Hans Bethe will be presented. An overall personal perspective on nuclear physics in the 21st century will conclude the talk.

2008-2009

General Colloquium: Jim Allen, Katie Freese

Fall 2008: http://www-personal.umich.edu/~jwallen/F08Colloq/

Sept. 3, 2008

- **Myron Campbell**, Chair, Physics Department, University of Michigan
-
- *"State of the Department"*

Sept. 10, 2008

- **William Happer**, Princeton University
-
- *"Gas-Cell Spin Physics"*
-
- Research on optically pumped, spin-polarized, alkali-metal atoms in inert buffer gases like nitrogen or argon continues to provide unexpected and useful new physics. Applications of these simple systems include atomic clocks, magnetometers, hyperpolarized He3 and Xe129 gases for medical imaging and precision measurements. Alkali-metal atoms in buffer gases can be efficiently pumped with inexpensive lasers, and they lose their spin polarization very slowly in collisions with the buffer gas or with the cell walls. Unraveling the causes of the spin relaxation has provided many unexpected insights into optical, gas-phase and surface interactions -- many of which are important in atomic clocks.

Sept. 17, 2008

- **Rachel Bean**, Cornell University
-
- *"Dark Energy Schizophrenia"*
-
- We discuss the current status of theoretical investigations into the nature of dark energy. As well as Einstein's cosmological constant a variety of alternative scenarios, including novel matter and modifications to General Relativity, are currently under consideration. We discuss expected observational implications for matter and gravity-based theories and how these can provide insights into dark energy's underlying origin.

Sept. 24, 2008

- **David Smith**, University of California Santa Cruz
-
- *"Gamma-rays from Lightning"*
-
- Although lightning has been studied since the days of Franklin, a surprising number of open questions about it remain, in particular the triggering mechanism for the lightning strike. Electric fields in thunderclouds are high, but never high enough to directly drive the conventional electrical breakdown of air. Over the last sixteen years, a candidate triggering mechanism called relativistic breakdown has been theoretically developed, starting from an insight first described by C. T. R. Wilson in 1925. At the same time, observations of gamma-rays associated with thunderstorms have been made from the ground, from aircraft and high-altitude balloons, and from observations in low-Earth orbit. The most dramatic of these observations are the Terrestrial Gamma-ray Flashes (TGFs), millisecond bursts of gamma-rays up to > 20 MeV visible from space. These bursts are probably bremsstrahlung from electrons accelerated in the relativistic breakdown process. I will review both the observational and theoretical developments and show how we are poised to answer the most important remaining questions in the next few years.

Oct. 1, 2008

- **Sharon Glotzer**, University of Michigan
-
- *"Self Assembly of Nanoparticles and Colloids: The Shape of Things to Come"*
-
- Recent breakthroughs in particle synthesis leading to nanocolloidal particles of unusual shape and patterning have paved the way for a revolution in materials formed from the self-assembly of these building blocks. The unprecedented anisotropy of today's new nanoparticle and colloidal building blocks starkly contrasts with the isotropic, spherical colloids that have been the focus of particle assembly for more than a generation. No general theory exists to predict the range of structures possible for these new building blocks as a function of thermodynamic conditions, and the complementary problem of inverse design of a particular building block that can self-assemble into desired target structure is difficult with as yet no standard design algorithm. In this talk, we discuss the physics of self-assembly of these new building blocks and present a conceptual framework with which to consider the key factors controlling their assembly. We present results of computer simulations of patchy particle design and assembly, and show how various measures of anisotropy, including particle shape, patterning, functionalization and interaction selectivity, can be combined and exploited to achieve complex mesoscale one-, two- and three-dimensional structures such as wires, sheets, virus-like shells and colloidal "molecules," diamond, icoshedral, gyroid, and other complex structures through self-assembly, with applications ranging from energy to communications to medicine and beyond.

