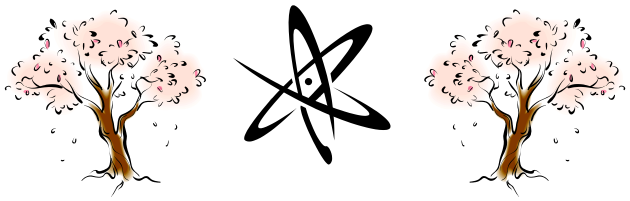
University of Washington

Physics Colloquium Schedule

Spring Quarter 2009



Mondays, 4:00 P.M. Ronald Geballe Auditorium, Rm. A102
Coffee & cookies at 3:45 P.M. in the lobby

www.phys.washington.edu/colloquia.htm
~Spring Quarter Colloquium Chair: Professor Anna Goussiou~

March 30

Dimitri Kusnezov (National Nuclear Security Administration, DoE)
Title: *"The New Frontier of Computational Science: Applications to High Leverage Decisions"*
Abstract: Today's supercomputers have already surpassed the petaflop mark. Is there something new to be had here, or should we expect more of the same, only faster? While there are many technical challenges at this scale, I believe it symbolizes the scale at which our approach to computational science - today's archetype - requires revision. We are reaching the point where raw computational power is no longer the limiting factor - rather what constrain us are our vision and our ability to ensure the veracity of our predictions. Computing at the petascale will open doors to discovery, and we must not be limited by the current way we approach computing. At the same time, expectations for great achievement will likely outpace our ability to effectively use these systems for innovation. This is becoming critical as these results have the potential to exert greater influence on high-consequence decisions.

April 6

Anton Zeilinger (University of Vienna and Institute of Quantum Optics and Quantum Information, Austrian Academy of Sciences)
Title: "*Entangled Photons from the Foundations of Quantum Physics to Quantum Information"*
Abstract: Entanglement of photons, besides being of fundamental interest, is central to many quantum information protocols like quantum cryptography, quantum teleportation and all-optical one-way quantum computation. In entanglement-based quantum cryptography an automatic system for the encoding of voice mail or video streams was developed. Recent experiments also include novel fundamental tests of quantum physics. In one series of experiments entangled photons are distributed between the Canary islands of Tenerife and La Palma separated by 144 km.These allow for the first time a Bell test implementing the so-called free will condition.

April 13

Bill Dougherty (Applied Precision, Inc.)

Title: *"Super-Resolution: Fluorescence imaging of biological structure well-below the diffraction limit"*

Abstract: Cell biologists are never satisfied. The most tantalizing cellular structures always seem to be just beyond the resolution of the best optical microscopes of the day. Although physics may never relieve this condition, practical new fluorescence microscopies just now appearing in the biology laboratories offer resolutions of 100–10 nm, up to an order of magnitude better than the Abbé limit. No physical laws are broken, but these inventions entail some pretty clever lawyering. Information is encoded into a series of images that separately obey the classical diffraction rules, but permit the recovery of a high resolution image through (generally heavy) computation. We will review the physics behind 3D structured illumination microscopy (3D-SIM), STED, PALM, non-linear SIM and other optical microscopies currently moving out of the physics lab and into the biology lab. Compelling new images will reward our efforts. The biologists are cheered, if not satisfied.

April 20

Bob Rutledge (McGill University)

Title: "*Measuring the Dense Matter Equation of State with the International X-ray Observatory"*

Abstract: Observations of the thermal emission from hydrogen atmosphere neutron stars can provide simultaneous measurements of neutron star masses and radii, made possible with future large-collecting area, high spectral resolution X-ray observatories. In this talk, I will briefly review the observational situation of neutron star radii measurements using this technique, where future observations are headed, and how observations with the proposed International X-ray Observatory can provide tight, simultaneous measurements of both neutron star masses and radii. These methods will be sufficient for determining the dense matter equation of state, which has challenged nuclear physicists for decades.

April 27

Rajan Gupta (Los Alamos National Laboratory)

Title: *Geospatial Cognition and Understanding of Global Energy Systems*

Abstract: Energy systems are enormous, complex, dynamical and adaptive. Understanding them is crucial as energy is the key to development and is the basis of modern technological societies and, at the same time, because of rising concern for associated environmental impacts and contributions to climate change. Fossil fuels (oil, coal, and gas) provided over 80 percent of the energy in the 20th century and will, most likely, persist well into the 21st century in spite of our best intentions.

How does one help transform existing and planned regional approaches to provide affordable clean energy to 9 (maybe 10) billion people in the coming decades? I will review the global situation and describe the Global Energy Observatory project to build, with public participation, a comprehensive picture of the world's energy systems so that we can understand regional variations, choices, and needs, and follow their full cycle: from sources to generation to global movements to use to impacts.

