ABSTRACTS

March 5 (Fri), 2004

Speaker: **Atsuto Suzuki**
Title: ***The 21st Century COE Program: Exploring New Science by Bridging Particle-Matter Hierarchy***
Abstract:
The project: Exploring New Science by Bridging Particle-Matter Hierarchy started up as the 21th Century Center of Excellence (COE) program. This program aims at exploring particle-, nuclear, condensed matter- and astro-physics as well as matter science interdisciplinary over these fields. All the theoretical and experimental research activities in the Departments of Mathematics, Physics and Astronomy, and Cyclotron & Radioisotope Center, Center for Low Temperature Science, and Institute for Materials Research interplay in this program. Through this program, we intend to establish new science by bridging "Particle-Matter Hierarchy". PhD students and postdoctoral fellows are encouraged to propose their own research projects, which will be financially supported in this program.

Speaker: **Herbert Amann**
Title: ***Coagulation-Fragmentation Models***
Abstract:
In this talk we are concerned with mathematical models for the evolution of very large numbers of particles which can coagulate to orm clusters. The clusters can again coagulate to form larger clusters, or they can fragment into smaller ones. Of particular interest and mathematical challenge are cases in which diffusion occurs. Thus we concentrate on continuous diffusive coagulation-fragmentation equations. We describe some recent results and inherent mathematical difficulties.

Speaker: **Toshihiro Kawakatsu**
Title: ***Dynamical Self-Consistent Field Theory for Inhomogeneous Dense Polymer Systems -- Bridging between Microscopic Chain Structures and Dynamics of Mesoscopic Domains --***
Abstract:
We develop dynamical self-consistent field (SCF) theory for

phase ordering dynamics and rheology of inhomogeneous polymer systems. SCF theory is a useful tool for predicting mesoscopic domain structures based on the microscopic chain structures. As typical examples of this dynamical SCF theory, we show several simulation results on formation of complex domain structures and structural phase transitions between mesophases of block copolymers.

A trial to bridge such SCF theory and macroscopic/mesoscopic hydrodynamic model is also being under way. This new model is successfully applied to rheological behavior of dense polymer systems under strong external deformations.

Speaker: **D. D. Sarma**

Title: ***Semiconducting Nanoparticles: Flexible Properties out of Tunable Sizes***

Abstract:

It is now well understood that the bandgap, and therefore, the associated electronic and optical properties, of semiconductor nanocrystals can be tuned by varying their sizes, as a consequence of quantum confinement effects. There have been several attempts to exploit this effect for useful applications and to provide theoretical approaches to understand these changes quantitatively. However, most of these theoretical approaches turn out to be either computationally very heavy and hence lack general applicability, or of insufficient accuracy, often leaving them in the realm of empiricism. We combine detailed experimental investigations of the electronic structure and realistic and accurate theoretical approaches to provide a new and reliable methodology that leads to a deeper understanding of the electronic properties of such systems. As a novel application of our approach, we show how a detailed study of the electronic structure, not only helps to understand electro-optical properties, but can also provide important insights into the shape, size and the growth mechanism of such systems. We also show that these methods can be easily generalized and are applicable to all semiconductor nanocrystal systems.

Speaker: **Youichi Murakami**
Title: ***Orbital Ordering Studied by Resonant X-Ray Scattering***
Abstract:
We have studied the orbital ordering of strongly correlated electron systems using the resonant x-ray scattering (RXS) technique. The orbital ordering states of many compounds (manganites, vanadates, titanates, and some f-electron systems) have been elucidated by this technique. After the introduction of development of this technique, recent results of titanates will be presented. The orbital ordering states and their collapse in the hole-doped system will be discussed in relation to their magnetism. In order to study the dynamics of orbital ordering, we have carried out resonant inelastic x-ray scattering from an orbitally ordered manganite and the hole-doped samples. We have observed an electronic excitation across the Mott gap. The weak dispersion and characteristic azimuthal angle dependence of this excitation are well reproduced by a theory.

