Friday, January 6, 2012
Speaker: Dmytro Pesin, Dept. of Physics, University of Texas, Austin
Title: Current induced magnetization dynamics in spin-orbit coupled thin film ferromagnets

We consider the effect of an in-plane current on the magnetization dynamics of a two-dimensional spin-orbit coupled nanoscale itinerant ferromagnet. By solving the appropriate kinetic equation, we show that Rashba spin-orbit interaction provides transport currents with a switching action, as observed in a recent experiment (I. M. Miron et al., Nature 476, 189 (2011)). The dependence of the effective switching field on the magnitude and direction of an external magnetic field in our theory agrees well with experiment.

Friday, January 13, 2012
Speaker: Steve Steinke, Schwab group
Title: Position sensing and quantum measurement back-action of a BEC coupled to a mechanical oscillator

We study theoretically the dynamics of a hybrid mechanical-cold atom system. The system consists of a micron-scale mechanical membrane coupled to a spinor Bose-Einstein condensate via a nanomagnet attached to the membrane. We demonstrate that this coupling permits us to monitor indirectly the center-of-mass motion of the membrane via measurements of the Larmor precession of the condensed atoms. We examine the back-action of making projective spin measurements of the condensate on the membrane and find potential to create non-classical motional states. We also consider the effects of a more dispersive measurement procedure via phase contrast imaging and include the effects of decoherence to examine the overall potential and limitations of this type of position measuring scheme.

Friday, January 20, 2012
Speaker: Kin Chung Fong, Schwab Group
Title: Ultra-sensitive thermal measurements of graphene: pathway to single microwave photon detector

Graphene is a material with remarkable electronic properties and exceptional thermal transport properties near room temperature. However at very low temperatures the thermodynamic and thermal transport properties are much less well explored, and somewhat surprisingly, is expected to exhibit extreme thermal isolation. Here we demonstrate an ultra-sensitive measurement scheme to probe the thermal transport and thermodynamic properties of the electron gas of graphene. We employ Johnson noise thermometry at microwave frequency to sensitively measure the temperature of the electron gas with resolution of 4 mK/Hz^ (1/2). We have determined the electron-phonon coupling from 2-30 K at a charge density of ~10^11cm-2. Utilizing bolometric mixing, we have sensed temperature oscillations with period of 430 ps and have found the heat capacity of the electron gas to be ~10^-21 J/K µm^2 at 5 K which is consistent with that of a two dimensional, Dirac electron gas. These measurements suggest that graphene-based devices can generate substantial advances in the areas of ultra-sensitive bolometry, calorimetry, microwave detection, and terahertz photo-detection, and bolometric mixing for applications in areas such as observational astronomy and quantum information and measurement.

Friday, January 27, 2012
Speaker: Martin Pototschnig, Kimble Group
Title: Controlling amplitude and phase of a laser beam by a single molecule

Efficient interaction of photons and single quantum emitter was pioneered using high finesse cavities. Recently, it was shown that a single molecule, a quantum dot or an atom could also have a significant impact on the transmission if only the excitation light was focused tightly. In this talk, I will show that a single molecule can not only attenuate a laser beam, but it can also amplify it [1]. The action of the molecule on the first beam is controlled via a second laser beam, thus light-light interaction is realized. Furthermore, I will present a phase shift measurement of an incident laser beam affected by a molecule [2]. By applying electric fields, a Stark shift of the molecular resonance is induced. This way the magnitude of the phase shift is controlled in a fast and convenient fashion. I will pinpoint advantages of transmission and phase shift measurements concerning theoretical limits in a free space coupling situation.

