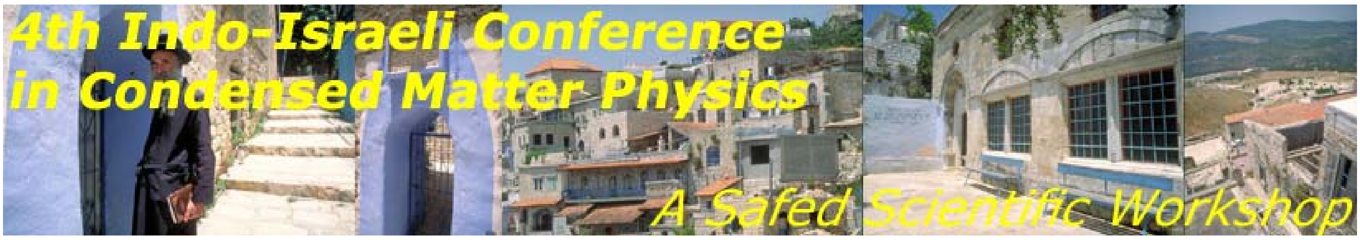

2-6 November, 2008 – Safed, Israel

Program and Abstracts

Conference sponsored by:

The Safed Scientific Workshops

Tel Aviv University

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Program

Sunday, November 2, 2008

14:00 Pickup at Maxim Hotel in Tel Aviv and transfer to Merkazi Hotel in Tzfat
18:00 – 19:00 Registration at Merkazi
19:00 – 20:00 Dinner at Merkazi
20:00 – 22:00 Informal get-together

Monday, November 3, 2008

09:00 – 10:00 Registration

10:00 – 11:00 Opening Session
Chair**: Ron Lifshitz,** Tel Aviv University, Tel Aviv

10:00 **Greetings and opening remarks**
Ron Lifshitz
Tel Aviv University, Tel Aviv

10:15 *Opening Keynote Lecture:*
The Rashba-Aharonov-Bohm interferometer: A spin polarizer analyzer.
Amnon Aharony
Tel Aviv University, Tel Aviv & Ben Gurion University, Beer Sheva

11:00 – 11:30 Coffee Break

11:30 – 12:30 Low-Dimensional Systems I
Chair**: Alexander Palevski,** Tel Aviv University, Tel Aviv

11:30 **Time-resolved study of growth mechanisms of semiconductor nanocrystals via the solution route.**
D. D. Sarma,
Indian Association for the Cultivation of Science, Kolkata

12:00 **Structural, magnetic, and chemical effects in low-dimensional systems.**
Shobhana Narasimhan,
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore

12:30 – 14:00 Lunch at Merkazi

Monday, November 3, 2008 (continued)

14:00 – 16:00 Dynamics I
Chair**: Moshe Schwarz,** Tel Aviv University, Tel Aviv

14:00 **Cooling in freely-evolving granular gases.**
Sanjay Puri
Jawaharlal Nehru University, New Delhi

14:30 **Finite time collapses in freely cooling granular gases.**
Itzhak Fouxon
Tel Aviv University, Tel Aviv

15:00 **Growing length and time scales in glass forming liquids.**
Chandan Das Gupta
Indian Institute of Science, Bangalore

15:30 **Response-correlation inequality in dynamical systems.**
Eytan Katzav
King's College, London

16:00 – 16:30 Coffee Break

16:30 – 18:00 Dynamics II
Chair**: Haim Taitelbaum,** Bar Ilan University, Ramat Gan

16:30 **Instabilities and nonlinearities in bulk and nanopatterned superconductors.**
Satyajit Banerjee
Indian Institute of Technology, Kanpur

17:00 **Death of a vortex at the (spiraling) hands of a density interface.**
Rama Govindarajan
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore

17:30 **Fascinating dynamics of surfactant micellar gels under shear.**
Ajay K. Sood
Indian Institute of Science, Bangalore

19:00 – 20:00 Dinner at Merkazi

20:00 – 22:00 Posters & Drinks at Merkazi

Tuesday, November 4, 2008

09:00 – 10:30 Biophysics – Assembly & Regulation
Chair**: Shimshon Barad,** Tel Aviv University Tel Aviv

09:00 **Cellular architecture of genome assembly and its regulation.**
G.V. Shivashankar
National Centre for Biological Sciences, TIFR, Bangalore

09:30 **Exploring the efficiency of protein-complex production in the cell.**
Eli Eisenberg
Tel Aviv University, Tel Aviv

10:00 **Wires, reporters, and information capsules: Cellular journalism with DNA.**
Yamuna Krishnan
National Centre for Biological Sciences, TIFR, Bangalore

10:30 – 11:00 Coffee Break

11:00 – 12:30 Correlated Systems & Novel Ground States
Chair**: Ora Entin-Wohlman**
Tel Aviv University, Tel Aviv & Ben Gurion University**,** Beer Sheva

11:00 **Electron spectroscopy of correlated electron systems.**
Kalobaron Maiti
Tata Institute of Fundamental Research, Mumbai

11:30 **Hidden topological order in 1D Bose insulators.**
Ehud Altman
Weizmann Institute of Science, Rehovot

12:00 **Variational wavefunction studies of a triangular lattice supersolid.**
Kedar damle
Tata Institute of Fundamental Research, Mumbai

12:30 – 14:00 Lunch at Merkazi

14:00 – 16:00 Walking Tour of Tzfat

16:00 – 16:30 Coffee Break

Tuesday, November 4, 2008 (continued)

16:30 – 18:00 Low-Dimensional Systems II
Chair**: Efrat Shimshoni,** Bar Ilan University, Ramat Gan

16:30 **Type-II behavior in wurtzite InP/InAs/InP core-multishell nanowires.**
Bipul pal
Indian Institute of Science Education and Research, Kolkata

17:00 **Dissipative quantum Hall transport at the Dirac point of graphene.**
Venkateswara Pai
Technion – Israel Institute of Technology, Haifa

17:30 **Coupling of spin and orbital motion of electrons in ultra-clean carbon nanotubes.**
Shahal Ilani
Weizmann Institute of Science, Rehovot

19:00 – 22:00 Conference Banquet at *Palacio Domain*

Wednesday, November 5, 2008

09:00 – 10:30 Magnetism & Superconductivity
Chair**: Aviad Frydman,** Bar Ilan University, Ramat Gan.

09:00 **Similarity and difference between electron and hole-doped cuprates.**
Yoram Dagan
Tel Aviv University, Tel Aviv

09:30 **The de Gennes effect and giant magnetoreistance in ferromagnet-superconductor heterostructures.**
Ramesh C. Budhani
Indian Institute of Technology, Kanpur

10:00 **Nuclear spin pumping in semiconductor devices.**
Vikram Tripathi
Tata Institute of Fundamental Research, Mumbai

10:30 – 11:00 Coffee Break

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The Hebrew University of Jerusalem, Jerusalem

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Bar Ilan University, Ramat Gan.

11:30 **Motoring along the intracellular highway: The real engines of creation.**
Debashish Chowdhury
Indian Institute of Technology, Kanpur.

