing resources may be required. Research in the area of scientific computing is inherently multidisciplinary, involving applied mathematicians, scientists from diverse fields (e.g., physics, chemistry, biology), and computer scientists. The researchers at the Mathematics and Computer Science Division work closely with scientists in many fields with the ultimate goal of making scientific computing a reliable, high-performance tool for advancing science. Note: candidates do not need to be computer specialists or have programming experience.

NE 1) Preparation of Instructional Materials on the Fundamentals of Nuclear Technology and Nuclear Energy

This is an opportunity to work in close collaboration with senior Argonne staff members on development of instructional materials for conveying the fundamentals of nuclear technology and nuclear energy. A teacher will focus on one or more of the areas outlined below, depending on his/her interests and time available. The target level of the instructional materials would include international course participants having no previous background in nuclear energy or advanced placement high school classes in the physical sciences or energy-related topics. The expected deliverable would be a PowerPoint or similar classroom presentation, with accompanying lecture notes and activities, if applicable. Up to three participants could be accommodated, with the possibility of working as a team on multiple topics.

1. History and Fundamentals of Atomic and Nuclear Physics – Early discoveries (including people involved): radioactivity; alpha, beta, gamma decay; discovery of the neutron; development of the nuclear model of the atom; discovery of nuclear fission; the liquid-drop model of fission; the fission chain reaction; concepts of cross-sections and reaction rates.

2. Radiation, Radiation Detection and Radiation Protection - Radioactive decay and half-life; interactions of radiation with matter; types of detectors; concepts of radiation protection - distance, time, shielding; dose measurements and units; allowable doses. (This topic would lend itself well to laboratory demonstrations of radiation detection and shielding.)

3. Non-reactor Uses of Nuclear Technology - Isotope production; medical uses of isotopes for diagnosis and treatment of disease; industrial uses - gages, well-logging, gemstone enhancement, etc.; activation analysis and applications; food and water purification; isotope hydrology; agricultural uses.

4. Nuclear Reactors - The status of nuclear power plants and research reactors in the world; the role of nuclear power in national energy planning; types of power and research reactors; fundamentals of how a reactor works - chain reaction, neutron balance, control rods; fundamentals of power production.

5. Safety Culture in Organizations - The underlying principles that impact the culture in an organization; development of a good organizational culture developed; the consequences of healthy vs. dysfunctional culture; impact of

organizational culture on safety and product quality; ways to improve culture, especially safety culture.

6. Introduction to Thermodynamics - Laws of thermodynamics; basic concepts of heat and energy; different forms of energy; changing energy from one form to another; thermodynamic efficiency; dimensional analysis; practical examples of thermodynamic concepts; introduction to heat transfer in solids and liquids.

EVS

1) Integrated assessment for sustainability of bio-energy development at a large watershed scale.

This project is a part of the energy-water nexus initiative at University of Chicago and Argonne. The project has established a model for Mississippi River Basin to simulate hydrological processes, energy crop development/management, changes in land use, water use for other major energy developments in the region, and chemical runoff under the current and future climate forcing conditions. The various, limited tasks are available to perform assessments based on available observed data and simulated results for the region.

2) Research for the Solar Energy Development Programmatic Environmental Impact Statement

This project is designed to facilitate environmentally responsible solar development on public lands in western United States. The primary areas of interest and background from the teacher are: renewable energy, land use planning, energy policy, air and water quality, and global warming. The teacher will undertake a limited portion of this research project, one that can be completed in the 8-week timeframe.

THE END