

Spring Quarter 2008 Physics Colloquia

March 31

Title: Preparing for physics at the LHC with the ATLAS experiment

Speaker: Fabiolla Gianotti, CERN

Host: Anna Goussiou

Abstract: The CERN Large Hadron Collider (LHC) will start operation in Summer 2008. I will review the LHC main physics goals, and the status of the accelerator and of the ATLAS experiment, with emphasis on the presently-ongoing detector commissioning with cosmic runs.

I will then discuss a few examples of physics measurements that can be performed with the very first data in 2008-2009.

Special Colloquium, Wed. April 2

Title: The Origin of the Universe and the Arrow of Time

Speaker: Sean Carroll, Caltech

Host: Eric Adelberger

Abstract: Over a century ago, Boltzmann and others provided a microscopic understanding for the tendency of entropy to increase. But this understanding relies ultimately on an empirical fact about cosmology:

the early universe had a very low entropy. Why was it like that?

Cosmologists aspire to provide a dynamical explanation for the observed state of the universe, but have had very little to say about the dramatic asymmetry between early times and late times. I will argue that the search for a natural explanation for the observed breakdown of time-reversal symmetry in cosmology leads us directly to interesting conclusions about inflation, quantum gravity, and the multiverse.

April 7

Title: 2-D Non-linear Electrophoresis for Bio-Molecule Concentration

Applications to Forensics and Metagenomics

Speaker: Andre Marziali, University of British Columbia

Host: Jens Gundlach

Abstract: We present a novel technique capable of electrophoretically isolating and pre-concentrating nucleic acids to at least 10,000 fold DNA enrichment from dilute solutions, allowing a similar increase in the sensitivity of subsequent detection steps. Due to the non-mechanical nature of the process, it is also possible to isolate and extract high molecular weight DNA up to 1Mb in length without shearing, making this method very useful for metagenomics – the study of unculturable organisms by DNA analysis.

Taking advantage of DNA's non-linear response to electric fields, we apply a novel form of 2-D nonlinear electrophoresis such that rotating electric fields cause specific DNA fragments to concentrate in a tight central focus. We achieve powerful separation and high concentration of DNA from contaminants without the clogging, losses, cost, and

mechanical shearing associated with filtration. This technique represents a general method for simple, inexpensive, and selective concentration of nucleic acids that is particularly well suited for low abundance or high molecular weight DNA purification.

In recent results, we show detection of DNA at zeptomolar concentrations, by pre-concentration followed by PCR. This talk will present an overview of this technology, and applications to forensics and metagenomics.

April 14

Title: From Bach to Einstein and Beyond *or* What is to be done?

Speaker: Vladimir Chaloupka, University of Washington

Abstract: Issues of Science and Society will be examined in a musico-logical setting (with emphasis on the hyphen). An experimental test of “How well tempered was Bach’s clavier?” will be mentioned, and the audience will be invited to contemplate a quantum-mechanical puzzle. After debunking several myths about Albert Einstein, the question “What have we learned from nuclear physics?” will be discussed and the theories of the Basic Problem and Big Gap will be presented. Experience with teaching physics majors and English majors in the same classroom will be described, and a report on a recent expedition to the Center for Governance and International Affairs at the University of Bristol will follow. The final summary (and the subtitle of the talk) might be reminiscent of the most famous piece by the speaker’s infamous namesake. It is hoped that by the end of the talk, the somewhat unlikely combination of topics will merge into a coherent whole.

April 21

Title: Precision length measurements in LIGO: Finding gravitational waves and more

Speaker: Stefan Ballmer, Caltech

Host: Eric Adelberger

Abstract: The Laser Interferometer Gravitational-Wave Observatory finished its two-year long science run last fall. While the analysis of this data set is still underway, some preliminary results that are of astrophysical interest have already been published. I will discuss these results in this talk.

Meanwhile the LIGO interferometers embarked on an incremental upgrade path that will ultimately, with the completion of the Advanced LIGO project, reach an at least ten times better sensitivity. This promises the observation of astrophysical events on a regular basis. But it also makes the interferometers themselves interesting to fundamental science, as effects such as the pondermotive squeezing of the light resonating in the interferometer and the optical cooling of macroscopic mirrors become relevant. In addition, laboratory measurements of space-time curvature effects like the Shapiro Time delay will become feasible.

