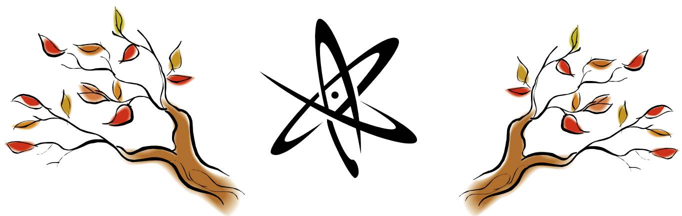
University of Washington

Physics Colloquium Schedule

Autumn 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
~Autumn Quarter Colloquium Chair: Professor Nikolai Tolich~

October 5

Ivan Deutsch (University of New Mexico)
Title: *"Quantum Control and Measurement: Two Keys to Quantum Information Processing"*
Abstract: When we first learn about quantum mechanics it appears to be a paler version of classical physics. Quantities are fundamentally uncertain, random, and one cannot measure one thing without disturbing another. This notion cannot be further from the truth. Quantum physics is now understood to be fundamentally MORE powerful for performing certain information processing tasks, from factoring large numbers to sharing secrets. Bringing this promise into laboratory and ultimately real devices has been a grand challenge. In this colloquium I will discuss two key components -- quantum control and measurement. These are flip sides of the same coin. In quantum control, one applies an external force to affect a dynamical map on the system of interest. In quantum measurement, information about the system is mapped to the probe, which can then be detected as a macroscopic signal. These paradigms are explored in a near ideal platform -- ultracold atomic spins controlled and measured through magneto-optical interactions. I will discuss the theoretical development of new protocols and their implementation in the laboratory in collaboration with Prof. P. S. Jessen.

October 12

Mark G. Raizen (University of Texas at Austin)
Title: *"Comprehensive Control of Atomic Motion"*
Abstract: The method of laser cooling has opened the door to low temperature physics of dilute gases. Despite the great success of this method, it has been limited to a very small set of atoms in the periodic table and no molecules. I will describe in this talk new approaches to trapping and cooling that have been developed in my group. The first step uses pulsed magnetic fields to stop atoms and molecules where they

can be magnetically trapped. The next step is an experimental realization of informational cooling as first proposed by Leo Szilard in 1929 in an effort to resolve the paradox of Maxwell's demon. Together, these provide a two-step comprehensive solution to trapping and cooling.
I will describe our progress in applying these new methods to trapping and cooling of hydrogen isotopes. In the short term, we are working to trap hydrogen and deuterium, which will serve as a step towards trapping of atomic tritium. This system will be used for precision measurement of beta decay towards determination of the neutrino rest mass. Our methods are also very applicable to trapping and cooling of anti-hydrogen, and a collaboration at an accelerator laboratory is being pursued.

October 19

Mark Strikman (Pennsylvania State University)
Title: *Nucleon Close Encounters*
Abstract: Novel processes probing the decay of nucleus after removal of a nucleon with momentum larger than Fermi momentum by hard probes finally proved unambiguous evidence for long sought presence of short-range correlations~(SRCs) in nuclei. Analysis of these processes in combination with the analysis of several other processes allows us to conclude that in heavy nuclei about 25% of nucleons have momenta above the Fermi momentum and predominantly belong to proton - neutron pairs. The observed absolute probabilities and the isospin structure of two nucleon SRCs confirm the important role that tensor forces play in I nternucleon interactions. We find also that the presence of SRCs leads to a significantly faster neutrino cooling of cold neutron stars and plays an important role in the fragmentation of nuclei in heavy ion collisions. We also outline directions for future theoretical and experimental studies of the nucleonic and quark-gluon structure of two and three nucleon SRCs at high energy electron and hadron facilities.

October 26

Spencer Klein (Lawrence Berkeley National Laboratory and University of California, Berkeley)
Title: *Searching for Neutrinos from Extreme Accelerators in Antarctic Ice*
Abstract: Large surface detectors have observed cosmic rays with energies up to $3*10^{20}$ eV, comparable to the energy of a well hit tennis ball. However, despite decades of effort we still know little about the sources of these energetic particles. Cosmic neutrinos have many advantages over cosmic nuclei - they interact weakly, so can escape from dense sources, and, being uncharged, are not affected by interstellar magnetic fields.   IceCube, a 1 km^3 neutrino detector is being built at the South Pole, to search for 100 GeV to 100 EeV (1 EeV = 10^{18} eV) neutrinos from cosmic accelerators. It is currently about 2/3 complete. In this talk, I will discuss how IceCube works, and present some recent results using data from the partially completed detector. I will also discuss future initiatives toward a 100 km^3 detector to search for radio pulses from EeV neutrinos.