Oct. 8, 2008

- **Will Kinney**, University at Buffalo
-
- *"Inflationary Cosmology: Where are we, and where are we going?"*
-

- Inflationary cosmology has emerged as the most compelling model for the physics of the very early universe. New cosmological observations such as that from the WMAP satellite and the Sloan Digital Sky Survey have achieved unprecedented precision: Uncertainties in cosmological parameters such as the curvature of space and the density of matter have shifted from order unity to of order a few percent. As a result, it is possible for the first time to place meaningful constraints on the physics of the universe during the epoch of inflation, when the universe is believed to have expanded exponentially and quantum processes created the seeds for structure in the universe. I will review the current status of observational constraints on inflation, and discuss where we may be headed over the next few years.

Oct. 15, 2008

- **Gabi Kotliar**, Rutgers University
-
- *"Strongly Correlated Electron Systems: a Dynamical Mean Field Theory Perspective"*
-
- Correlated electron systems display a plethora of remarkable phenomena ranging from metal to insulator transitions and high temperature superconductivity to anomalous thermoelectricity and volume collapses. They continue to surprise us with their exceptional physical properties and the prospectives for new potential applications. The discovery of interesting strongly correlated compounds was always the result of serendipity, and the application of the Edisonian approach. For example, this year high temperature superconductivity was found in layered materials based on iron arsenides.
-
- From a theoretical perspective correlated electron systems pose one of the most difficult non-perturbative problems in physics. In the past decade there has been significant progress in the description of the electronic structure of correlated materials through the development of the dynamical mean field theory (DMFT) approach. In this colloquium I will introduce the subject of strongly correlated electron systems and DMFT. We will then show some applications of the method to problems previously untractable with other methods. We will conclude with the challenges ahead and the prospective for facing the grand challenge of material design using strongly correlated electron systems.
-
- References:
- G. Kotliar *et al*., Reviews of Modern Physics **78**, 000865 (2006).
- G. Kotliar and D. Vollhardt, Physics Today **57**, 53 (2004).

Oct. 22, 2008: Ta-You Wu Lecture

- **Frank Wilczek**, Massachusetts Institute of Technology
-
- *"The Universe is a Strange Place"*
-
- Over the course of the twentieth century we have constructed a very successful fundamental theory of the behavior of matter. Viewed in this perspective, the world looks very different from our everyday reality. It is a very strange place, and a beautiful one -- in particular, we've come to understand that the building blocks of matter appear as notes in a Music of the Void. I'll describe this using a combination of facts, pictures, and

jokes. Finally I'll discuss some recent discoveries indicating that the world is even stranger than we've understood so far, and how we're rising to the challenge.

Oct. 29, 2008

- **John Goodenough**, University of Texas
-
- *"Lessons From Transition-Metal Oxides"*
-
- Three lessons will be highlighted: (1) the first-order character of localized to itinerant electronic transitions and its consequences for high-Tc superconductivity in the copper-oxides at a quantum critical point (QCP); (2) the intrinsic octahedral-site distortions in orthorhombic perovskites and how their bias of Jahn-Teller distortions without and with the presence of spin-orbit coupling influences orbital and magnetic transition temperatures as well as changes from Type-A antiferromagnetic order to ferromagnetic order in $La_{(1-x)}Y_xTiO_3$ and $LaMn_{(1-x)}Ga_xO_3$; and (3) the itinerant ferromagnetism in the $ARuO_3$ (A=Ca,Sr,Ba) perovskites existing between a Griffiths phase on one side and a Pauli paramagnetic phase on the other side.

Nov. 5, 2008

- **Brian Fields**, University of Illinois at Urbana-Champaign
-
- *"When Stars Attack! Live Radioactivities as Signatures of Near-Earth Supernova Explosions"*
-
- The lifespans of the most massive stars are a symphony of the fundamental forces, culminating in a spectacular and violent supernova explosion. While these events are awesome to observe, they can take a more sinister shade when they occur closer to home, because an explosion inside a certain "minimum safe distance" would pose a grave threat to life on Earth. We will discuss these cosmic insults to life, and ways to determine whether a supernova occurred nearby over the course of the Earth's existance. We will then present recent evidence that a star exploded near the Earth about 3 million years ago. Radioactive iron-60 atoms have been found in ancient samples of deep-ocean material, and are likely to be debris from this explosion. Recent data confirm this radioactive signal, and for the first time allow sea sediments to be used as a telescope, probing the nuclear reactions that power exploding stars. Furthermore, an explosion so close to Earth was probably a "near-miss," which emitted intense and possibly harmful radiation. The resulting environmental damage may even have led to extinction of species which were the most vulnerable to this radiation.