Speaker: **Takashi Takahashi**
Title: ***Bogoliubov Quasiparticle in High-Tc Superconductors Observed by Angle-Resolved Photoemission Spectroscopy***
Abstract:
The recent remarkable improvement in the resolution of angle-resolved photoemission spectroscopy (ARPES) has made a great contribution to our better understanding of novel properties of strongly correlated electron systems. I report here the first direct observation of Bogoliubov quasiparticles (BQPs) in high-Tc superconductor by ARPES. The goodquantitative agreement in the band dispersion of BQPs and the coherence factors between the ARPES experiment and the prediction from the BCS theory indicates the basic validity of the BCS framework in describing the superconductivity in high-Tc superconductors as well as the new breakthrough to the quasiparticle physics by ARPES.

Speaker: **Takeo Moroi**
Title: ***Particle Physics, Cosmology, and Supersymmetry***
Abstract:
Supersymmetry is one of the most beautiful ideas to solve various naturalness problems in particle physics and

cosmology. I will discuss some of the important roles of supersymmetry in these fields. A possible model of inflation in the framework supersymmetry and its experimental signals will be also discussed.

Speaker: **Thomas Buchert**
Title: ***Cosmological Parameters are `dressed' -- a Key to Bridging the `Dark Energy' Gap ?***
Abstract:
The standard model of cosmology describes the Universe in terms of homogeneous-isotropic solutions of Einstein's laws for self-gravitating systems. The so-called `concordance model' summarizes the values of its parameters that best match with current observational data. Accepting this model implies that a number of questions about the nature of Dark Matter and Dark Energy arise, challenging the standard model of particle physics.

In this talk we shall examine more closely the assumptions behind both cosmological model building and observational interpretation, and we come up with a possible solution for bridging the `Dark Energy' gap.

The central idea will consist in taking care of geometrical fluctuations in the actual geometry of inhomogeneous spacetimes, and devicing a procedure of how to smooth them out. The result is a `dressing' of cosmological parameters, an effect that can be evaluated through geometrical corrections to the standard model.

Speaker: **Yasushi Suto**
Title: ***Weighing the Universe; Baryons, Dark Matter and Dark Energy***
Abstract:
Particle physics in the 20th century has significantly advanced our understanding of the hierarchy in the microscopic world. Recent cosmological observations including the first-year data of the Wilkinson Microwave Anisotropy Probe among others, on the other hand, revealed that our universe is dominated by entirely dark components; 23 percent in dark matter, and 73 percent in dark energy, both of which are not yet properly incorporated in the standard model of particle physics. More surprisingly, even the remaining 4 percent, cosmic baryons, has largely evaded the direct detection so far, i.e., most of the baryons (around 75 percent) is indeed dark.

I will first show why cosmologists have to accept those surprising conclusions on the composition of our universe, and then discuss future prospects for observational cosmology in the new millennium.

March 6(Sat), 2004

Speaker: **M.S. Dresselhaus**
Title: ***Perspectives on Nanoscience***
Abstract:
Nanoscience research is now entering a new phase where the structure and properties of materials can be investigated, characterized and controlled at the nanoscale. New physics appears at the nanoscale, giving rise to new physics frontiers as part of the rapidly developing interdisciplinary nanoscience field, where physicists are working with chemists, materials scientists, mathematicians and engineers to understand new nanoscale phenomena that give rise to unexpected materials properties, with promise for significant industrial applications. In this talk, special emphasis will be given to one-dimensional nanowires and nanotubes because they, in particular, exhibit unusual physics, due to their reduced dimensionality and their enhanced surface/volume ratio. These unusual properties have attracted much interest because of their potential for applications in novel electronic, optical, magnetic and thermoelectric devices. Some examples of research accomplishments and opportunities at the nanoscale will be described, with special mention made of bismuth nanowires and carbon nanotubes.

