CondMat Physics Student Symposium 2020 B

Sunday, June 28th, Dach Hall / ZOOM
https://zoom.us/j/97114764862

SESSION CHAIRS

09:00 opening words, Prof. **Yoram Dagan**.	
09:10-09:35 **Yoav Shoshan (MSc, Eli Eisenberg)** The Adaptiveness of A-to-I RNA Editing	**Yoram Dagan**
09:35-10:00 **Ruti Balter (MSc, Eli Eisenberg)** Non-canonic genetic information flow	**Yohai Bar Sinai**
10:00-10:50 **Liran Hareli (PhD, Alon Bahabad)** Macroscopic manipulation of High Harmonic Generation	**Hadas Soifer**
10:50-11:10 coffee break	
11:00-11:35 **Roee Friedman (MSc, Aviva Melchior)** Pressure Induced Metallization of $LaTiO_3$	**Eli Eisenberg**
11:35-12:00 **Yael Sternfeld, (MSc, Koby Scheuer)** Electromagnetically induced transparency in Raman gain for realizing a superluminal ring laser	**Haim Suchovski**
12:00-13:00 Lunch break	
13:00-13:25 **Michael Faran (MSc, Miriam Furst-Yust)** Biophysics of the Inner Ear and its Applications	**Roy Beck**
13:25-13:50 **Ilan Sher (MSc, Haim Suchowski)** Nonlinear Signal Generation from Nanoparticles	**Yoav Lahini**
13:50-14:00 coffee break	
14:00-14:25 **Aviel Boag (MSc, Guy Cohen)** Inclusion-Exclusion Principle for Many-Body Diagrammatics	**Moshe Goldstein**
14:25-14:50 **Yuval Orsher (MSc, Mark Shein-Idelson)** Static Cortical Activity Patterns Induce Apparent Waves in Phase Latency Maps	**Yacov Kantor**

Yoav Shoshan (MSc, Eli Eisenberg)

The Adaptiveness of A-to-I RNA Editing

A-to-I RNA editing by ADAR modifies RNA sequences at single sites. It has been suggested that the preponderance of nonsynonymous editings in protein coding RNA sequences of some species could imply that this phenomena is beneficial in terms of increased fitness as it promotes phenotypic diversification.
We propose a statistical model to test the adaptiveness of A-to-I RNA editing in protein coding sequences.
We use next generation sequencing (NGS) techniques together with bioinformatic algorithms to identify and quantify the editomes of various cephalopods species and to test our model along the evolutionary tree of those animals

Ruti Balter (MSc, Eli Eisenberg)

Non-canonic genetic information flow

I describe briefly two projects: **Quantifying Proteome diversification due to A-to-I RNA editing in squids' brain:** A-to-I RNA editing is a common post-transcriptional modification that alters genetic information from its genomic blueprint. When it modifies coding mRNA, the inosines are recognized as guanosines by the translational machinery, leading to novel protein isoforms. In most organisms studied so far, recoding by editing is quite rare, and the number of editing-dependent isoforms is limited. However, in cephalopods, many transcripts harbor dozens of recoding sites, potentially leading to a multitude of isoforms. Here we employ ultra-deep sequencing to quantify the diversity achieved by recoding in 19 squid transcripts. We study in depth inter-dependencies, and demonstrate up to 17,000 distinct editing-isoforms are expressed for a single protein-coding sequence.

Characterizing Circular DNA sequences in symbiotic dinoflagellates: The symbiosis between dinoflagellate (algae) of the genus Symbiodinium and corals is of crucial importance to the coral survival. In addition to regular chromosomes, the dinoflagellate have an unknown number of circular DNA molecules, some of which include a single gene each. Using a new DNA sequencing technique producing long (10s kbp) sequences that span several periods of the circular DNA, a computational pipeline was constructed to characterize those circles. Eight mini-circles were found, and the full minicircle was identified for some the first time. Five of these encode previously identified Symbiodinium proteins.

Liran Hareli (PhD, Alon Bahabad)

Macroscopic manipulation of High Harmonic Generation

High harmonic generation (HHG) is an extreme nonlinear frequency up-conversion process during which extremely short duration optical pulses at very short wavelengths are emitted. major concern of HHG is the small conversion efficiency at the single emitter level. Thus ensuring that the emission at different locations are emitted in phase is crucial. At high pump intensities it is impossible to phase match the radiation without reverting to ordered modulations of either the medium or the pump field itself, a technique known as Quasi-Phase-Matching (QPM). During this talk I will discuss how we can use a structured pump beam to macroscopically manipulate the emission spectrum of HHG and its polarization.