12:00 **Intracellular fluid dynamics in rapidly moving cells.**
Kinneret Keren
Technion – Israel Institute of Technology, Haifa

12:30 – 14:00 Lunch at Merkazi

14:00 – 16:00 Condensates & Cold Atoms
Chair**: Yigal Meir,** Ben Gurion University, Beer Sheva

14:00 **How atoms interact with surfaces.**
Ron Folman
Ben Gurion University, Beer Sheva

14:30 **Ultracold polar molecules near quantum degeneracy.**
Avi Pe'er
Bar Ilan University, Ramat Gan

15:00 **Correlated phases of cold dipolar exciton fluids: A Bose-Einstein condensate or a liquid?**
Ronen Rapaport
The Hebrew University of Jerusalem, Jerusalem

15:30 **The a.c. and d.c. Josephson effects in a Bose-Einstein condensate.**
Jeff Steinhauer
Technion – Israel Institute of Technology, Haifa

16:00 – 16:30 Coffee Break

Wednesday, November 5, 2008 (continued)

16:30 – 18:00 Mesoscopic Systems
Chair**: Sushanta Dattagupta**
Indian Institute of Science Education & Research, Kolkata

16:30 **Superconducting fluctuations in small rings.**
Yuval Oreg
Weizmann Institute of Science, Rehovot

17:00 **The conductance of small mesoscopic disordered rings.**
Doron Cohen
Ben Gurion University, Beer Sheva

17:30 **Superconducting phase qubits – Measuring noise and controlling decoherence.**
Nadav Katz
The Hebrew University of Jerusalem, Jerusalem

18:00 – 18:15 Closing

18:00 **Farewell and closing remarks**
Ron Lifshitz
Tel Aviv University, Tel Aviv

19:00 – 20:00 Dinner at Merkazi

20:00 – 22:00 Klezmers (Tentative)

Thursday, November 6, 2008

09:00 – 20:00 Post-conference tour of the Golan Heights.
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List of Posters

Arranged alphabetically by presenting author

1. **Crystals and beyond**
Shelomo I. Ben-Abraham
Department of Physics, Ben-Gurion University of the Negev, Beer-Sheba

2. **Persistence in Reactive-Wetting Interfaces**
Yael Efraim and Haim Taitelbaum
Department of Physics, Bar-Ilan University, Ramat-Gan

3. **Signature of small and large Fermi momentum in electrical transport of one dimensional Kondo lattice**
Arti Garg[1], Efrat Shimshoni[2], Achim Rosch[3], and Natan Andrei[4]
[1] *Physics Department, Technion, Haifa 32000*
[2] *Dept. of Physics, Bar Ilan University, Ramat Gan*
[3] *Institute for Theoretical Physics, University of Cologne, 50937 Cologne, Germany*
[4] *Center for Material Theory, Rutgers University, Piscataway, NJ 08854, USA*

4. **The Effect of temperature on the dynamics and geometry of reactive-wetting interfaces**
Meital Harel, Avraham Be'er and Haim Taitelbaum
Department of Physics, Bar Ilan University, Ramat Gan

5. **Pattern selection in parametrically-driven arrays of nonlinear resonators**
Eyal Kenig[1], Ron Lifshitz[1], and M.C. Cross[2]
[1] *Raymond & Beverly Sackler School of Physics and Astronomy, Tel Aviv University*
[2] *Condensed Matter Physics, California Institute of Technology, Pasadena, CA*

6. **Itinerant ferromagnetism in the electron localization limit**
Noa Kurzweil and Aviad Frydman
Department of Physics, Bar Ilan University, Ramat Gan

7. **DNA brushes: Transitions induced by competitive binding of counterions**
Shlomi Medalion, Shay. M. Rappaport and Yitzhak Rabin
Department of Physics, Bar Ilan University, Ramat Gan

8. **Non-equilibrium work fluctuation theorems for a system in contact with a time reversible heat reservoir**
Punyabrata Pradhan, Yariv Kafri, and Dov Levine
Physics Department, Technion – Israel Institute of Technology, Haifa

9. Breaking of phase symmetry in non-equilibrium Aharonov-Bohm oscillations through a quantum dot

Vadim Puller[1] and Yigal Meir[1,2]
[1] *Department of Physics, Ben-Gurion University of the Negev, Beer Sheva 84105*
[2] *The Ilse Katz Center for Meso- and Nano-scale Science and Technology, Ben-Gurion University, Beer Sheva 84105*

10. Model of DNA bending by cooperative binding of proteins

S.M. Rappaport[1] and Y. Rabin[2]
[1] *Department of Physics, Bar Ilan University, Ramat-Gan 52900*
[2] *Nano-materials Research Center, Institute of Nanotechnology and Advanced Materials, Bar-Ilan University, Ramat-Gan 52900*

11. Covalency effects on the magnetism of $EuRh_2P_2$

Robert Schmitz
Physics Department, Technion – Israel Institute of Technology, Haifa

12. Experimental investigation of the coupling between magnetic and super-conducting order parameters in LSCO films

Meni Shay and Amit Keren
Physics Department, Ben-Gurion University of the Negev, Beer Sheva

13. Slow dynamics and glassiness in a lattice model

Ziv Rotman and Eli Eisenberg
Raymond & Beverly Sackler School of Physics and Astronomy, Tel Aviv University

14. Manipulating the optical transparency of meta-materials with a strong magnetic field and liquid crystals

Y.M. Strelniker[1], D.J. Bergman[2], D.G. Stroud[3], and A.O. Voznesenskaya[4]
[1] *Department of Physics, Bar Ilan University, Ramat-Gan 52900*
[2] *Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv 69978*
[3] *Department of Physics, The Ohio State University, Columbus, Ohio 43210*
[4] *St. Petersburg State University of Information Technologies, Mechanics and Optics, St. Petersburg 197101*

Lecture Abstracts

The Rashba-Aharonov-Bohm interferometer: A spin polarizer analyzer

Amnon Aharony[1,2]

[1] *Raymond & Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv*

[2] *Department of Physics, Ben Gurion University, Beer Sheva*

Spintronics aims at utilizing both the electron's spin and charge for information storage and readout. Here I review some of our recent work on spin transport through mesoscopic loops with both the Rashba spin-orbit interaction and the Aharonov-Bohm flux. For appropriate tuning of the parameters, such devices can either fully polarize the spins of the outgoing electrons, or allow the identification of the spin polarization using only measurements of the electronic charge transmission.

Work with O. Entin-Wohlman, Y. Tokura and S. Katsumoto.

Time-resolved study of growth mechanisms of semiconductor nanocrystals via the solution route

D. D. Sarma

Centre for Advanced Materials, Indian Association for the Cultivation of Science, Kolkata 700032, India

It is now well understood that the bandgap, and consequently associated electronic and optical properties, of semiconducting nanoparticles can be tuned by varying the size due to quantum confinement effects. Colloidal methods constitute an important class of synthesis of such nanoparticles due to their high degree of flexibility, providing easy control over the average size. More than the average size, the entire size distribution function controls the properties of such samples. This method of synthesis depends basically on controlling the reaction process leading to the formation of the semiconductor in a solution by controlling various factors like temperature and concentration. The primary difficulty of this method is the strong interplay between various factors in a way that is very little understood; however these very processes control the size along with the size distribution of the generated particles. Thus, the techniques of synthesis of high quality nanocrystals, indicated by the ability to grow a pre-defined size with a narrow size distribution, have remained largely in the realm of empiricism. Obviously there is a need to understand the mechanism of the growth process of the nanocrystals, though very little is known about it in such a complex reaction, often carried out in presence of a capping agent. We employ already established state-of-the-art techniques as well as a few novel approaches to study in real time the growth kinetics of a host of semiconductor materials to unravel a wide range of unexpected behaviors. We show that such studies help us to design routes to rational synthesis of high quality samples for possible device applications.

References:

[1] S. Sapra and D. D. Sarma, *Phys. Rev. B* **69**, 125304 (2004).
[2] R. Viswanatha, S. Sapra, T. Saha-Dasgupta and D. D. Sarma, *Phys. Rev. B* **72**, 045333 (2005).
[3] R. Viswanatha and D. D. Sarma, *Chem. – A European J.* **12**, 180 (2006).
[4] R. Viswanatha, H. Amenitsch and D. D. Sarma, *J. Am. Chem. Soc.* **129**, 4470 (2007).
[5] R. Viswanatha, C. Das Gupta and D. D. Sarma, *Phys. Rev. Lett.* **98**, 255501 (2007).
[6] R. Viswanatha et al., unpublished results.