Speaker: **F. Steglich**
Title: ***Kaleidoscope of Heavy Electrons: Superconductivity, Magnetism, Quantum Critical Points***
Abstract:
25 years after the discovery of heavy-fermion superconductivity in CeCu2Si2 [1] it has been widely accepted by now that this state may develop either out of a Landau-Fermi-liquid (LFL) state or out of a so-called non-Fermi-liquid (NFL) state. The hexagonal compound UPd2Al3 belonging to the former class is the first and yet only superconductor for which quasiparticle tunneling and inelastic neutron scattering strongly point towards a non-phononic, i.e., magnetic-exciton mediated, Cooper-pair state [2].

For the tetragonal NFL superconductor CeCu2Si2 pronounced deviations from LFL behaviour are observed in its low-temperature normal-state properties [3]. These can be related to the vicinity of an antiferromagnetic (AF) quantum

critical point (QCP) at which a low-moment incommensurate spin-density-wave (SDW) phase [4] disappears in a continuous way (TN 0). For this compound, two distinct superconducting phases can be well separated on the pressure (p) axis by deliberately reducing the quasiparticle mean free path, i.e., by weak doping with Ge: The low-p phase is centered around the AF QCP, while the high-p phase occurs in the neighborhood of a weak first-order valence transition [Ce3+ Ce(3+ $B&D (B)+] [5]. This observation highlights the (co-) existence of two different types of pairing mechanisms mediated by soft fluctuations of the spin density (at low p) and of the charge density [6] (at high p). While the NFL effects in CeCu2Si2 are consistent with an itinerant (SDW) scenario for the QCP, in YbRh2Si2 a new variant of quantum criticality has been found [7] which seems to be phenomenologically related to that in the prototypical material CeCu5.9Au0.1 [8]. Here, the most critical spin fluctuations are apparently of a local rather than an itinerant nature. YbRh2Si2, isostructural to CeCu2Si2, is not a superconductor suggesting that a local-moment QCP might be unfavorable for heavy-fermion superconductivity.

References

1. F. Steglich et al., Phys. Rev. Lett. 43, 189 (1979).
2. N.K. Sato et al., Nature 410, 340 (2001).
3. P. Gegenwart, Phys. Rev. Lett. 81, 1501 (1998).
4. O. Stockert et al., Phys. Rev. Lett. (forthcoming).
5. H.Q. Yuan et al., Science 302, 2104 (2003).
6. Y. Onishi and K. Miyake, J. Phys. Soc. Jap. 69, 3955 (2001).
7. J. Custers et al., Nature 424, 524 (2003).
8. A. Schroder et al., Nature 407, 351 (2000).

Speaker: **Motoko Kotani**

Title: ***Electron Transfer on a Crystal Lattice with and without Magnetic Field***

Abstract:

A crystal lattice is a mathematical model of atom distribution in N-dimensions. We discuss longtime behavior of electrons on a crystal lattice with and without magnetic fields, from a geometrical point of view.

Speaker: **Tetsuya Hattori**
Title: ***Renormalization Group Approach to a Generalization of the Law of Iterated Logarithms for One-Dimensional (Non-Markovian) Stochastic Chains***
Abstract:
We consider a general one-dimensional renormalization group associated to sequences of measures on paths (discrete-time walks with nearest neighbor jumps) on integers. Our concern is to formulate simple mathematically rigorous statements which contain renormalization group idea in essential ways. The main results of the talk are:
(i) the existence of stochastic chains compatible with the renormalization group (at the fixed point), and
(ii) a generalization of the law of iterated logarithms for the chains, with an explicit relation of the `exponents' to the differential at the fixed point of the renormalization group.