Nov. 12, 2008

- **Peter Cariani**, Harvard Medical School
-
- *"As if time really mattered: temporal codes and music perception."*
-
- Music perception involves the analysis of temporal patterns on both millisecond microtemporal scales (pitch, timbre, consonance) and longer, macrotemporal scales

(durations, rhythms, musical structure). For over 150 years auditory theorists have debated whether the auditory system is best seen as a frequency-domain Fourier analyzer or a time-domain periodicity analyzer. The problem of musical pitch, i.e. the low pitch of harmonic complex tones at their fundamental frequencies, has been at the heart of this debate. At the level of the auditory nerve strong single-unit neurophysiological evidence (J Neurophysiol 76:1698-174) suggests that the early neural representation of musical pitch is based on temporal patterns of spikes (temporal code) rather than in which neurons fire most (channel or rate-place code). The temporal code for pitch is based on global, population-wide distributions of all-order interspike intervals that provide robust, level-invariant autocorrelation-like representations of stimulus periodicities below 4 kHz (the upper limit of musical tonality). Despite considerable recent advances, cortical representation of musical pitch still remains enigmatic. We will also discuss implications of micro- and macroscale temporal codes for timbre, consonance, harmony, rhythm, and auditory grouping phenomena in music perception.

Nov. 19, 2008

- **William Zajc**, Columbia University
-
- *"The Fluid Nature of Quark-Gluon Plasma"*
-
- Collisions of heavy nuclei at very high energies explore the phase transformation from hadronic to partonic degrees of freedom which is predicted to occur at several times normal nuclear density and/or for temperatures in excess of 10^{12} K. Such a state, often referred to as a quark-gluon plasma, is thought to have been the dominant form of matter in the universe in the first few microseconds after the Big Bang. While data from Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) clearly demonstrate that these very high temperatures and densities have been achieved, there is also compelling evidence that the matter does *not* behave as a quasi-ideal state of free quarks and gluons. Rather, its behavior is that of a dense fluid with very low kinematic viscosity, approaching a conjectured viscosity bound obtained via string theory methods. As such, the matter produced at RHIC may be the most perfect fluid ever studied in the laboratory.

Nov. 26, 2008

- No colloquium due to Thanksgiving break.

Dec. 3, 2008

- **Hitoshi Murayama**, University of California – Berkeley
-
- *"The Big World of Little Neutrinos"*
-
- This is the historic era in neutrino physics. I first review the properties of neutrinos and discuss why neutrino masses are interesting probes to physics beyond the Standard Model. Then I discuss how we have recently learned that they do have tiny mass and will learn in the near future how to settle the remaining issues. Finally I argue that neutrino masses may well be relevant to the question "why do we exist" in our universe.

Dec. 10, 2008

- No colloquium now planned -- final exam study day

Winter 2009: http://www-personal.umich.edu/~mcmoops/F08Colloq/

Jan. 7, 2009

-
-

Jan. 14, 2009

- **Myriam Sarachik**, City University of New York
- *"Tunnelling and Deflagration in Molecular Nanomagnets"*
-
- Molecular magnets, or "single molecule magnets", are organic crystals that contain a very large (Avogadro's) number of nominally identical magnetic molecules of large total spin. Straddling the quantum and classical regimes, they exhibit interesting effects such as "macroscopic" quantum tunneling of the magnetization and quantum interference between tunneling paths. Interest in these materials has grown dramatically in the last several years, owing to their potential usefulness as qubits for quantum computation. Typical behavior of the class will be examined by considering Mn12-acetate, a particularly simple prototype. The talk will end with a brief description of our recent discovery of magnetic deflagration, a phenomenon closely analogous to the propagation of a flame front through a flammable chemical substance (combustion).
-