Structural, Magnetic and Chemical Effects in Low-Dimensional Systems

Shobhana Narasimhan

Jawaharlal Nehru Centre for Advanced Scientific Research Jakkur, Bangalore, India

My work focuses on applying the techniques of *ab initio* density functional theory to studying the properties of low-dimensional systems, such as surfaces, interfaces, wires and clusters. As an example of how structural and vibrational properties change as a function of coordination number, I will describe our work on the reconstruction of Pt(111), and a study of the size-dependent properties of Si, Sn and Pb clusters. I will also briefly discuss our work on the adsorption and dissociation of NO on Rh surfaces and clusters. Finally, I will present some of the highlights of our work on two-dimensional surface alloys that consist of two immiscible metals co-deposited on the surface of a third metal.

Cooling in freely-evolving granular gases

Sanjay Puri

School of Physical Sciences, Jawaharlal Nehru University, New Delhi

We consider a freely-evolving granular gas which continuously loses energy (or cools) due to the inelastic collisions amongst granular particles. In the late stages of cooling, the gas undergoes a clustering instability in the density and velocity fields. We study various properties of this asymptotic state, e.g., pattern morphologies, time-dependence of cluster sizes, velocity distributions, etc.

Finite time collapses in freely cooling granular gases

Itzhak Fouxon

Raymond & Beverly Sackler School of Physics & Astronomy, Tel Aviv University, Tel Aviv

We consider dynamics of a most basic model of a dissipative system – a dilute collection of hard spheres that collide inelastically. Such dissipative or granular gas is the simplest model of a granular material. In contrast to ordinary gases, the free evolution of a granular gas leads to the appearance of localized structures. We show that the tendency to form clusters of particles is reflected via finite-time singularity in the equations of idealized granular gas dynamics. We also introduce new soliton-like solutions of the gas dynamics and discuss their relevance to the general evolution of the gas.

Growing length and time scales in glass forming liquids

Smarajit Karmakar,[1] Chandan Das Gupta,[1,2] and Srikanth Sastry[2]

[1]*Centre for Condensed Matter Theory, Department of Physics, Indian Institute of Science, Bangalore, India.*
[2] *Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore 560064, India.*

Explaining the enormous increase in the viscosity and relaxation time of a liquid upon supercooling is essential for an understanding of the structural glass transition. Although the notion of a growing length scale of 'cooperatively rearranging regions' is often invoked to explain dynamical slow down, the role of length scales relevant to glassy dynamics is not well established. Recent studies of spatial heterogeneity in the local dynamics provide fresh impetus in this direction. Using finite-size scaling for the first time for a realistic glass former, we establish that the growth of dynamical heterogeneity with decreasing temperature is governed by a growing dynamical length scale. However, the dependence of the simultaneously growing relaxation time on system size does not exhibit the same scaling behavior as the dynamical heterogeneity. We show that the relaxation time is instead determined, for all studied system sizes and temperatures, by the configurational entropy, in accordance with the Adam-Gibbs relation, but in disagreement with the prevailing belief that the configurational entropy is not relevant above the critical temperature of mode coupling theory.

Response-correlation inequality in dynamical systems

Eytan Katzav[1] and Moshe Schwarz[2]

[1] *Depatment of Mathematics, Disordered Systems Group, King's College London*
[2] *Raymond & Beverly Sackler School of Physics & Astronomy, Tel Aviv University, Tel Aviv*

The flurry of activity in non equilibrium statistical phenomena covers many fields of theoretical and practical importance such as growth models, front propagation, crack propagation and many more. We present a derivation of an exact inequality relating the response function, measuring the response of the physical field of interest to an external probe, and the correlation function. Assuming scaling, that inequality is turned into an exponent inequality. The usefulness of the inequality is demonstrated by checking against it some theoretical and experimental results which violate the inequality.

Instabilities and nonlinearities in bulk and nanopatterned superconductors

Satyajit Banerjee

Department of Physics, Indian Institute of Technology, Kanpur – 208016, U. P. India

The behavior of a collection of vortices in type II superconductors can be described with elastic modulii which is a million to billion times smaller than an ordinary atomic solid. The softness of the vortex state makes it susceptible to disordering influence from local impurities/defects and thermal fluctuations. Therefore, the collection of vortices (also known as vortex matter) is a convenient prototype for studying properties of soft materials in the presence of a random disordering environment. The ability to easily vary the density of vortices by varying the applied magnetic field and thereby change the interaction amongst vortices gives one the ability to study a variety of different phases of vortex matter. The perfectly hexagonally ordered vortex lattice predicted by Abrikosov, exists in only in hypothetical superconductors with zero impurity/defects. Experiments with realistic superconductors have revealed configurations of vortices which are not explained by the mean field like calculation by Abrikosov. In recent times the influence of microscopic disorder in the superconductor has been viewed to play a crucial role in influencing the configuration of vortices. Studies on the nature of the static and the driven phase of the vortex solid have revealed a diverse array of glassy phase of the vortex configuration with varying degree of positional order and symmetry. Most recent studies have focused on investigating the properties associated with the transformations, from a reasonably well ordered elastic vortex solid (Bragg glass phase) into a topologically defective vortex glass phase in the static case, or the plastically deformed vortex solid for the driven case. In this talk I will be presenting results of our recent investigations into the dissipation properties of the driven vortices [1], via which we have found the existence of possible symmetry changes deep within the well ordered elastic vortex solid [1]. The result is significant, as it requires a revision of understanding the properties of the so called 'benign' elastic vortex solid. We have also studied the nonlinear properties of the driven vortex solid [2] through a random pinning environment and have found interesting highly nonlinear fluctuation in the time domain. We believe our results indicate the presence of process deep within the elastic driven phase which is a precursor to the plastic transformation in the vortex matter. If time permits I will also try to briefly provide an overview of our recent results on the unique behavior of the vortices in a nanostructured superconductor [3], which holds potential for future application in memory storage device.

References:
[1] Shyam Mohan, Jaivardhan Sinha, S. S. Banerjee, and Yuri Myasoedov, *Phys. Rev. Lett*. **98**, 027003 (2007).
[2] Shyam Mohan, Jaivardhan Sinha, S. S. Banerjee, A. K. Sood, S. Ramakrishna, A. K. Grover (submitted, 2008).
[3] Gorky Shaw, Shyam Mohan, Jaivardhan Sinha and S. S. Banerjee (submitted, 2008).

Death of a vortex at the (spiraling) hands of a density interface

Harish Dixit and Rama Govindarajan

Engineering Mechanics Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore 560064, India

A vortex placed at a density interface winds it into an ever-tighter spiral. Interesting dynamics then follow as we show: a centrifugal Rayleigh-Taylor instability combined with a spiral Kelvin-Helmholtz type of instability. The latter occurs only because a spiral is not quite circular, and grows faster than exponentially. Breakdown into a turbulence-like state follows, and the original vortex is no longer discernible. In such studies, the Boussinesq approximation is usually made, but none of this dynamics would happen under that approximation. The study could have implications for cyclones approaching land, and aircraft trailing vortices.

Fascinating dynamics of surfactant micellar gels under shear

Ajay K. Sood

Department of Physics, Indian Institute of Science, Bangalore

Soft matter like surfactant gels exhibit strong response to modest external perturbations. This talk will bring out fascinating flow dynamics of surfactant worm-like micellar gels. In our recent studies, a rich dynamic behavior exhibiting regular, quasiperiodic, intermittency and chaos is observed. Our experiments show that the route to chaos is via intermittency [1-5]. Polarized light scattering experiments have quantified the spatially inhomogeneous orientational dynamics en route to chaos. The dynamics of 2D Taylor like velocity rolls, stacked along the vorticity directions, is correlated with the stress fluctuations [6, 7].

Most recently [8], we have shown that the shear rate at a fixed shear stress in a micellar hexagonal phase exhibits large fluctuations, including several negative values. The probability distribution functions (PDF's) of the global power flux to the system derived from the shear rate fluctuations are Gaussian or non-

Gaussian, depending on the external drive (applied stress) on the system. In both cases, the PDF is consistent with the Gallavotti-Cohen steady state fluctuation theorem. We show that an effective temperature of the jammed state can be measured using a fluctuation theorem.