May 4

Neil Weiner (Center for Cosmology and Particle Physics, New York University)

Title: *Illuminating Dark Matter*

Abstract: The existence of dark matter has been confirmed by a wide variety of experiments, on a wide variety of length scales. However, the nature of the dark matter remains elusive. One intriguing class of candidates - weakly interacting massive particles or "WIMPs" - offer the prospect of detection in cosmic rays, in direct detection experiments, and at colliders. Of late, there has been an increasing set of experimental signals, principally from cosmic rays, which may be providing a first sign of dark matter. I will explore the range of signals and anomalies, and the challenges of understanding all of them in terms of dark matter. We will see that, if dark matter is responsible for these anomalies, it may be pointing us to a much richer set of physics in the dark sector.

May 11

LuAnne Thompson (UW School of Oceanography)

Title: *Climate Change and Ocean Physics*

Abstract: Understanding the physics of the ocean is essential for understanding and grappling with global warming. Besides acting as a sink for carbon dioxide, the ocean stores and transports heat, and plays a key role in the hydrological cycle. In this talk, I will discuss how climate models are being used or misused to quantify the role that the ocean plays both in short term and long term climate change. Climate system models include a dynamical atmosphere, ocean, cryosphere, sometimes biosphere, and the coupling among these subsystems. However, climate models have deficiencies, both because of the because of lack of computational power in the current generation of computers and lack of understanding of the fundamental physics of the each component of the climate system. Important physical processes in the ocean span from dissipation of turbulent motions at the molecular scale to adjustments to changes over centuries in the deepest parts of the ocean. Thus, in order to model long term climate variability and change, we must parameterize sub grid scale motions. Despite advances in understanding ocean physics, these parameterizations are still lacking, and ocean models are still challenged to accurately represent how the ocean advects and stores heat. Two examples will be briefly discussed in this context: the role of ocean circulation changes in abrupt climate change, and decadal predictability from coupled ocean-atmosphere modes of variability.

May 18

Rocky Kolb (Fermi National Accelerator Laboratory and University of Chicago) (Boris Jacobsen Memorial Lecture: selected by UW Physics Grad Students)

Title: *Dark Energy: Taking Sides*

Abstract: Dark energy is the name for the phenomenon responsible for the apparent acceleration of the expansion of the universe. Although dark energy may comprise as much as 70% of the present mass-energy of the universe, there is no persuasive explanation for its existence or magnitude.

In the colloquium I will review various proposals for the phenomenon known as dark energy.

May 25 **No Colloquium**
Memorial Day Holiday

June 1 **Thomas Loftus (UW Physics)**

Title: *An Improved Limit on Permanent Electric Dipole Moment (EDM) of ^{199}Hg*

Abstract: A finite permanent electric dipole moment (EDM) of a particle or atom would violate time reversal symmetry *(T)*, and would also imply violation of the combined charge conjugation and parity symmetry *(CP)* through the *CPT* theorem. EDMs are suppressed in the standard model of particle physics (SM), lying many orders of magnitude below current experimental sensitivity. It is generally accepted, however, that extra sources of *CP* violation are needed to account for baryogenesis and many theories beyond the SM, such as supersymmetry, naturally predict EDMs within experimental reach.

To date, EDM searches have yielded null results. The most precise and significant limits have been set on the EDM of the neutron[1] , the electron[2], and the ^{199}Hg atom[3], leading to tight constraints on supersymmetric extensions of the SM. I will describe the results from a new experimental search for the EDM of ^{199}Hg. We find $d(^{199}\mathrm{Hg}) = (0.49 \pm 1.29_{stat} \pm 0.76_{syst}) \times 10^{-29}\, e$ cm, and interpret this as a new upper bound, $d(^{199}\mathrm{Hg}) < 3.1 \times 10^{-29}\, e$ cm (95% C.L.)[4]. This result improves our previous ^{199}Hg limit by a factor of 7 and offers a yet more exacting probe of possible new sources of CP violation.

The experiment utilizes a stack of four spin-polarized Hg vapor cells in a common *B*-field. The middle two cells have oppositely directed *E*-fields, resulting in EDM-sensitive Larmor shifts of the opposite sign; the outer two cells, enclosed by the high voltage (HV) electrodes and thus placed at $E = 0$, are free of EDM effects and instead allow cancelation of *B*-field gradient noise and checks for spurious HV-correlated *B*-field shifts. The dataset consists of 166 runs, with each run lasting roughly 24 hours and compromising several hundred *E*-field reversals. Measurements were performed for nine different vapor cells, four electrodes, two cell-containing vessels, and multiple vapor cell and electrode orientations. An unknown, HV-correlated, EDM-mimicking offset was added to the fitted values of the middle cell precession frequencies. This fixed blind offset masked the measured EDM and was revealed only after the data collection, data cuts, and error analysis were complete.

In addition to experimental results, I will briefly outline the resulting new upper bounds on fundamental CP violating parameters.

[1] C.A. Baker, *et al.*, Phys. Rev. Lett. **97**, 131801 (2006).
[2] B.C. Regan, *et al.*, Phys. Rev. Lett. **88**, 071805 (2002).
[3] M.V. Romalis, *et al.*, Phys. Rev. Lett. **86**, 2505 (2001).
[4] W.C. Griffith, *et al.*, Phys. Rev. Lett. 102, 101601 (2009).