November 2 **Marc Kamionkowski (California Institute of Technology)**
Title: *Is the Universe (Statistically) Isotropic?*
Abstract: Inflation predicts that the Universe is homogeneous and isotropic---that is, it is the same everywhere and in every direction. Cosmological homogeneity and isotropy are generally *assumed* to be true, but this is a prediction that can be tested quantitatively. I will first discuss some new tests of statistical homogeneity and isotropy. I will then review briefly some recent evidence that may show a departure from homogeneity and present a theoretical model that may account for this anomaly. In the last few minutes, I may speculate wildly about the pre-inflationary Universe.

November 9 **Aleksei Aksimentiev (University of Illinois at Urbana-Champaign)**
Title: *Physical Approaches to Sequencing DNA*
Abstract: After water and oxygen, DNA is, very likely, the most famous molecule of life known to men. This is not surprising, as we all know that an eye-catching, double-helical molecule of DNA carries instructions to manufacture and assemble all the components of a living organism. The wealth of information encoded in DNA often overshadows its unusual physical properties, for example, the possibility of effective attraction between same-charge DNA molecules. Furthermore, the methods used to determine the informational content of DNA—its nucleotide sequence—until now relied on biological processes. The high cost of the conventional DNA sequencing procedures limits the application of personal genomes in medicine. In this talk, I will describe our recent efforts to characterize the physical properties of DNA through atomistic simulations and demonstrate how these properties can be exploited in a physics-based technology for sequencing DNA.

November 16 **Renee D. Diehl (Pennsylvania State University)**
Sam Fain Symposium
Title: *Sam Fain's Legacy- Keep it Simple!*
Abstract: Much of Sam Fain's research output was concerned with understanding two-dimensional matter. He studied the simplest forms of 2D matter in order to obtain the deepest and most general understanding of the effects of dimensionality on its properties. Many of his discoveries have maintained their relevance in the study of more complex systems, and the experimental techniques that he invented are in use around the world.
Over the past 30 years, the field of Surface Science has been driven by technological demands, such as the development of better catalysts, ever-smaller integrated circuits, nanostructures, molecular motors, systems for drug delivery and more. As the systems become more complex, it is useful to keep in mind that much of the understanding of these complex systems builds on the fundamental understanding established over the years.
In this talk, I will present a few examples of studies of complex surfaces that form part of the connection between the simple systems studied by Sam Fain and the technological innovations that transform our world.

November 23 **Elio Abbondanzieri (Harvard)**

Title: *Molecular Gymnastics: The Dynamic Binding Orientations of HIV Reverse, Transcriptase*

Abstract: Genetic information is encoded in the nucleic acids DNA and RNA in all organisms. However, it is only through the interaction of proteins with these nucleic acids that this genetic code can be dynamically processed to create life as we know it. Recent advances in fluorescence microscopy have made it possible to probe these crucial interactions at the molecular level in real time. Here, we developed a single-molecule assay to probe the interactions between nucleic acid substrates and a multifunctional enzymatic protein, reverse trancriptase (RT) from HIV. These experiments revealed distinct orientational dynamics of RT on different substrates. RT adopted opposite binding orientations on duplexes containing generic DNA or RNA primers, directing the DNA synthesis or RNA hydrolysis activity, respectively. The relative binding energies of each orientation were governed by the backbone composition at specific nucleotides within the primer. On duplexes containing specific sequences from the HIV genome the enzyme can bind in both orientations, rapidly flipping between the two states without releasing the substrate. On longer duplex substrates, RT was observed to bind at the front and back ends of the duplex and to shuttle between these positions. Shuttling allowed RT to find ends of the nucleic acid rapidly to perform synthesis of new DNA. Shuttling also allowed RT to zip up a frayed duplex displaced by a third nucleic acid strand. These results indicate that the enzymatic activities of RT are determined by its binding orientation on the substrate. Furthermore, by rapidly altering its binding orientation RT is able to catalyze enzymatic reactions more efficiently.

November 30 **Vitaly Efimov (UW Physics)**

Title: *What are Efimov States and How are they Observed in Ultracold-Atom Experiments?*

Abstract: Quantum mechanics predicts the existence of giant few-body systems, many times larger than the characteristic length scale of the interparticle forces. These systems can be atomic or nuclear. Quantum mechanics says the mechanism responsible for the existence of such systems is universal. A striking feature of this prediction is that if one such giant is spotted, you can be sure many more may exist, with all of them essentially being copies of one another zoomed in or out by a factor of (22.7)^n , n = 1, 2, ...

The first evidence for the existence of a giant was obtained in 2006 in an experiment with an ultracold gas of cesium atoms. Since then the hunt for the giants has become a hot topic of ultracold physics. I will briefly review recent advances in this field, including the confirmation of the 22.7 scaling factor in experiments with ultracold gases of potassium and lithium atoms.

December 7 **Paul Kinahan (UW Imaging Research Laboratory)**
Title: *TBA*
Abstract: TBA