References:
[1] R. Ganapathy and A.K. Sood, *Phys. Rev. Lett*. **96**, 08301(2006)
[2] R. Ganapathy and A.K. Sood, *Pramana-J. Phys* **67**, 33 (2006)
[3] R. Ganapath, G. Rangarajan and A.K. Sood, *Phys. Rev. E*. **75**, 016211(2007)
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[6] R. Ganapathy, S. Majumdar and A.K. Sood, *Eur.Phys. J.B*. **64**, 537 (2008).
[7] R. Ganapathy, S. Majumdar and A.K. Sood, *Phys. Rev. E*. **78**, 21504 (2008).
[8] S. Mazumdar and A.K. Sood*, Phys. Rev. Lett*. **101**, 78301 (2008).

Physical biology of genome assembly & regulation

G.V. Shivashankar

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Genomic DNA, which is almost a meter long, is remarkably efficiently packaged into the cell nucleus, hardly a few microns across, using histones and other nuclear proteins. Recent evidence suggests that the extent and form of such packaging (chromatin) within living cells is central to its gene expression pattern and hence function. Further, gene expression patterns in cultured cells or cells within an organism, are responsive to nanoscale mechanical forces experienced at the cell membrane that are transduced into biochemical signals to alter genome function. However the physical basis behind the creation and maintenance of genome assembly & its subsequent modulation in the context of its function are unclear. Progress in high resolution live-cell imaging combined with biomechanics and functional genomics developed in many laboratories including ours have provided a new paradigm in understanding genome regulation. Using a multi-disciplinary approach, our laboratory studies the impact of cellular architecture in governing genome assembly and its regulation. For this we use mammalian cell lines, stem-cells undergoing differentiation and developing Drosophila embryos as model systems. We address in living cells and embryos, the spatio-temporal variation in the compaction of the genome assembly during differentiation and development and correlate these changes with cellular transcription control and memory. We have obtained insights into the mechanical coupling of cellular architecture on genome organization by controlled physical manipulation of the latter. Such controlled physical modulation of genome architecture could pave the way to artificially engineering transcription programs in diverse developmental contexts for cell/tissue engineering applications. In this talk I will discuss some of our recent experiments outlining our insights in these directions and the implications of the physical coupling of genome organization to cellular architecture.

References:
[1] "Probing the dynamic organization of transcription compartments and gene loci within the nucleus of living cells." Deepak Kumar Sinha, Bidisha Banerjee, Shovamayee Maharana, & G.V. Shivashankar, *Biophysical Journal.* In press (2008).
[2] "Dynamics of chromatin decondensation reveals the structural integrity of a mechanically prestressed cell nucleus." Aprotim Mazumder, T.Roopa, Aakash Basu, L.Mahadevan & G.V. Shivashankar, *Biophysical Journal*. In press (2008).

[3] "Gold-nanoparticle-assisted laser ablation of chromatin assembly reveals unusual aspects of nuclear architecture within living cells." Aprotim Mazumder & G.V. Shivashankar. *Biophysical Journal* **93** (2007) 2209-2216.
[4] "Direct measurement of chromatin fluidity using optical trap modulation force spectroscopy." T.Roopa & G.V. Shivashankar. *Biophysical Journal* **91** (2006) 4632-4637.
[5] "Core and linker histones diffuse via distinct mechanisms within living cells." Dipanjan Bhattacharya, Aprotim Mazumder, M. Anne & G.V. Shivashankar. *Biophysical Journal* **91** (2006) 2326-2336.
[6] "Chromatin assembly exhibits spatio-temporal heterogeneity within the cell nucleus." Bidisha Banerjee, Dipanjan Bhattacharya & G.V. Shivashankar. *Biophysical Journal* **91** (2006) 2297-2303.

Exploring the efficiency of protein-complex production in the cell

Eli Eisenberg

Raymond & Beverly Sackler School of Physics & Astronomy, Tel Aviv University, Tel Aviv

Cell function necessitates the assemblage of several proteins into a protein complex. We use newly available data on yeast protein complexes and the concentration of their building-blocks, together with a mathematical model of complex synthesis to show how several characteristics of protein concentrations and their noise are regulated to optimize complex production, in terms of better utilization of the available molecules and better resilience to stochastic variations.

Wires, reporters and information capsules: Cellular journalism with DNA

Yamuna Krishnan

National Centre for Biological Sciences, TIFR, GKVK, Bangalore 560 065, India

DNA is rapidly taking on a new aspect where it is finding use as a construction element for architecture on the nanoscale [1]. Thus far, directed DNA assembly has relied on Watson-Crick base pairing, and this has been a powerful and preferred approach in structural DNA nanotechnology. I will discuss a paradigm shift in design and strategy that uses a four-stranded building block, the i-tetraplex, to create rigid scaffolds and dynamic nanolevers. We have been interested in developing tetraplex building blocks for applications in structural DNA nanotechnology [2]. I will describe a strategy to build rigid 1D scaffolds, called I-wires, using the i-tetraplex. The i-tetraplex consists of two parallel-stranded duplexes, each held together by C^{+}H-C base pairs, intercalated in an anti-parallel orientation [3]. High stability, attractive dimensions, structural uniformity and amenability of self-assembly to external control make the I-wire a 1D scaffold that could overcome physical limitations associated with B-DNA [4]. We have also used the i-tetraplex to construct a proton-sensitive DNA nanoelectromechanical system (NEMS). The NEMS senses a proton input which is coupled through an i-tetraplex actuator that realizes nanomechanical motion corresponding to a second order lever. The estimated opening and closing forces are ~9 pN, commensurate with cellular motor-proteins. We demonstrate the first intracellular application of DNA nanomotors by mapping spatiotemporal pH changes within cells using the present NEMS [5]. I will also discuss how 3D DNA polyhedra can be constructed using a modular assembly approach and their possible applications in targeted drug delivery [6].

Funded by NSTI, DST, Govt. of India & DBT, Govt. of India via the Innovative Young Biotechnologist Award.

References:
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Electron spectroscopy of correlated electron systems

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The investigation of the role of electron correlation in various electronic properties is a paradigmatic problem in solid state physics. 3d transition metal oxides have drawn much attention in this direction during last few decades due to various exotic properties exhibited by these systems. Various recent studies show that 4d and 5d transition metal oxides (TMO) also exhibit varieties of interesting and unusual properties although the electron correlation strength is expected to be weak due to large radial extensions of the 4d and 5d orbitals. We have employed high resolution photoemission spectroscopy to study these systems. For example, ruthenates (4d TMO) in the perovskite structure exhibit a transition from Fermi liquid to Non-Fermi liquid behavior and unusual magnetic properties [1], although the electron correlation is found to be significantly weak [2,3]. Doping of Ti at the Ru sites leads to a transition from weakly correlated metal to a band insulating phase [4] via a half metallic phase [5]. A 5d TMO, $BaIrO_3$ exhibits CDW/unusual electronic phase transition despite being an insulator. High resolution photoemission studies show that such unusual ground state appear due to localized electronic states at the Fermi level [6]. Electron correlation strength may not be strong in this system [7]. $Y_2Ir_2O_7$ is proposed to be a Mott insulator although the partially filled 5d orbitals are expected to be highly extended [8]. In this talk, I will provide a brief overview of our findings in these systems and try to bring out open questions related to these studies. The details can be found in the following references.

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Hidden topological order in 1D Bose insulators

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Ground states of integer spin chains are known since the late 80's to sustain highly non local order described by infinite string operators of the spins. Such states defy the usual Landau theory description and can be considered simple prototypes of topological order. Recently we established the existence of an analogous phase of spinless bosons, which exhibits similar string order in terms of the boson density. This phase can be realized in systems of ultra cold molecules with extended (e.g. dipolar) interactions. The Bose system can be tuned across quantum phase transitions between the exotic phase, which we term Haldane insulator, and the conventional Mott and density wave states. The response of the system near these phase transitions is revealing of the unusual character of the string order. In particular I will show how a perturbation, seemingly unrelated by symmetry to either phase, eliminates the critical point between the Mott and Haldane phases and allows adiabatic connection between them. Finally I will establish the existence of a distinct collective mode that can serve to identify the new phase in Bragg spectroscopy experiments.