[1] J. Hwang et al., Nature 460, 76-80 (2009) [2] M. Pototschnig et al., Phys. Rev. Lett. 107, 063001 (2011)

Friday, February 3, 2012
Speaker: Junho Suh, Roukes Group
Title: Back-action evading measurement of micromechanical motion near the zero-point level

Back-action evading (BAE) measurement of mechanical resonators allows, in principle, detection of a single quadrature of motion with sensitivity far below the standard quantum limit, limited in practice only by the non-idealities in the measurement. A strong BAE measurement with force feedback is also predicted to generate mechanical squeezed states. We realize two-tone BAE in a tightly coupled cavity quantum electro-mechanical system and measure the position imprecision on one quadrature reaching twice the zero-point motion. A parametric instability bounds the measurement imprecision and it is induced by the thermal shift of mechanical resonance frequency due to excess dissipation in the microwave cavity. The device requirements to avoid the parametric instability and perform measurements below the zero-point level is discussed.

Friday, February 10, 2012
Huan Yang, Chen group
Title: Macroscopic quantum mechanics in advanced gravitational-wave detectors

Abstract: Laser-interferometer gravitational-wave detectors with kg-scale test masses are approaching the Standard Quantum Limit. Not only will they allow us to probe tiny ripples in spacetime created by gravitational waves, but also to explore quantum behaviors of macroscopic objects. We demonstrate feasibilities of (i) preparing macroscopic test masses into nearly pure quantum states and probing their dynamics, e.g., the breathing of position or momentum squeezed states, (ii) demonstrating quantum entanglement between the test masses and the optical field by steering the test-mass quantum states, (iii) creating entanglement among test masses and testing the gravity decoherence conjecture, and (iv) teleporting test-mass quantum states between two coherently operating interferometers via classical feedback control.

Friday, February 17, 2012
Speaker: David Pekker, Condensed Matter Theory group
Title: The amplitude mode at the superfluid-Mott insulator transition

We study a two dimensional gas of repulsively interacting bosons in the presence of both an optical lattice and a trap using optical lattice modulation spectroscopy. The strongly interacting superfluid supports two types of low energy modes associated with the symmetry breaking at the phase transition: gapless phase (Goldstone) modes and gapped amplitude (Anderson-Higgs) modes. Both experimentally and in theoretical simulations lattice modulation spectroscopy shows an onset of absorption at a frequency associated with the amplitude mode gap, followed by a broad absorption peak at higher frequencies. From the simulations, we learn that energy is being absorbed by amplitude modes, which inside a trap resemble the modes of a (gapped) drum. Our main results are: (1) despite coupling to the phase modes, modulation spectroscopy shows a sharp absorption onset at the frequency associated with the amplitude mode gap; (2) as we approach the Mott transition the gap softens and finally disappears at the transition point.

Friday, February 24, 2012
Speaker: Chen-Lung Hung, Kimble Group
Title: Observation of quantum criticality in two-dimensional quantum gases

Quantum criticality emerges when a many-body system is in the proximity of a continuous phase transition driven by quantum fluctuations. In the quantum critical regime, exotic, yet universal properties are anticipated; ultracold atoms provide a clean system to test these predictions. In this talk, I will discuss the experimental observation of quantum criticality with two-dimensional (2D) Bose gases in optical lattices. Based on in situ density measurements, we observe scaling behavior of the equation of state at low temperatures, locate the quantum critical point, and constrain the critical exponents. We observe a finite critical entropy per particle ~2k_B carrying a weak dependence on the atomic interaction strength. I will further discuss possible extensions to the study of quantum critical dynamics, for example, by extracting structure factors of 2D gases from density-density correlation measurements. I will discuss an example of measuring dynamics of static structure factor after quenching the atomic interaction strength near a Feshbach resonance.

(This work was carried out in Chin group at the University of Chicago)

Friday, March 2, 2012
Speaker: Anika Pflanzer, MPQ
Title: Quantum superpositions with levitating optomechanical systems

We provide a general quantum theory to describe the coupling of light to the motion of a nano-dielectric inside a high-finesse optical cavity.
Based on this, different designs for light-mechanics interfaces to prepare non-Gaussian states of the mechanical motion, such as quantum superpositions of Fock states, are proposed. While these

protocols are described for the specific setup of levitating dielectrics, we demonstrate that they are applicable to any optomechanical system.
Furthermore, a method to prepare and verify spatial quantum superpositions of levitating nanospheres separated by distances of the order of their size is proposed. Finally, we extend the theory to objects larger than the optical wavelength taking into account all orders of rescattering events in the light-matter interaction.