Jan. 21, 2009

- **William Bialek**, Princeton University
- *"Physics Problems in Early Embryonic Development"*

One of the most beautiful phenomena in nature is the emergence of a fully formed, highly structured organism from a single undifferentiated cell, the fertilized egg. Biologists have shown that in many cases the “blueprint” for the body is laid out with surprising speed and is readable as variations in the expression levels of particular genes. As we try to understand how this happens, we face a number of physics problems: How can spatial patterns in the concentration of these molecules scale with the size of the egg, so that organisms of different sizes have similar proportions? What insures that the spatial patterns are reproducible from one embryo to the next? Since the concentrations of all the relevant molecules are small, does the random behavior of individual molecules set a limit to the precision with which patterns can be constructed?

Although the phenomena of life are beautiful, one might worry that these systems are just too complicated and messy to yield to the physicists' desire for explanation in terms of powerful general principles. For the past several years, a small group of us have been struggling with these problems in the context of the fruit fly embryo. To our delight, we have been able to banish much of the messiness, and to reveal some remarkably precise and reproducible phenomena. In particular, the first crucial step in the construction of the blueprint really does involve the detection of concentration differences so small that they are close to the physical limits set by the random arrival of individual molecules at their targets. This problem may be so serious that the whole system for constructing the blueprint has to be tuned to maximize how much signal can be transmitted against the inevitable background of noise, and this idea of optimization is a candidate for a more general principle from which the behavior of such biological systems can be derived.

•

Jan. 28, 2009

- **Gordon Belot**, University of Michigan

"Philosophy of Physics? Why Bother?"

The talk will offer an opinionated overview of the relation between physics and philosophy, past, present, and future.

•

Feb. 4, 2009

- **Keith Olive**, University of Minnesota
- *"BBN Concordance: What's the Matter with Li".*
- An overview of the standard model of big bang nucleosynthesis (BBN) in the post-WMAP era is presented. With the value of the baryon-to-photon ratio determine to relatively high precision by WMAP, standard BBN no longer has any free parameters. In this context, the theoretical prediction for the abundances of D, He4, and Li7 is discussed. The observational determination of the light nuclides is also discussed. While concordance for D is excellent, and acceptable within the uncertainties for He4, the prediction for Li7 exceeds the observational determination by a factor of about four.

Feb. 11, 2009

- **Konrad Gelbke**, Michigan State University
- *"Plans for the Facility for Rare Isotope Beams (FRIB) at MSU"*
- On December 11, 2008, the U.S. Department of Energy (DOE) announced "that Michigan State University (MSU) in East Lansing, MI has been selected to design and establish the Facility for Rare Isotope Beams (FRIB), a cutting-edge research facility to advance understanding of rare nuclear isotopes and the evolution of the cosmos." In this talk I will provide a high-level summary of the envisioned science program, the facility layout and user interface for the planned facility. In addition, I will highlight existing and newly emerging rare isotope research opportunities for future FRIB users who can initiate or participate in cutting edge rare isotope research programs at the existing NSCL, which can seamlessly transition to FRIB.

Feb. 18, 2009

- **Bruce Winstein**, University of Chicago
- *"The Polarization of the Cosmic Microwave Background Radiation"*
- We will review the exciting science that becomes accessible in precise measurements of the CMB, particularly its polarization. After a general introduction, the QUIET experiment which has been collecting data in Chile for nearly 4 months will be discussed. Coherent detectors are used to study the possible Inflationary Gravity Wave Background. A positive detection allows the exploration of physics at the highest imaginable energy scales. The challenges in detecting a signal are formidable: we'll take a little time to consider if the current approach is the ideal one.

Feb. 25, 2009

- Winter Break, No Colloquium

Mar. 4, 2009

- **David Garfinkle**, Oakland University
- *"Black Holes and Gravitational Collapse"*

Several topics are covered on gravitational collapse and the formation of black holes.