Variational wavefunction studies of a triangular lattice supersolid

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We present a variational wave function which explains the behavior of the supersolid state formed by hard-core bosons on the triangular lattice. The wave function is a linear superposition of only and all configurations minimizing the repulsion between the bosons (which it thus implements as a hard constraint). Its properties can be evaluated exactly; in particular, the variational minimization of the energy yields (i) the surprising and initially controversial spontaneous density deviation from half-filling (ii) a quantitatively accurate estimate of the corresponding density wave (solid) order parameter.

Reference:
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Variational wavefunction studies of a triangular lattice supersolid

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We study optical transitions from a periodic array of vertically grown, highly uniform InP/InAs/InP core-multishell nanowires (NWs) by using time- and spectrally-resolved photoluminescence (PL) and PL excitation (PLE) spectroscopy. In this novel sample [1] the ultrathin InAs inner shell is surrounded by InP layers from all sides and is subject to compressive strain in all three directions, unlike ultrathin InAs/InP quantum wells (QWs). Furthermore, in this NW sample both InP and InAs have wurtzite crystal structure, in contrast to InAs/InP QWs where InP and InAs crystalize to a zincblende structure. There are a few experimental and theoretical studies available on ultrathin InAs/InP QWs having zincblende structure. These studies seem to show type-I direct transitions in zincblende InAs/InP QWs. However, electronic structure and optical properties of InP/InAs/InP core-multishell nanowires (CMNs) having wurtzite structure are practically unknown due to the novelty of this sample.

Our optical measurements on this novel sample show multiple peaks in the PL spectra due to monolayer-scale variation in the width of the InAs shell. Carrier diffusion between regions of different monolayer thickness is evident from the PLE spectra. Observation of a large Stokes shift between PL and PLE spectra and the absence of strong PLE peaks suggest a type-II radiative recombination. A blueshift of the PL peaks with a cube-root dependence on the excitation power is observed which confirms the type-II behavior [2]. Time-resolved PL measurements by using time-correlated single photon counting technique reveal a slow and nonexponential decay of PL with an effective decay time of 16 ns, consistent with type-II radiative transitions. Band-offset calculation based on "model-solid theory" of C. G. Van de Walle [3] for wurtzite InP/InAs/InP heterostructure assuming three-dimensional compressive strain shows type-II band line-up in agreement with our experimental observations.

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Dissipative quantum Hall transport at the Dirac point of graphene

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Graphene is a novel two dimensional electronic system with quasiparticles exhibiting Dirac-like dispersion. In presence of a magnetic field it exhibits quantum Hall effect which is quite different from conventional systems. Most interestingly, the Dirac point Hall plateau is associated with a nonvanishing diagonal resistivity that shows a 'metal-insulator transition' as a function of field. We propose that magnetic impurities have a nontrivial effect on the spin domain wall formed at $\nu = 0$ leading to a dissipative diagonal resistivity accompanying the quantum Hall plateau via a 'chiral Kondo effect'. An effective model capturing this physics will be described. We find that the resistivity at finite temperatures may exhibit a crossover from metallic to insulating behavior as the Luttinger parameter of the non-chiral edge mode is tuned across a threshold value. In the insulating regime, low temperature resistivity diverges as the Luttinger parameter approaches a critical value, manifesting a scaling law characteristic of a quantum Kosterlitz-Thouless transition.

Work done in collaboration with Efrat Shimshoni and Herb Fertig.

Coupling of Spin and Orbital Motion of Electrons in Ultra-Clean Carbon Nanotubes

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Electrons in atoms possess both spin and orbital degrees of freedom. In non-relativistic quantum mechanics, these are independent, resulting in large degeneracies in atomic spectra. However, relativistic effects couple the spin and orbital motion, leading to the well-known fine structure in their spectra. It is widely believed that the electronic states of defect-free carbon nanotubes are four-fold degenerate, owing to independent spin and orbital symmetries, and also possess electron–hole symmetry. In this talk I will show our recent measurements, which demonstrate that in ultra-clean nanotubes the spin and orbital motion of electrons are coupled, thereby breaking all of these symmetries. This spin–orbit coupling is directly observed as a splitting of the four-fold degeneracy of a single electron in ultra-clean quantum dots. It further breaks the electron-hole symmetry by aligning the orbital and spin magnetic moments differently for electrons and holes. Our observations are consistent with recent theories, which predict that in the cylindrical topology of nanotubes, the motion of electrons along closed orbits would be coupled to their spin. These findings have important implications on our basic understanding of the electronic properties of nanotubes as well as on the future use of carbon-based systems for spin-based applications.

Similarity and difference between electron and hole-doped cuprates

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Electron-doped cuprates may be somewhat easier to understand comparing to hole-doped ones. The phase diagram is simpler and does not contain the pseudogap phase, at least not in the form present in hole-doped cuprates. This enables us to detect and follow for example the temperature and doping dependence of the supercondcting order parameter by performing S/I/S tunneling measurements. We find that the temperature dependence of the order parameter follows the BCS prediction. On the underdoped side the superconducting gap is not obscured by the pseudogap that has a dominating effect on the tunneling spectra in most of the STM experiments. The superconducting gap in electron-doped cuprates follows the doping dependence of T_c, similar to the doping dependence of the coherent energy scale in hole-doped cuprates probed by Andreev-Saint James reflections.

Our transport data can be interpreted using a spin density wave model. The Fermi surface changes from small electron pockets to hole like Fermi surface that closes completely at a quantum critical point. A similar process seems to occur in hole doped cuprates according to recent quantum oscillations measurements.

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The de Gennes Effect and Giant Magnetoresistance in Ferromagnet–Superconductor Heterostructures

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Electron transport and magnetic ordering in ferromagnet (FM) – superconductor (SC) heterostructures display a plethora of novel phenomena which acquire increasing richness in systems where the nature of the FM and SC orders is exotic. Heterostructures of manganites and high temperature superconducting cuprates offer such systems.

Here examine the relevance of pair breaking by dipolar and exchange fields and injected spins in a low carrier density cuprate $Y_{1-x}Pr_xBa_2Cu_3O_7$ (YPBCO) which has insulating c-axis resistivity and hence a poor spin transmittivity. We further address the issue of giant MR in $La_{2/3}Sr_{1/3}MnO_3$ – $Y_{1-x}Pr_xBa_2Cu_3O_7$ – $La_{2/3}Sr_{1/3}MnO_3$ trilayers, in three distinctly illuminating ways which involve; i) current density dependence of MR over a broad range of temperature below T_c, ii) field dependence of MR when the magnetizations of $La_{2/3}Sr_{1/3}MnO_3$ (LSMO) layers $\mathbf{M_1}$ and $\mathbf{M_2}$ are parallel and fully saturated and, iii) dependence of MR on the angle between current and field below and above the critical temperature (T_c). These measurements permit disentanglement of the contributions of flux flow and pair breaking effects in YPBCO, and the intrinsic anisotropic MR of LSMO layers to GMR in FM-SC-FM trilayers, and establish a fundamental theorem which warrants diverging MR in the limit of infinitely conducting spacer.

In addition, the issue of inhomogeneous vortex state and field enhanced superconductivity in nanoengineered FM-SC heterostructures will be addressed.

This research has been supported by grants from the Department of Science and Technology, Board for Research in Nuclear Sciences and the Department of Information Technology, Government of India.

Nuclear spin pumping in semiconductor devices

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We propose a new method for dynamic nuclear polarization in a quasi one-dimensional quantum wire utilizing the spin-orbit interaction, the hyperfine interaction, and a finite source-drain potential difference. In contrast with current methods, our scheme does not rely on external magnetic or optical sources, which makes independent control of closely placed devices much more feasible. Using this method, a significant polarization of a few per cent is possible in currently available InAs wires which may be detected by conductance measurements. This may prove useful for nuclear-magnetic-resonance studies in nanoscale systems as well as in spin-based devices where external magnetic and optical sources will not be suitable.