Roee Friedman (MSc, Yoram Dagan)

Pressure Induced Metallization of $LaTiO_3$

The transition-metal perovskite oxides, with the formula ABO3, exhibit many interesting physical phenomena. Their behaviour is mostly determined by the d-electrons on the transition metal ion B. An important family of the transition-metal perovskite oxides is perovskite titanates, ATiO3, in which there is one d-electron per Ti ion, and the orbital, magnetic and electric properties are determined by the competition between the crystal field potential and the magnetic superexchange due to the Coulomb repulsion between electrons on the same ions. In the titanates, the cubic structure is orthorhombically distorted, and there exists gaps between the three low-lying (single electron) t2g states. The crystal field potential determines ordering of the electronic orbital states. Under ambient conditions there are also Mott gaps (between the singly and doubly occupied ions), and one observes a Mott insulating antiferromagnet. However, an application of high pressure increases the hopping energy between Ti ions, and thus decreases the Mott gap and can yield a transition to metallic state. In this talk, I will represent high pressure electrical resistance measurements of LaTiO3, carried out in a diamond anvil cell at low temperatures. Resistance measurements are a direct way to observe electronic changes in a material and especially insulator-metal transitions.

Yael Sternfeld, (MSc, Koby Scheuer)

Electromagnetically induced transparency in Raman gain for realizing a superluminal ring laser

Superluminal lasing is a unique scenario which can be obtained in a cavity exhibiting average group velocity which is larger than the speed of light (or equivalently, a group index which is much smaller than one and can ideally reach to zero). Such scenario can be realized by introducing an anomalously dispersive gain medium into a regular cavity. It has been shown in previous studies that superluminal lasing can be highly useful for precision metrology and sensing applications. Particularly, the sensitivity of a ring laser to perturbations in the cavity optical length, which is inversely proportional to the group index of the medium, can be dramatically enhanced by operating in the superluminal regime. This property makes the superluminal laser highly attractive for various applications sensing such as gravitational waves detection, navigation, and more.

We describe a new approach for realizing a superluminal ring laser using a single isotope of Rb vapor, by producing electromagnetically induced transparency (EIT) in Raman gain. We show that by modifying the detuning and the intensity of the optical pump field used for generating the two-photon population inversion needed for generating Raman gain, it is possible to generate a dip in the center of the gain profile that can be tuned to produce vanishingly small group index, as needed for making the Raman laser superluminal. We first investigate the behavior of the gain/dispersion spectra in the passive case, an iterative algorithm is then used to determine a self-consistent solution of the single-mode laser equation for a ring cavity and obtain the degree of enhancement in sensitivity.

Michael Faran (MSc, Miriam Furst-Yust)

Biophysics of the Inner Ear and its Applications

While sound sensation is intuitive to us, the process of information propagation in the auditory system is complex and gradual. One of the main reasons of deafness is hypothesized to be deficits in the inner hair cells. A biophysical model of the inner hair cells along with its challenges and synergy in the auditory pathway are to be presented.

Can this biophysical modeling be applied for practical purposes? Can the model predict the microscopical reason for hearing loss? To be discussed.

Ilan Sher (MSc, Haim Suchowski)

Nonlinear Signal Generation from Nanoparticles

Nonlinear Optics (NLO) is a phenomenon where a system's response is not proportional to applied optical field. The early attempt to give theoretical ground to NLO was made by introducing a nonlinear harmonic oscillator model that has yielded good results in predicting material's nonlinear response for variety materials with different geometries. Recently, it was found experimentally, that for metamaterials with changing geometry, nonlinear oscillator model cannot predict optimal geometry for Second Harmonic Generation (SHG). However, it was shown that nonlinear scattering theory is consistent with their experiment results. Within this theory, not only amplitude of generated nonlinear SH signal contributes to measurement, but also relative phase between different points on the structure.

The goal of this work was to observe SHG signal from the nanostructures surface, e.g. near field regime by utilizing Near Field Scanning Optical Microscopy (NSOM) with Ultra-Fast Femto-Second laser. Observing strong SH signals on a surface of bar shaped nanostructure would prove the concept of nonlinear scatter theory and can take advantage of designing meta-materials with desired nonlinear properties.

Aviel Boag (MSc, Guy Cohen)

Inclusion-Exclusion Principle for Many-Body Diagrammatics

Quantum impurity models are used to model magnetic atoms embedded in a host material or adsorbed on a surface, electron transport through quantum junctions, and local correlations in strongly correlated materials. However, reliable and accurate numerical modelling of general impurity problems remains extremely challenging. Recent successes have been based on Monte Carlo methods employing diagrammatic resummation techniques, but are restricted by the need to sum over factorially large classes of diagrams individually. I will present a fast algorithm for summing over the diagrams appearing in the Inchworm hybridization expansion. The method relies on the inclusion-exclusion principle to reduce the scaling in perturbation order from factorial to exponential. We analyze the growth rate and compare with related algorithms for expansions in the many-body interaction. Even for a minimal physical model, compared to the previous state of the art, our algorithm scales better asymptotically and provides practical performance gains of two orders of magnitude.

Yuval Orsher (MSc, Mark Shein-Idelson)

Static Cortical Activity Patterns Induce Apparent Waves in Phase Latency Maps

While traveling waves of cortical activity have been the subject of past and current research, not much is known about their underlying mechanism or function in neural coding. One of the prominent ways to identify and characterize these waves are the phase latency maps, which show the progression of the wave across the cortex. In my talk I will discuss how different kinds of spatiotemporal patterns of activity are presented on these maps, and how static independent patterns might appear as continuous traveling wave. I will also present data from neural recordings supporting these claims.