Friday, March 9, 2012
Speaker: Marcus Teague, Yeh Group
Title: Scanning tunneling spectroscopic (STS) studies of strain induced pseudo-magnetic fields and charging effects in single layer graphene.

Atomically resolved imaging and spectroscopic properties of graphene grown by chemical vapor deposition (CVD) on copper are investigated by means of scanning tunneling spectroscopy. Mechanically exfoliated graphene on silicon dioxide demonstrates strain induced local conductance modulations. Similarly in comparison, CVD-grown graphene on a copper substrate exhibits ripples and appears strongly strained, with different regions exhibiting different lattice structures and electronic density of states (DOS). In particular, non trivial strain along ridgeline imperfections, results strain-induced giant pseudo-magnetic fields B= 35~50 T, where quantized Landau levels are manifested by peaks of DOS at quantized energies. Additionally, both integer and fractional quantum Hall states due to strain-induced B are observed and may be attributed to significant short-range Coulomb interactions of Dirac fermions in graphene mediated by the underlying Cu substrate, which yields an onsite Coulomb interaction of U ~ 3.2 eV larger than the nearest-neighbor hopping energy t ~ 2.8 eV. In contrast CVD grown graphene transferred to SiO2 show reduced strain effects and opens the possibility of strain engineering of the local electronic properties for device applications.

Friday, March 16, 2012
Speaker: Alexey Gorshkov, IQI
Title: Quantum Magnetism with Polar Molecules: Tunable Generalized t-J Model

We show that dipolar interactions between ultracold polar molecules in optical lattices can be used to realize a highly tunable generalization of the t-J model. The "spin" is encoded in the rotational degree of freedom of the molecules, while the interactions are controlled by applied static electric and continuous-wave microwave fields. We show that the tunability and the long-range nature of the interactions in our generalized t-J model enable enhanced superfluidity in one dimension and controllable preparation of robust d-wave superfluids in two dimensions. The latter may provide fundamental insights into high-temperature superconductivity.
[References: Phys. Rev. Lett. 107, 115301 (2011); Phys. Rev. A 84, 033619 (2011); Phys. Rev. A 84, 063639 (2011)]

Friday, April 6, 2012
Speaker: Glen Evenbly, IQI
Title: The Scale-Invariant MERA and Quantum Criticality

The multi-scale entanglement renormalization ansatz (MERA) is a class of tensor network state for quantum lattice systems, which is based upon a coarse-graining transformation known as entanglement renormalization. MERA has been demonstrated to accurately represent the ground states of a variety of strongly correlated systems lattice systems in one and two spatial dimensions and, in particular, have been seen to offer a very natural description of quantum critical systems.

In this talk I will discuss the theoretical foundations of the MERA and also describe the application of MERA for the study of scale-invariant critical systems, including a prescription for extracting the conformal data (including the scaling dimensions, OPE coefficients, central charge etc) of a scale-invariant theory.

Friday, April 13, 2012
Speaker: Debaleena Nandi, Eisenstein Group
Title: "Perfect" Coulomb Drag of Interlayer Excitons in Bilayer Quantum Hall Systems

An exciton is a negatively charged electron bound to a positively charged hole because of coulomb attraction. Even though electrons and holes are each fermions, the excitons are charge neutral bosons. This gives rise to the possibility of Bose-Einstein Condensation of excitons and exotic phenomenons like excitonic superfluidity. I will briefly review previous experiments that suggested a superfluid like excitonic condensate state can be achieved in bilayer Quantum Hall systems. In this realization of exciton condensation, the electrons in one layer are tightly bound to holes are in the other layer. We demonstrate that injecting an electron current in one layer simultaneously generates a hole current of equal magnitude in the other layer which is part of a closed loop. Thus, a dc current flows in a closed loop without a drive voltage (battery).