Reference:
Europhysics Letters **81**, 68001 (2008).

Organization of telomeres and its diffusion in the nucleus of the cell

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The human genome contains tens of thousands of genes that are organized in chromosomes and packed in the nucleus of the cell in a non-random manner. We are studying the organization of the genome in normal and cancer cells by observing the telomeres and their dynamics. The distribution of the telomeres is found to be cell-cycle dependent and in tumor cells the telomeres form aggregates. We are currently studying the telomere fusion dynamics by following the telomeres in living cells. These studies require combining three-dimensional microscopy, image processing algorithms, and novel physics methods.

We find that telomere diffusion is anomalous (subdiffusion) at short time scales (10^{-2} sec) and changes to approximately normal diffusion at longer time scales. Our overall measurement of the diffusion covers about 5 orders of magnitude in time, namely $10^{-2} – 10^{3}$ sec.

Motoring along intracellular highways: The real engines of creation

Debashish Chowdhury

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RNA polymerase (RNAP) is an enzyme that synthesizes a RNA strand which is complementary to a single-stranded DNA template. From the perspective of physicists, an RNAP is a molecular motor that utilizes chemical energy input to move along the track formed by a DNA. Similarly, a ribosome is also a motor, but it moves on a mRNA track. In many circumstances a large number of such motors move simultaneously along the same track; we refer to such collective movements of the motors as traffic. In this talk, I'll present our recent models which incorporate the steric interactions between motors as well as the mechano-chemical cycle of individual motors. By a combination of analytical and numerical techniques, we have calculated the rates of synthesis and the average density profile of the motors on the nucleic acid track. Very recently, we have also introduced two new measures of intrinsic noise in transcription and translation. In this talk, I'll also show how the level of intrinsic noise and the corresponding "burst statistics" depends on the concentrations of the motors as well as on those of some of the reactants and the products of the enzymatic reactions catalyzed by the motors. I'll also suggest appropriate experimental systems and techniques for testing our theoretical predictions.

Intracellular Fluid Dynamics in Rapidly Moving Cells

Kinneret Keren

Technion – Israel Institute of Technology, Haifa

Molecular mechanisms and biophysical processes are intimately intertwined to generate the robust large-scale self-organization manifested by a moving cell. While much research has been devoted to the molecular mechanisms underlying cell motility, less is known about its biophysical aspects such as the intracellular fluid dynamics. To investigate the existence and the direction of fluid flow in rapidly moving cells, we introduce inert quantum dots into the lamellipodium of fish epithelial keratocytes and analyze their distribution and motion. Under normal conditions, our results indicate that fluid flow is directed from the cell body toward the leading edge in the cell frame of reference, at ~40% of cell speed. We propose that the forward-directed flow is driven by increased hydrostatic pressure generated at the rear of the cell by myosin contraction, and show that inhibition of myosin II activity by blebbistatin reverses the direction of fluid flow and leads to a decrease in keratocyte speed. We present a physical model for fluid pressure and flow in moving cells that quantitatively accounts for our experimental data.

How atoms interact with surfaces

Ron Folman

Dept. of Physics, Ben Gurion University, Beer Sheva

We use ultra cold atoms trapped on an atom chip to study the affect of a “classical environment” (the chip) on a “quantum system” (the atom). We will describe the affect of different materials and configurations on atomic spin flips, heating and decoherence, as well as static corrugations of the trapping potential. All these effects are induced by the nearby surface of the atom chip and more specifically by the behavior of the electrons in the surface.

Ultracold polar molecules at the absolute ground state near quantum degeneracy

Avi Pe’er

Bar Ilan University, Ramat Gan

Ultracold polar molecules are predicted to exhibit novel collective quantum phenomena due to their long range dipole-dipole interactions. I will describe experiments performed in JILA, Colorado that recently succeded in production of ultracold polar molecules at their absolute rovibrational state. In the experiment, loosely bound ultracold KRb molecules are produced by Feshbach ‘magneto-association’, and then transferred into more deeply bound states via Raman transitions. The two color laser system driving the experiment is stabilized to an ultrafast frequency comb, which emerged in recent years as a main tool for precision spectroscopy and control. I will review the motivation, describe the experimental techniques (especially the role of the frequency comb) and show some results.

Correlated phases of cold dipolar exciton fluids: A Bose-Einstein condensate or a liquid?

Ronen Rapaport

The Hebrew University of Jerusalem, Jerusalem

Recent advancements of electro-optic control of the many-body excitonic systems in semiconductor quantum structures, in which macroscopic condensation and quantum coherence have been discovered in the last couple of years, open up new channels for utilizing such states in the versatile environment of an “on a chip” nanoscale semiconductor devices, and potentially lead to a new methodology in electro-optics and nanophotonics. It is these two main avenues, namely, the ability to control the excitonic systems and the understanding and utilization of their macroscopic condensed state, that are at the heart of our current research effort in this direction, and the main topic of this talk.

Recent results in this field, regarding both new insights into the nature of the collective ground state properties of this intriguing, low-dimensional, correlated bosonic fluid and new concepts of active control devices will be discussed, together with an outlook to the possibilities of future excitonic devices and circuits based on macroscopic quantum coherence.

The a.c. and d.c. Josephson effects in a Bose-Einstein condensate

Jeff Steinhauer

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We report the first observations of the a.c. and d.c. Josephson effects in a single BEC Josephson junction [1]. We also measure the chemical potential – current relation of the BEC Josephson junction. The coherent tunneling of the BEC is qualitatively altered by the thermal cloud, whose presence is varied. The system reported here constitutes a trapped-atom interferometer with continuous readout, which operates on the basis of the AC Josephson effect. This BEC Josephson junction is the first application of our BEC system with ultra high-resolution, capable of applying almost arbitrary potentials and imaging on a tunneling length scale.

Reference:
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Superconducting fluctuations in small rings

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We study theoretically the contribution of fluctuating Cooper pairs to the persistent current in superconducting rings threaded by a magnetic flux. For sufficiently small rings, in which the coherence length χ exceeds the radius R, mean field theory predicts a full reduction of the transition temperature to zero near half-integer flux. We find that nevertheless a very large current is expected to persist in the ring as a consequence of Cooper pair fluctuations that do not condense. For larger rings with $R \gg \chi$ we calculate analytically the susceptibility in the critical region of strong fluctuations and show that it reflects competition of two interacting angular modes.

The conductance of small mesoscopic disordered rings

Doron Cohen

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The calculation of the conductance of disordered rings requires a theory that goes beyond the Kubo-Drude formulation. Assuming “mesoscopic” circumstances the analysis of the electro driven transitions show similarities with a percolation problem in energy space. We argue that the texture and the sparsity of the perturbation matrix dictate the value of the conductance, and study its dependence on the disorder strength, ranging from the ballistic to the Anderson localization regime. An improved sparse random matrix model is introduced to captures the essential ingredients of the problem, and leads to a generalized variable range hopping picture.

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Superconducting phase qubits – Measuring noise and controlling decoherence

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Superconducting phase qubits are a controllable quantum system, with external electrical leads tuning the energy levels and driving transitions. We use the qubit as a probe for measuring noise driven effects and determine the spectral density of the flux noise. The leads also cause decoherence and dissipation. We demonstrate control of the qubit energy dissipation through a readout SQUID, which agrees well with a semi-classical model of impedance transformations.

Poster Abstracts

Crystals and beyond

Shelomo I. Ben-Abraham

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I intend to draw the attention of the Condensed Matter community to some current issues in crystallography and materials science. Since the discovery of quasicrystals there is an ongoing discussion on what is a crystal. The best up-to-date answer is that it is a solid whose Fourier spectrum has a pure point part; in other words, it shows Bragg peaks. On the other hand, there is growing interest in quasiregular heterostructures. These are artificially fabricated layer structures according to certain algorithms consisting mainly of substitution rules. Most of them are expected to have quite exotic diffraction patterns, such as a singular continuous spectrum.

