Condensed Matter Student's Symposium

Second semester, Sunday 17/6/2018, Melamed Hall

Time	Degree	Student name	Advisor name
9:00-9:50	PhD	Eyal Cornfeld	Prof. Eran Sela
9:50-10:15	MSc	Roni Majlin	Prof. Yoram Dagan
10:15-10:40	MSc	Or Golan	Prof. Eran Sela
10:40-11:00		Coffee break	
11:00-11:50	PhD	Aviad Landau	Prof. Eran Sela
11:50-12:15	MSc	Itay Fisher	Prof. David Horn
12:15-13:00		Lunch	
13:00-13:25	MSc	Elior Dekel	Prof. Shimshon Bar-Ad
13:25-13:50	MSc	Nadav Fain	Prof. Tal Ellenbogen
13:50-14:15	MSc	Tsafrir Abir	Prof. Tal Ellenbogen
14:15-15:00		Drinks and snacks	

Titles and Abstracts

Eyal Cornfeld: *True facts about degeneracy, entanglement, and the Ising model.*

Abstract: Critical systems present intriguing relations between the groundstate degeneracy and the entanglement entropy; beforehand, however, some general discussion of these topics is due. The technique of next-to-adiabadic perturbation theory will be presented and used to investigate general properties of flux pumping in degenerate systems; results for synthetic magnetic crystals will be presented; often-overlooked properties of a Thouless topological pump will be discussed. A tested experimental protocol for measuring entropy in bosonic systems will be explained; the latest results on fermionic systems will be presented; proven extensions to other entanglement measures will be mentioned. Finally, the critical Ising model in the presence of a boundary magnetic field will be explored; conformal field theory and compex analysis methods will be used to derive exact results for the renormalization group flow of the groundstate degeneracy and the boundary entropy - which are one and the same.

Roni Majlin: *Heat capacity of the layered transition-metal dichalcogenide 6R-TaS2*

Abstract: TaS2 in its 6R polytype is a non-centrosymmetric crystal, built from quasi two dimensional layers of TaS2. It is superconducting and can be doped with Se to enhance Tc and stabilize the structure. The transport critical field is strongly anisotropic, becoming very large for magnetic field applied parallel to the two-dimensional (2D) layers. The non-centrosymmetric structure and the strong parallel critical field make this material a possible realization for an Ising superconductor. We measure the heat capacity of 6R-TaS2 in the low temperature regime and at various magnetic fields and orientations. From the zero field data we calculate the free energy and extract the thermodynamic critical field, the condensation energy and the density of states at the Fermi energy. Assuming an isotropic gap, we find it

to be ~0.35meV. From a small anomaly in the heat capacity at very low temperatures, which may be attributed to a Schottky term, we extract the g-factor. We discuss the consistency of our results with the possible scenario of exotic superconducting states in this material.

Or Golan: *Topological phases in number-conserving systems*

Abstract: Number conserving systems, while not very common in typical condensed matter experimental setups, are commonplace in cold-atom systems. By utilizing new experimental tools developed in the field of cold-atoms, we suggest two different topological phases in such particle conserving systems. The first system is a new take on the well known Kitaev chain with its Majorana zero-modes, illuminating the possibilities of the field. The second system we propose exhibits Parafermion zero-modes, while bypassing existing engineering difficulties blocking experimental realization in current experimental condensed matter systems.

Aviad Landau: *Kondo effect and beyond in topological systems*

Abstract: We study a topological superconductor island with spatially separated Majorana modes coupled to multiple normal metal leads by single electron tunneling in the Coulomb blockade regime. The non-local quantum spins formed from the charge degrees of freedom give rise to a "topological Kondo effect". We predict several unique transport properties of this Kondo effect, which demonstrate non-fermi liquid behavior such as fractional conductance, Fano-factor and low temperature corrections. More over, we validate the potential of such systems to serve as a platform for topological quantum computation.

Itay Fisher: *Parcellation of the mammalian brain: Shape study of 3d MRI images*

Abstract: The cortical layers define the architecture of the gray matter and its neuroanatomical regions and are essential for brain function. Abnormalities in cortical layer development, growth patterns, organization, or size, can affect brain physiology and cognition. We employ the Shape component of the Parzen window distribution to the study of 3d MRI images of the brain. With appropriate thresholding it allows for segmentation of the gray matter. Applying Quantum Clustering to the segmented image we develop a non-biased grouping model, which allows for parcellation of the brain. Our method is universal: it does not require prior anatomical knowledge, it is applicable to any mammalian brain type, for both T1 & T2 MRI data sets. We demonstrate results on one human brain, four macaque brains, and one rat brain.

Elior Dekel: *Beam Propagation in Optically-Thick Rubidium Vapor: Saturating Near-Resonant Nonlinearities*

Abstract:The resonant optical nonlinearity of Rubidium is investigated. Narrow bandwidth light, near-detuned from the D2 transition line, is propagated through a few centimeters of a warm Rubidium vapor while the intensity dependent absorption and refraction are analyzed. We find that for collimated beams, the beam width at the output of the Rubidium cell exhibits a non-monotonic dependence on the incident power. A saturated absorption model is put forth which qualitatively captures the non-monotonic behavior. The model is further developed into a simulation which integrates propagation effects. Good agreement with the experimental data is achieved for a saturation intensity of

$1.6\,mW\!/cm^2$ when simulating the beam width, absorption, and free space propagation after leaving the Rubidium cell.

Nadav Fain: *Strong coupling between localized surface plasmons and excitons*

Abstract: Localized surface plasmons are resonant collective oscillations of surface electrons in a metal nanoparticle that can be excited by irradiation of light. Consequently, the electromagnetic field is confined near the nanoparticle and dramatically enhanced. Placing excitonic systems in the vicinity of the nanoparticle may give rise to strong coupling between the excitons and the electromagnetic field which significantly alters the transmission and absorption spectra of the system. The coupled system exhibits an anti-crossing behavior due to new upper polariton and lower polariton eigen-states that are formed. Even though the phenomenon has been widely researched by using far field reflection and transmission spectra it has not yet been studied in the near field of the nanoparticles. In my talk I will explain the basic theory and the measures taken to observe the near field and will present numerical and experimental results of the phenomenon in the near field. Specifically, I will present a numerical comparison of transmission spectra and near-field maps of aluminum nano disks covered with excitonic layer, displaying a distinct anti-crossing behavior. In addition, I will present a dynamical chart of the strongly coupled system, showing the near field energy exchange between the collective exciton population and the plasmonic modes which depends on the excitonic species density.

Tsafrir Abir: *Coupling between excitons in lead-halide perovskite nanocrystals and optical guided modes*

Abstract: In the last decade, organic-inorganic lead-halide perovskites have gained much attention in the photovoltaic research. Moreover, their pronounced optoelectronic properties have motivated the exploration and integration in other research fields as well. Specifically, these materials have penetrated the field of colloidal semiconductor nanocrystals and expanded into fully inorganic semiconductor quantum emitters. Their light emission is generated by bound electronic states known as excitons that were shown to have enhanced light-matter interaction which has made them very favorable constituent in optoelectronic devices and experiments. In my talk, the research of CsPbBr3 perovskite nanocrystals embedded in polymer matrix to form optical waveguide will be presented and the coupling of the excitons to the guided modes will be discussed. Specially, I will show how the resonating electromagnetic mode density alters the isotropic spontaneous emission of the nanocrystals, making it polarized and momentum matched to the guided optical modes.