These include cosmic censorship, critical gravitational collapse, and the nature of gravitational singularities.

Mar. 11, 2009

- **Laura Greene**, University of Illinois, Urbana Champaign
- *"Andreev reflection in Heavy Fermion Superconductors: Focus on CeCoIn5 "*
- Andreev reflection, a retro-reflection of an incoming electron as a hole at a normal-metal/superconductor interface, is well understood in conventional superconductors; but for heavy-fermion superconductors (HFS), the consequences of the heavy electronic mass remain an open question. After an introduction to Andreev reflection and the "Rosetta Stone of HFS" CeCoIn5, data over a wide temperature and voltage range in three crystallographic orientations are presented. We show how this measurement is a spectroscopic probe of the symmetry of the order parameter. Furthermore, our observed Andreev signal and observed asymmetry in the background conductance can be accounted for by model based on two-fluid phenomenology and a Fano interference effect between two conductance channels.

This work is in collaboration with Wan Kyu Park, John L. Sarrao, and Joe N. Thompson.

Mar. 18, 2009

- **Jeff Kimble,** Caltech
- *"Quantum Networks"*
- Quantum networks offer a unifying set of opportunities and challenges across exciting intellectual and technical frontiers, including for quantum computation, communication, and metrology [1]. The realization of quantum networks composed of many nodes and channels requires new scientific capabilities for the generation and characterization of quantum coherence and entanglement. Fundamental to this endeavor are quantum interconnects that convert quantum states from one physical system to those of another in a reversible fashion. Such quantum connectivity for networks can be achieved by optical interactions of single photons and atoms, thereby enabling quantum state transfer and teleportation between nodes. Within this setting, I will describe ongoing research in the Caltech Quantum Optics Group related to cavity QED with single atoms strongly coupled to the fields of high-quality optical resonators and collective interactions of atomic ensembles with single photons and entangled states of light.

Mar. 25, 2009

- **Alan Guth**, MIT
-
-
-
-

Apr. 1, 2009

- **Randall Hulet**, Rice University
- *"Fermion Pairing with Ultracold Atoms "*
-
- Ultracold atomic fermions have the potential for simulating unsolved models of condensed matter physics, and perhaps, to uncover unexpected new physics. These systems are clean and well-characterized, and physical parameters such as interaction strength, temperature, density, and dimensionality are readily tunable. I will discuss experiments on the pairing of 6 Li, a composite fermion, where tunable interactions enable the realization of the BEC-BCS crossover. We have investigated two-component Fermi gases with unequal spin populations, and find phase separation between a fully paired core and the surrounding unpaired atoms (shown below). Finally, I will present data from a new experiment on a spin-imbalanced Fermi gas in 1D, which is predicted to exhibit the elusive FFLO modulated superfluid state.
-

Apr. 8, 2009

- **Eva Silverstein** , Stanford University
-

  "Inflation, String Theory, and Signatures in the CMB"
- Inflationary Cosmology -- accelerated expansion driven by the potential energy of a scalar "inflaton" -- is a very general framework for solving basic problems in primordial cosmology. The next generation of Cosmic Microwave Background (CMB) experiments promises to discriminate among very different possibilities for the mechanism behind inflation. These observables of primordial cosmology are sensitive to the short-distance completion of general relativity. For example, the observation of or constraint on primordial gravity waves -- at the level accessible via upcoming measurements of CMB polarization -- determines the ratio of the inflaton field strength and the Planck energy scale, and tests of the Gaussianity of the spectrum constrain microscopic interactions. This "UV sensitivity" motivates modeling inflation in string theory, as a candidate UV completion of particle physics and gravity. After reviewing these motivations, I will present basic classes of inflationary models within the framework of string theory, along with their signatures. In particular, I will explain a broad class of models descending from string theory -- via a ubiquitous formal mechanism known as "monodromy" -- which is falsifiable on the basis of its gravity wave signature.
-
-

Apr. 15, 2009

- **Elena Aprile**, Columbia University

Apr. 22, 2009

Keith, there is nothing listed for Apr. 22nd on the website.