Persistence in Reactive-Wetting Interfaces

Yael Efraim and Haim Taitelbaum

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The nontrivial persistence exponent θ describes a power law decay of the probability of a fluctuating variable to stay above or below a certain reference level, $P(t) \sim t^{-\theta}$. The persistence exponent has been calculated in the last decade for a wide range of theoretical, numerical and experimental systems. We study the persistence probability in propagating reactive-wetting interfaces of a mercury droplet ($\sim 150 \mu m$) spreading on a thin ($4000 A$) flat silver substrate in room temperature. We calculate the persistence exponent and study its relation to well known exponents such as the growth exponent β, which describes the dynamic growth of the reactive-wetting interface width.

Our results show that there are three kinetic regimes in our system. In the first one, while the interface width itself is not yet growing, the persistence exponent is $\theta = 0.5 \pm 0.05$, which is typical for random walk behavior. In the second time regime, there is an effective growth of the interface width, with growth exponent $\beta = 0.68 \pm 0.07$, and the value of θ is $\theta = 0.37 \pm 0.05$. In this time regime, the well known relation, $\theta + \beta = 1$, seems to hold for our experimental system. The third time regime is where the interface width saturates, and the roughness exponent α is measured. In this regime, the persistence exponent value is $\theta = 0.47 \pm 0.01$, which again reflects a random walker behavior. The results are compared with two sets of numerical simulations, based on two models, the QKPZ (Quenched Kardar-Parisi-Zhang) equation and the Ising model in zero temperature.

Signature of small and large Fermi momentum in electrical transport of one dimensional Kondo lattice

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We study the electrical transport properties of a doped one dimensional Kondo lattice model, a system consisting of a one-dimensional electron gas (1DEG) coupled to a spin-1/2 chain by the Kondo interaction. We use the memory function approach to calculate the effect of Kondo coupling on the resistivity, and show that its behavior as a function of temperature T differentiates between the weakly and strongly coupled phases of this system. In particular, we find a direct signature of the "large" and "small" Fermi momentum manifested in the resistivity at low T: in the weakly coupled phase, the low-T resistivity reflects the contribution of scattering events with momentum transfer of both $2k_F$ and $2k_F^*$, where $k_F^* = k_F + \pi/2$ is the large Fermi momentum. In contrast, in the strongly coupled Kondo lasmo phase, the low-T resistivity is dominated by scattering events with momentum transfer of $2k_F^*$ only, leaving no trace of the small Fermi momentum k_F. In addition, we show that the two phases are distinct in their response to a weak disorder in the charge sector, as the leading back-scattering term in the disorder is suppressed in the coupled Kondo lasmo phase. This strongly coupled phase, where conduction electrons hybridize with the local spins, is therefore a better conductor. Finally, we show that the low temperature resistivity in the spin-Peierls phase does not have any contribution from the scattering events with momentum transfer $2k_F^*$, which is a signature of breakdown of the Kondo effect in this phase.

The Effect of temperature on the dynamics and geometry of reactive-wetting interfaces

Meital Harel, Avraham Be'er and Haim Taitelbaum

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The temperature effect on the dynamics and geometry of mercury droplet (~150 μm) spreading on silver substrate (4000A) was studied. The system temperature was set in the temperature range of -15°C<T<25°C using a heating stage, and the spreading process was monitored using an optical microscope. In this reactive-wetting system, the temperature variation affects the surface tension of the materials, the chemical reaction rate and the mercury viscosity. We studied the wetting dynamics (droplet radius $R(t)$ and velocity) and the kinetic roughening properties (roughness (α) and growth (β) exponents), all as a function of time and temperature.

At early times, $R(t) \sim t$ for all temperatures. This means that this typical reactive-wetting behavior is independent on temperature. However, the constant velocity of the interface at each temperature increases with temperature. At low temperatures there exists only one front, whereas at high temperatures there are two fronts in the spreading process. We discuss the variation of the reaction rate with temperature, as well as the activation energy in the studied temperature range.

Regarding the kinetic roughening of the triple line, we found that the growth exponent (β) increases with temperature which means that the droplet's interface width grows faster with the increasing temperature. The interface roughness also increases with temperature, since the mercury viscosity

decreases with temperature, and the non linear growth dominates. However, the roughness exponent (α) was found to be the same for all temperatures, with a value around 0.8 below the correlation length. This means that the roughness exponent (α) in this temperature range is materials dependent, and does not depend on the spreading dynamics. We compare these results with relevant results in the literature.

Pattern selection in parametrically-driven arrays of nonlinear resonators

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Motivated by recent experimental studies of microelectromechanical and nanoelectromechanical systems (MEMS & NEMS) [1] we have been studying the nonlinear dynamics of arrays of coupled nonlinear micromechanical and nanomechanical resonators [2,3]. Here we study the problem of pattern selection in an array of parametrically-driven nonlinear resonators using a novel amplitude equation [4]. We describe the transitions between standing-wave patterns of different wave numbers as the drive amplitude is varied either quasistatically, abruptly, or as a linear ramp in time. We find novel hysteretic effects, which are confirmed by numerical integration of the original equations of motion of the interacting nonlinear resonators, suggesting new possibilities for future experiments [5].

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Itinerant ferromagnetism in the electron localization limit

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We present Hall effect, $R_{xy}(H)$, and magnetoresistance**,** $R_{xx}(H)$, measurements of ultrathin films on Ni, Co and Fe with thicknesses varying between 0.2-8nm and resistances between 1MΩ to 100 Both measurements show that for films having sheet resistance above a critical value, R_C, (thickness below a critical value, d_C) there are no signs for ferromagnetism. Ferromagnetism appears only for films with R< R_C. R_C is material dependent and seems to correlate with the atomic magnetic moment. We raise the possibility that the reason for the absence of spontaneous magnetization is suppression of itinerant ferromagnetism by electronic disorder and localization**.**

DNA brushes: Transitions induced by competitive binding of counterions

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Following recent experiments on short single stranded DNA molecules grafted to a gold surface via a thiol group, we present a mean field theory of reversibly grafted charged polymer brushes. We assume that the negatively charged DNA molecules are completely neutralized by counterions and that the excluded volume repulsion between the polymers depends on the type of the bound counterions. We show that in the case of large size difference between the counterions, preferential adsorption of smaller counterions on the brush may take place, even when their concentration is significantly larger than that of the larger counterions. By varying the concentration difference (in bulk solution) between the counterions, we can pass between the stretched-brush (binding of large counterions) and the collapsed-brush (binding of small counterions) regimes. The results are in qualitative agreement with recent experiments of Ray et al. [1] in which replacement of sodium counterions by protons was observed.

[1] S.G. Ray, H. Cohen, R. Naaman, and Y. Rabin, *J. Am. Chem. Soc.* **127** (2005) 17138.

Non-equilibrium work fluctuation theorems for a system in contact with a time reversible heat reservoir

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The recently discovered non-equilibrium fluctuation theorems deal with large deviations and symmetries of quantities such as entropy production, heat exchange, or work performed during an irreversible process. Two examples which have received much attention are the work fluctuation theorems, the Jarzynski equality (JE) and the Crooks' theorem (CT). We study the JE and CT for a test system coupled to a spatially extended heat reservoir whose degrees of freedom are explicitly modeled. The sufficient conditions for the validity of the theorems are discussed. When the conditions are met the fluctuation theorems are shown to hold despite the fact that the immediate vicinity of the test system goes out of equilibrium during an irreversible process.

Breaking of phase symmetry in non-equilibrium Aharonov-Bohm oscillations through a quantum dot

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Linear response conductance of a two terminal AB interferometer is an even function of magnetic field, as dictated by Onsager-Büttiker relations. This *phase symmetry* is generally known to break beyond the linear response regime. In simple AB rings the phase of AB oscillations changes smoothly with voltage bias. We show that the behavior of the AB phase in voltage-biased quantum dot interferometers in the cotunneling regime is strikingly non-monotonous: breaking of phase symmetry starts only after the onset

of inelastic cotunneling, and becomes significant only when the contributions of different levels to the even component of the AB oscillations nearly cancel out (e.g., due to different parity of these levels).