References:
1) J.P. Eisenstein and A.H. MacDonald, Nature 432, 691 (2004).
2) D. Nandi, A.D.K. Finck, J.P. Eisenstein, L.N. Pfeiffer and K.W. West, arXiv 1203.3208v1 (2012)

Friday, April 20, 2012
Speaker: Mark Rudner, IQIM/Ohio State University
Title: Spin-nanomechanical coupling in carbon nanotube quantum dots

Nanostructures made out of atomically-thin carbon-based materials such as graphene and carbon nanotubes (CNTs) feature low masses and high stiffnesses. These properties naturally lead to high mechanical oscillation frequencies and open many avenues for exploring both fundamental phenomena and potential applications based on the coupling of nanomechanical and electronic degrees of freedom. The recently discovered strong spin-orbit coupling in CNTs provides an intrinsic coupling between electron spins and mechanical deflections of the nanotube. For a long nanotube with a quasi-continuous phonon spectrum, we show that this coupling gives rise to a dramatic enhancement of the electron spin relaxation rate near a level crossing in the Zeeman spectrum of a few-electron nanotube quantum dot, as observed in recent experiments. For a short suspended nanotube with well-separated discrete phonon modes, this system can provide a natural solid state realization of the Jaynes-Cummings model of quantum optics. Our estimates indicate that, with currently achievable experimental parameters, the strong coupling regime of coherent spin-phonon exchange may be within reach. Detection schemes and potential applications will be discussed.

Friday, April 27, 2012
Speaker: Matt Matheny, Roukes group
Title: Synchronization of two nanomechanical oscillators

Nanoelectromechanical systems (NEMS) have been used to explore a wide range of nonlinear dynamics due to their low dissipation, short ringdown times, and easily accessible nonlinearities. There are proposals to use a large array of NEMS to study synchronization, a nonlinear phenomenon more commonly observed in biological systems. Here we show the simplest case of synchronization: the mutual entrainment of two coupled oscillators. In particular, we synchronize two piezoelectric/piezoresistive 13MHz nanobeams sustained by two separate feedback loops, but coupled through a common third feedback loop. We first explore the case of low oscillator coupling, where the amplitudes do not play a role in the synchronization. Later, we show the synchronization space for a wide range of system parameters, including the case of large coupling. Finally, as theory suggests, for a synchronized state, we show that the phase noise of the two oscillators is reduced by 3dBc/Hz at a 1kHz offset, which is promising for making low noise frequency sources. This work suggests that NEMS could make an excellent candidate for studying large arrays of synchronized oscillators.

Friday, May 4, 2012
Speaker: Yi Zhao, Kimble group
Title: Suppression of extraneous thermal noise in cavity optomechanics*

Extraneous thermal motion can limit displacement sensitivity and radiation pressure effects, such as optical cooling, in a cavity-optomechanical system. Here we present an active noise suppression scheme and its experimental implementation. The main challenge is to selectively sense and suppress extraneous thermal noise without affecting motion of the oscillator. Our solution is to monitor two modes of the optical cavity, each with different sensitivity to the oscillator's motion but similar sensitivity to the extraneous thermal motion. This information is used to imprint "anti-noise" onto the frequency of the incident laser field. In our system, based on a nano-mechanical membrane coupled to a Fabry-Pérot cavity, simulation and experiment demonstrate that extraneous thermal noise can be selectively suppressed and that the associated limit on optical cooling can be reduced.

*This work is published as Yi Zhao, Dalziel J. Wilson, K.-K. Ni, and H. J. Kimble, "Suppression of extraneous thermal noise in cavity optomechanics," Opt. Express 20, 3586-3612 (2012)

Friday, May 11, 2012
Speaker: Bill Fefferman, IQI
Title: The classical power of quantum computation

How powerful are quantum computers? Despite the prevailing belief that quantum computers are more powerful than their classical counterparts, this remains a conjecture backed by little formal evidence. Shor's algorithm, for instance, gives an example of a problem (factoring), which can be solved efficiently on a quantum computer with no known efficient classical algorithm. Factoring however, is unlikely to be NP-Hard, meaning that few unexpected formal consequences would arise, should such a classical algorithm be discovered. Could it then be the case that any quantum algorithm can be simulated efficiently classically? Likewise, could it be the case that quantum computers can quickly solve problems much harder than factoring? In particular, what classical computational resources do we need to solve the hardest problem that has an efficient quantum algorithm?