April 28

Title: Measuring Holographic Noise

Speaker: Craig Hogan, Univ. of Washington

Abstract: A controversial but enduring idea in quantum gravity is that spacetime is "holographic", that is, a complete description of the world is possible on a 2D surface using fields with a Planck scale UV cutoff. Some of the motivation for this conjecture, such as quantum unitarity of black hole evaporation, will be reviewed. An even more controversial phenomenological consequence of this idea is that world should be blurred in a particular way: there should be an indeterminacy of transverse relative position, associated with the information limits of a 2D system. The talk will show that this indeterminacy would lead to a new kind of "holographic noise" that should be detectable in some currently-operating interferometers, whose measured noise power spectral density is now of the order of the Planck time, depending on the design of the system. The spectrum in absolute units of the noise, as well as its spatial character, can be predicted with zero parameters, providing a direct and meaningful probe of quantum gravity.

May 5

Title: Looking for WIMPs in the Galactic Halo: the Search for Dark Matter using Ultra-Cold Particle Detectors

Speaker: Daniel Akerib, Case Western University

Host: Eric Adelberger

Abstract: Overwhelming observational evidence indicates that most of the matter in the Universe consists of non-baryonic dark matter. One possibility is that the dark matter is Weakly-Interacting Massive Particles (WIMPs) that were produced in the early Universe. These relics could comprise the Milky Way's dark halo and provide evidence for new particle physics, such as Supersymmetry. After reviewing some of the evidence for dark matter and the WIMP hypothesis, I will describe the Cryogenic Dark Matter Search experiment, CDMS-II, which aims to see WIMPs using athermal-phonon and ionization sensitive detectors housed in a low-radioactive 20-milli-Kelvin environment 2000 feet below ground. Our searches have yielded some of the most sensitive limits to date on the interactions of WIMPs in the galactic halo with terrestrial detectors and begun to rule out some of the supersymmetric parameter space. I will report on these results, as well as the current status of the ongoing run of CDMS-II and our preparations for carrying out a next generation experiment, the SuperCDMS 25 kg experiment.

May 12

Title: Atom Traps, Krypton-81 and Saharan Water

Speaker: Zheng-Tian Lu, Argonne National Laboratory

Host: Blayne Heckel

Abstract: Since radiocarbon dating was first demonstrated in 1949, the field of trace analyses of long-lived cosmogenic isotopes has seen steady growth in both analytical methods and applicable isotopes. The impact of such analyses has reached a wide range of scientific and technological areas. A new method, named Atom Trap Trace Analysis (ATTA), was developed by our group and used to analyze ^{81}Kr ($t_{1/2} = 2.3 \times 10^5$ years, isotopic abundance $\sim 1 \times 10^{-12}$) in environmental samples. In this method,

individual ^{81}Kr atoms are selectively captured and detected with a laser-based atom trap. ^{81}Kr is produced by cosmic rays in the upper atmosphere. It is the ideal tracer for dating ice and groundwater in the age range of 10^4 – 10^6 years. As the first real-world application of ATTA, we have determined the mean residence time of the old groundwater in the Nubian Aquifer located underneath the Sahara Desert. Moreover, this method of capturing and probing atoms of rare isotopes is also applied to experiments that study exotic nuclear structure and test fundamental symmetries.

May 19

Title: Quantum Criticality and Black Holes

Speaker: Subir Sachdev, Harvard University

Host: Andreas Karch

Abstract: I will describe antiferromagnets and superconductors near quantum phase transitions. There is a remarkable analogy between their dynamics and the holographic description of Hawking radiation from black holes. I will show how insights from this analogy have shed light on experiments on the cuprate high temperature superconductors.

May 26 Holiday

June 2 *Boris Jacobsen Memorial Lecture: selected by UW Physics Grad Students*

Title: Nanocarbon: from terahertz transistors to atomic membranes

Speaker: Paul L. McEuen, Cornell University

Host: David Cobden

Abstract: Carbon takes many forms, from precious diamonds to lowly graphite. Surprisingly, it is the latter that is the most prized by nano physicists. Graphene, a single layer of graphite, can serve as an impenetrable membrane a single atom thick. Rolled up into a nanometer-diameter cylinder--a carbon nanotube --it makes great 1D transistors, quantum dots, and nanoguitar strings. In this talk, I will review some of our group's recent results on these remarkable materials, including ultrafast measurements of ballistic transport in nanotubes, studies of topological spin-orbit effects that arise from a nanotube's cylindrical geometry, and inflating a graphene balloon that is one atom thick.