Model of DNA bending by cooperative binding of proteins

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We present a model of non-specific cooperative binding of proteins to DNA in which the binding of isolated proteins generates local bends but binding of proteins at neighboring sites on DNA straightens the polymer. We solve the statistical mechanical problem and calculate the effective persistence length, site occupancy and cooperativity. Cooperativity leads to non-monotonic variation of the persistence length with protein concentration, and to unusual shape of the binding isotherm. The results are in qualitative agreement with recent single molecule experiments on HU-DNA complexes.

Slow dynamics and glassiness in a lattice model

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We study the supercooled liquid state of the hardcore N3 lattice gas model. Analysis of the Mayer cluster integral expansion predicts termination of the liquid branch at finite activity z_c with termination density lower than the closest packing density [1]. We conduct a Monte Carlo study to provide evidence for jamming in the supercooled liquid phase, in agreement with a recent study of a similar kinetically constrained dynamical model [2]. The movement of a trial particle shows a growing directional correlation, indicative of either caging or an increase in the probability of returning to the previous configuration. Such an increase was previously suggested as a mechanism leading to glass [3]. These results hint at the possibility of N3 being a simple model that may give insight into glassy phenomena.

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[2] C. Toninelli, G. Biroli and D. S. Fisher, *Phys. Rev. Lett*. **96**, 035702 (2006).
[3] V. Halpern *J. Chem. Phys*. **126**, 134506 (2007).

Covalency effects on the magnetism of $EuRh_2P_2$

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In experiments, the ternary Eu pnictide $EuRh_2P_2$ shows an unusual coexistence of a non-integral Eu valence of about 2.2 and a rather high Neel temperature of 50 K. We present a model which explains the non-integral Eu valence via covalent bonding of the Eu 4f-orbitals to P2 molecular orbitals. In contrast to intermediate valence models where the hybridization with delocalized conduction band electrons is known to suppress magnetic ordering temperatures to at most a few Kelvin, covalent hybridization to the

localized P2 orbitals avoids this suppression. Using perturbation theory we calculate the valence, the high temperature susceptibility, the Eu single-ion anisotropy and the superexchange couplings of nearest and next-nearest neighboring Eu ions. The model predicts a tetragonal anisotropy of the Curie constants. We suggest an experimental investigation of this anisotropy using single crystals. From experimental values of the valence and the two Curie constants, the three free parameters of our model can be determined.

Experimental investigation of the coupling between magnetic and superconducting order parameters in LSCO films

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It is experimentally known that superconductivity and magnetic order exist together in underdoped $La_{2-x}Sr_xCuO_4$. However, the nature of this coexistence is not clear. The Ginzburg-Landau description of the superconducting and magnetic phase transition provides two distinct views of the nature of this coexistence. One is referred to as phase separation, in which, locally the material is either super-conducting or magnetically ordered. The other is a homogeneous mixed phase, in which super-conductivity and magnetism exist together on the microscopic level. The distinction between the two views is made by the value of the coupling constant between the magnetic and superconducting order parameters. We investigate experimentally the value of this coupling constant. For this purpose, we used an 8 m long meander line ("wire") made of a $La_{1.94}Sr_{0.06}CuO_4$ film with a cross section of 0.5 x 100 square µm. The magnetic order parameter is determined by the new Low-Energy muon spin relaxation technique. The superconducting order parameter is characterized by transport measurements and modified by running a high current density through the wire. The magnetic-superconducting phase, known from bulk samples, is also found in this clean film. We place a surprisingly small upper limit on the coupling between the two order parameters. This suggests that the transition from a magnetic to superconducting state as a function of doping is better described by a second order phase transition with coexistence of both phases distributed homogeneously over the sample. Also we find that the magnetic order does not trap flux and does not change the value of the critical current.

Manipulating the optical transparency of meta-materials with a strong magnetic field and liquid crystals

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We have conducted a theoretical and calculational study of the transmission of light through a sub-wavelength-perforated metal film [1], as well as through a homogeneous metal film [2], with Drude *ac* conductivity tensor in the presence of a static magnetic field [3]. Both perforated and homogeneous metal films are found to exhibit a magneto-induced light transparency and a decreasing of reflectivity due to cyclotron resonance. In particular, the cyclotron resonance and the surface plasmon resonance of a

perforated metal film moves to higher frequencies with increasing magnetic field, bringing about large changes in the extraordinary light transmission peaks predicted to occur in such a film. In the case of periodic microstructures, these phenomena depend not only on the magnitude of the applied in-plane magnetic field, but also on its direction. This is due to the nonlinear dependence of the local electromagnetic response on that field. The practical possibility of changing the sample transparency by application of a static magnetic field (e.g., a new type of magneto-optical switch) is discussed.

Another possibility to manipulate the light propagation through the perforated film is by using liquid crystals [4]. We calculate the effective dielectric tensor of a metal film penetrated by cylindrical holes filled with a nematic liquid crystal (NLC). We assume that the director of the NLC is parallel to the film, and that its direction within the plane can be controlled by a static magnetic field, via the Freedericksz effect. The films are found to exhibit extraordinary light transmission [5] at special frequencies related to the surface plasmon resonances of the composite film. Furthermore, the frequencies of peak transmission are found to be substantially split when the dielectric in the holes is anisotropic. Thus, the extraordinary transmission can be controlled by a static magnetic or electric field whose direction can be rotated to orient the director of the NLC.

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4th Indo-Israeli Conference in Condensed Matter Physics – Program at a Glance

	Sunday November 2	**Monday November 3**	**Tuesday November 4**	**Wednesday November 5**	**Thursday November 6**
Early AM		9:00-10:00: ***Registration***	**Biophysics – Assembly & Regulation**	**Magnetism & Superconductivity**	**Conference Tour of the Golan Heights**
09:00-10:30		**Opening Session** 10:00-11:00: Chair: Lifshitz *Welcome*	Chair: Shimshon Barad G. V. Shivashankar Eli Eisenberg Yamuna Krishnan	Chair: Aviad Frydman Yoram Dagan Ramesh C. Budhani Vikram Tripathi	
10:30-11:00		Keynote: Amnon Aharony	Coffee Break		
Late AM		11:00-11:30: Coffee Break	**Correlated Systems**	**Biophysics – Dynamics**	
11:00-12:30		**Low-d systems 1** Chair: Alexander Palevski D. D. Sarma Shobhana Narasimhan	Chair: O. Entin-Wohlman Kalobaron Maiti Ehud Altman Kedar Damle	Chair: Nathalie Balaban Yuval Garini Debashish Chowdhury Kinneret Keren	
12:30-14:00		Lunch at Merkazi			
Early PM	**Drive from Tel Aviv to Tzfat**	**Dynamics 1**	**Conference Tour of Tzfat**	**Condensates / Cold Atoms**	
14:00-16:00		Chair: Moshe Schwarz Sanjay Puri Itzhak Fouxon Chandan Das Gupta Eytan Katzav		Chair: Yigal Meir Ron Folman Avi Pe'er Ronen Rapaport Jeff Steinhauer	
16:00-16:30		Coffee Break			
Late PM		**Dynamics 2**	**Low-d systems 2**	**Mesoscopic Systems**	
16:30-18:00	18:00-19:00: ***Registration***	Chair: Haim Taitelbaum Satyajit Banerjee Rama Govindarajan Ajay K. Sood	Chair: Efrat Shimshoni Bipul Pal Venkateswara Pai Shahal Ilani	Chair: S. Dattagupta Yuval Oreg Doron Cohen Nadav Katz 18:00: *Closing*	
19:00-20:00	Dinner at Merkazi		**Conference Banquet at Palacio Domain**	Dinner at Merkazi	
Evening					
20:00-22:00	**Get-together**	**Drinks & Posters at Merkazi**		**Klezmers**	