In this talk, we address these questions and give an overview of recent research toward proving new bounds for BQP (Bounded-error Quantum Polynomial time), the class of problems that can be solved efficiently on a quantum computer. No prior knowledge of complexity theory will be assumed.

Parts of this talk are based on joint work with Chris Umans (Caltech).

Friday, May 18, 2012
Speaker: Jiang Li, Vahala group
Title: Nonlinear optics with the new UHQ planar disk resonators

In this talk I will present two applications using the newly developed UHQ planar disk resonator in our group. Stimulated Brillouin lasers (SBL) and microcombs are demonstrated. For the SBL, it is the first demonstration of a chip-based Brillouin laser and the devices feature high-efficiency and single-line operation with the smallest recorded Schawlow-Townes frequency noise for any chip-based laser. For the microcombs, parametric oscillation and comb generation on mode spacings ranging from 2.6 GHz to 220 GHz are reported with threshold turn-on power at the milliWatt level. The coherence of the comb is also established by direct detection and phase noise measurement. A record number of comb lines around 1900 is demonstrated.

Friday, May 25, 2012
Speaker: Alex Krause, Painter group
Title: Design of a high-precision wide-bandwidth optomechanical accelerometer: Or, how I learned to stop worrying and love stress

In this talk I will cover our design and demonstration of a low-noise high-bandwidth optomechanical accelerometer. The accelerometer is fabricated from a beam of highly-stressed thin-film Silicon Nitride with mechanical quality factor over 1 million. Displacements of this beam are sensed via an integrated photonic crystal cavity. We demonstrate acceleration sensing over a 27kHz bandwidth with resolutions exceeding any commercial optical accelerometer system. Furthermore, we show cooling of the mechanical mode down to 1.5K from room temperature through a novel opto-thermo-mechanical process. Finally, I will discuss the prospects for this system to be used in commercial applications as well as reaching the quantum ground state via feedback cooling.

Friday, June 8, 2012
Speaker: Gorjan Alagic, IQI
Title: Quantum circuit obfuscation with braids

It is well-known that approximating the Jones Polynomial knot invariant is a universal problem for quantum computation. The central ingredient in the proof of this fact is an efficient "translation" from braids to quantum circuits, and vice-versa. In this talk, I will discuss how this translation procedure could be used to design interesting quantum-computational protocols. In particular, I will talk about the problem of program obfuscation: how to allow others to use your programs without revealing their internal structure.

Joint work with Stephen Jordan (now at NIST).

Joint IQIM/Condensed Matter Theory Seminar
Monday, July 9, 2012
Speaker: Norman Yao, Harvard University
Title: Topological Flat Bands from Dipolar Systems

Topological flat bands provide a fascinating route to the realization of novel strongly correlated phenomena. In this talk, I will describe and analyze a physical system that naturally admits nearly flat bands with non-zero Chern index. Our approach utilizes a two-dimensional array of three-level dipoles driven by inhomogeneous electromagnetic fields. I will demonstrate that dipolar interactions can generate arbitrary uniform background gauge fields for an effective collection of conserved hardcore bosons, namely, the dressed spin-flips. These gauge fields result in topological band structures, whose bandgap can be significantly larger than the corresponding bandwidth. To probe the many-body properties of this system, we perform exact diagonalization of the full interacting Hamiltonian at half-filling and uncover superfluid, crystalline, supersolid and fractional quantum Hall phases. An experimental realization using either spins in the solid-state or ultra-cold polar molecules is considered.