Speaker: **Dongho Chae**
Title: ***On the multi-string solutions of the Einstein equations Coupled with the Maxwell-Higgs system***
Abstract:
In this talk we present existence result and precise decay estimates at infinity of solutions to the Bogomol'nyi system of the static Einstein equations coupled with the Maxwell-Higgs fields with translational symmetry in one direction. The equations model cosmic strings (or superconducting strings) in equilibrium state. The Higgs fields of our solutions, in particular, tend to the symmetric vacuum at infinity. The construction of our solution is by the perturbation type of argument combined with the implicit function theorem.

Speaker: **T. Kobayashi**
Title: ***Nuclear Physics using RI Beams***
Abstract:
I will report the nuclear structure studies using RI beams. The topics include (1) systematic study of nuclear radii from reactioncross section measurements, (2) magic numbers at drip lines, (3) exotic resonances beyond the drip lines, (4) electromagnetic excitation of exotic nuclei, (5) nucleosynthesis and nuclear physics.

Speaker: **Hideyuki Saio**
Title: ***Helioseismology and Solar Models***
Abstract:
The internal structure of the Sun is computed based on the nuclear and atomic physics as well as on the astrometric determinations of the mass and radius of the Sun. On the other hand, we can infer the solar internal structure by using accurately determined frequencies of the solar 5-min oscillations (helioseismology).
I will talk about how well the recent solar models agree with the structure inferred by helioseismology.

Speaker: **Junpei Shirai**
Title: ***KamLAND: Neutrinos from Reactors to the Earth and the Sun***
Abstract:
Neutrino is one of the elementary particles, but unlike others it is much more mysterious with its tiny interactions and the mass being too light to be confirmed until very recently. Still, our world is known to be full of neutrinos coming from the sun, sky, etc and even from the earth.
Significant progress has been made in the last several years which has made clear the properties of neutrino; the finite mass and the flavor conversion.
The present talk covers the recent results from KamLAND, Kamioka Liquid scintillator Anti-Neutrino Detector, which made the first observation of the neutrino disappearance from distant power reactors. Also presented is near-future prospects of KamLAND for the real-time detection of terrestrial neutrinos and a challenge to 7Be solar neutrinos from the sun which would make great contribution to geophysics and solar physics as well as particle physics.

Speaker: **Patrice Payre**
Title: ***The Antares Neutrino Telescope***
Abstract:
The Antares collaboration is constructing a high energy neutrino detector 2400m below the Mediterranean Sea. The main electro-optical cable and the junction box to which up to 16 detector lines can be connected are in operation since a year. Using this base a segment of the final design line and an environmental monitoring line were tested.
I will review the design rationale of the detector and the associated R&D.

March 7 (Sun), 2004

Speaker: **Sandip Pakvasa**
Title: ***Neutrinos: Yesterday, Today and Tomorrow***
Abstract:
I will review the development of ideas and experimental results involving neutrinos starting from the "energy crisis" in the beta decay spectrum first seen in the 1920's. The invention,and eventual discovery of neutrinos will be traced. Neutrino properties as well as the discovery of several flavors of neutrinos were a major theme during the period 1950's to 1980's. This led to the ideas of neutrino mixing and oscillations and a whole new rich field of physics discoveries. Neutrinos from accelerators, the sun, supernova 1987A, and those produced in the atmosphere by cosmic rays have provided us with a rich spectrum of neutrinos with which to explore these phenomena. The last ten years have been very exciting and discoveries have come rapidly. There are many new projects underway or being proposed to proceed further. I will review some of them and also touch briefly on possible "uses" of neutrinos, such as in geophysics, nuclear disarmamment, or SETI. I will also discuss some aspects of neutrino astrophysics and cosmology, time permitting.

Speaker: **Lawrence S. Cardman**
Title: ***Nuclear Physics - Nature on the Femptometer Scale***
Abstract:
Nuclear Physics is focused on the understanding of strongly-interacting matter. It addresses fundamental questions such as: "how is nuclear matter constructed from quarks and gluons?", "How did matter emerge in the first moments of the Universe?" and "What is the origin of the elements in the cosmos?". The talk will review current activities in the field and outline plans for the future.