Joint work with: C. Laumann, A. V. Gorshkov, S. D. Bennett, E. Demler, P. Zoller, M. Lukin

Joint IQIM/ Condensed Matter Theory Seminar
Tuesday, August 14, 2012
Speaker: Stephen Lynch, Cardiff University, Wales
Title: Coherent Quantum Control of Phosphorus Donor Rydberg States in Silicon using THz Laser Pulses

Crystalline silicon can be conveniently doped by substituting a small number of silicon atoms at lattice sites with atoms from the adjacent pnictogen group-V column of the periodic table. At room temperature this results in an excess of free electrons and the material is n-doped. At low temperatures the extra electron left over after bonding remains loosely bound to the positive core. This object looks and behaves like an isolated hydrogen atom. There is an analogous Rydberg series of narrow lines in the absorption spectrum but it is down shifted towards much lower energies. Whereas the Rydberg series for hydrogen lies in the visible band, the corresponding series for the hydrogen-like donor lies in the THz band.

Silicon doped with phosphorus is a particularly interesting material from the point of view of quantum control, and this has lead to a dramatic resurgence of activity in the research field. Much of this renewed interest stemmed from a proposal by Kane that silicon doped with group-V donors might be exploited to realize a quantum computer [1].

The silicon phosphorus lifetime measurements in [2] will be discussed in detail. I will also discuss the discovery of a THz photon echo and how it was exploited to demonstrate quantum control [3].

[1] B. E. Kane, "A silicon-based nuclear spin quantum computer," Nature, vol. 393, pp. 133-137, May 1998.
[2] N. Q. Vinh, S. A. Lynch, et al., "Silicon as a model ion trap: time domain measurements of donor Rydberg states," Proc. Natl. Acad. Sci. USA, vol. 105, no. 31, pp. 10 649-10 653, August 2008.
[3] P. T. Greenland, S. A. Lynch, et al., "Coherent control of Rydberg states in silicon," Nature, vol. 465, no. 7301, pp. 1057-1061, June 2010.

Joint IQIM/ Condensed Matter Theory Seminar
Monday, August 27, 2012
Speaker: Dr. Michael Mockel, Max Planck Institute - Garching
Title: From prethermalization in quenched many-body systems to new approaches in condensed matter simulation

The time dependent fermionic Hubbard model represents a paradigm for the description of correlated electrons in nonequilibrium. Performing a small interaction quench allows to observe different relaxation timescales for the kinetic energy and the momentum distribution, known as prethermalization, already by means of a perturbative calculation. The time scales for the thermalization of both observables relate to the buildup and the subsequent relaxation of a nonequilibrium quasiparticle picture. Their separation may open a time window to observe elusive nonequilibrium transient phenomena (e.g. nonequilibrium BCS physics) and is interesting from its own right. Moreover, time scale separation motivates the development of composite tools to study the transient dynamics of excited many-particle systems. For the initial time regime perturbative or self-consistent mean field approaches are suitable. Subsequent relaxation can be modeled by linking the early evolution to an effective quantum Boltzmann description.

Friday, September 21, 2012
Speaker: Kristiaan De Greve, E. L. Ginzton Laboratory, Stanford University
Title: Ultrafast, coherent optical control and spin-photon entanglement in charged InAs quantum dots

I will discuss all-optical coherent control of individual electron and hole spin qubits in InAs quantum dots. With a magnetic field in Voigt geometry, broadband, detuned optical pulses couple the spin-split ground states, resulting in Rabi flopping. In combination with the Larmor precession around the external magnetic field, this allows an arbitrary single-qubit operation to be realized in less than 20 picoseconds[1,2,3]. By implementing a spin-echo sequence, we can filter out slow fluctuations in the Larmor precession frequency, which results in T2 coherence times up to 3 microseconds[3,4].

In addition, our optical pulse manipulation scheme allows us to probe the hyperfine interaction between the single spin and the nuclei in the quantum dot. Interesting non-Markovian dynamics could be observed in the free-induction decay of a single electron spin, whereas the complete absence of such effects illustrates the reduction of the hyperfine interaction for hole spin qubits. We measured and modeled these effects, and explain them as involving a feedback effect resulting from both the strong Overhauser shift of the electron spin and spin dependent nuclear relaxation[3,5].

Finally, I will discuss the verification of entanglement between a single quantum dot spin and the polarization of a spontaneously emitted single photon[6]. With a Larmor precession frequency of 10s of GHz, we demonstrate a novel technique to quantum erase the frequency-which-path information that would otherwise obfuscate spin-photon entanglement. We frequency-downconvert the single photons in a PPLN waveguide device to 1560 nm, using a few-ps mixing pulse, which provides the necessary timing resolution/frequency bandwidth to erase the frequency information. We measure spinphoton entanglement fidelities of over 80%, while the target wavelength of 1560 nm allows low-loss transmission of the downconverted photons in commercial telecom fiber.

References:
[1] J. Berezovsky, M. H. Mikkelsen et al. Science 320 349 (2008) [2] D. Press, T. D. Ladd, B. Zhang and Y. Yamamoto, Nature 456, 218 (2008) [3] K. De Greve, P. McMahon, D. Press et al., Nat. Phys. 7, 872 (2011) [4] D. Press, K. De Greve, P. McMahon et al., Nat. Phot. 4, 367 (2010) [5] T. D. Ladd, D. Press, K. De Greve et al., Phys. Rev. Lett. 105, 107401 (2010) [6] K. De Greve, L. Yu, P. McMahon et al., Nature accepted (2012)

Based on work with: Kristiaan De Greve1, P. McMahon1, D. Press1, L. Yu1, J. Pelc1, C. M. Natarajan1, N. Y.Kim1, E. Abe1, S. Maier3, B. Friess1,3, T. D. Ladd1,2,*, C. Schneider3, D. Bisping3, M.Kamp3, S. Höfling3, A. Forchel3 and Y. Yamamoto1,2 1E. L. Ginzton Laboratory, Stanford University, Stanford, CA 94305, USA 2National Institute of Informatics, Hitotsubashi 2-1-2, Chiyoda-ku, Tokyo 101-8403, Japan 3Technische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany *Currently at HRL laboratories, 3011 Malibu Canyon Road Malibu, CA 90265

Friday, September 28, 2012
Speaker: Ramathasan Thevamaran, Graduate Aerospace Laboratories of California Institute of Technology (GALCIT)
Title: Dynamics of Single and Multi Layer Vertically Aligned Carbon Nanotubes

Recent work in our laboratory has focused on the creation and investigation of forests of Vertically Aligned Carbon Nanotubes (VACNTs). This hierarchical macroscopic material, synthesized by thermal Chemical Vapor Deposition (tCVD) system, poses interesting mechanical properties. When subjected to compressive cyclic loading, they exhibit a nonlinear, foam-like hysteretic behavior and have the ability to recover strains up to 80%. Due to their superior fatigue resistance and energy dissipating characteristics, VACNTs can potentially find applications in reducing vibrations and absorbing impacts.
I will discuss the quasistatic and dynamic mechanical characterization of single layer VACNTs, highlighting how the mechanical properties can be tailored at various length scales through different synthesis techniques. This discussion will include an experimental technique we developed for the dynamic testing of the single layer VACNTs. I will also describe the dynamic behavior of multi-layered structures of VACNTs alternated with rigid inter-layers subjected to low velocity impacts. They exhibit highly tunable mechanical and acoustic properties.

Friday, October 5, 2012
Speaker: Chang Yu Hou, Postdoctoral Researcher UC Irvine/Caltech
Title: Charge fractionalization in graphenelike structures

Electron fractionalization is intimately related to topology. In one-dimensional systems, fractionally charged states exist at domain walls between degenerate vacua. In two-dimensional systems, fractionalization exists in quantum Hall fluids. In our works, we show that fractionally charged topological excitations exist on graphenelike structures in the presence of Kekule distortions that can be described as a complex mass order parameter. The phase twist of 2\pi, a vortex, in such complex mass gives a topological zero mode, with its mathematical structure similar to fractional vortices in p-wave superconductors. As Kekule distortions do not spontaneously form in graphene, the recent experiment on molecular graphene have give hopes for the detection of such fractionalized states.

Friday, October 12, 2012
Speaker: David Clarke, UC Irvine
Title: Non-Abelian anyons in one dimension: Majoranas and beyond

Non-Abelian anyons are widely sought for the exotic fundamental physics they harbor as well as for quantum computing applications. There now exist numerous blueprints for stabilizing the simplest type of non-Abelian anyon, defects binding Majorana fermion zero modes, by judiciously interfacing widely available materials, including several schemes for producing these modes in one-dimensional systems. Following this line of attack, we introduce
a device fabricated from conventional fractional quantum Hall states and s-wave superconductors for which defects along a one-dimensional line bind zero mode operators with parafermionic, rather than fermionic, commutation relations.
We show that these modes can be experimentally identified (and distinguished from Majoranas)

using Josephson measurements. Following earlier work on Majoranas in one dimension, we provide a practical recipe for braiding the defects and show that they give rise to non-Abelian statistics. Though the braid set is not universal for quantum computation in any of the cases discussed here, the braiding of parafermionic zero mode operators produces a richer set of topologically protected qubit operations when compared to the Majorana case.

Friday, October 19, 2012
Speaker: Akihisa Goban, Kimble Group
Title: A state-insensitive, compensated nanofiber trap

An exciting frontier in QIS is the integration of quantum elements into quantum networks [1]. Single atoms and atomic ensembles endow quantum functionality and the capability to build quantum networks. Following the realization of a nanofiber trap [2], we have implemented an optical trap that localizes single Cs atoms 215 nm from surface of a nanofiber [3]. By operating at magic wavelengths for counter-propagating red- and blue-detuned trapping beams, differential scalar light shifts are eliminated, and vector shifts are suppressed by 250. We measure an absorption linewidth 5.7 (0.1) MHz for the Cs 6S1/2, F = 4 - 6P3/2, F' = 5 transition, where 5.2 MHz in free space, and an optical depth of 66, corresponding to 0.08 per atom. The bandwidth for reflection from the 1D array scales linearly with the entropy for the multiplicity of trapping sites. These advances provide an important capability for quantum networks and precision atomic spectroscopy near dielectric surfaces.

[1] H.J. Kimble, The Quantum Internet, Nature 453, 1023 (2008).
[2] E. Vetsch et al., Phys. Rev. Lett. 104, 203603 (2010).
arXiv:1202.1494v2 [quant-ph] [3] A. Goban et al., Phy. Rev. Lett, 109, 033603 (2012).
http://resolver.caltech.edu/CaltechAUTHORS:20120515-133717073

Joint IQIM/ Condensed Matter Theory Seminar
Wednesday, October 31, 2012
Speaker: Ipsita Mandal, UCLS
Title: Amplitude mode of the d-density wave state and its relevance to high-Tc cuprates

We study the spectrum of the amplitude mode, the analog of the Higgs mode in high energy physics, for the d-density wave (DDW) state proposed to describe the anomalous phenomenology of the pseudogap phase of the high Tc cuprates. Even though the state breaks translational symmetry by a lattice spacing and is described by a particle-hole singlet order parameter at the wave vector q = Q = (pi, pi), remarkably, we find that the amplitude mode spectrum can have peaks at both q = (0, 0) and q = Q = (pi , pi). In general, the spectra is non-universal, and, depending on the microscopic parameters, can have one or two peaks in the Brillouin zone, signifying confluence of two kinds of magnetic excitations. In light of the recent unexpected observations of multiple magnetic excitations in the pseudogap phase our theory sheds important light on how multiple inelastic neutron peaks at different wave vectors can arise even with an order parameter that condenses at Q = (pi, pi). [Reference: arXiv:1207.6834]

Friday, November 2, 2012
Speaker: Roger Mong
Title: The Density Matrix Renormalization Group (DMRG): Methods and applications

DMRG is a powerful tool that has been extremely successful at numerically probing 1D quantum systems, but much of the algorithm and language used is confusing to the general public. Underlying the success of DMRG is encoding quantum information via the matrix product states (MPS) representation of a wavefunction. In this talk, I will describe what an MPS is, and sketch out the DMRG algorithm, explaining the strengths and pitfalls of the method. I will briefly present applications of these tools to spin-2 chains, 1D quantum phase transitions, as well as 2D quantum Hall effect with non-abelian statistics.