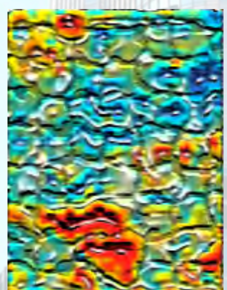
International Workshop:

Superconductor-Insulator Transition, 2010



November 16-19, 2010

Argonne National Laboratory

Organizers: Valerii Vinokur, Mike Norman

General Information

The nature of the superconductor-insulator transition is a subject of much fascination and one of the focuses of current efforts in condensed matter physics. It is an area of fundamental interest with an impact far outside the field of condensed matter physics. The purpose of this workshop is to survey the current status of this subject and answer the questions of where we are at, and where we are headed. To achieve this goal, we have brought together outstanding researchers from throughout the world to gather at Argonne for four days and exchange views on this important topic.

- The workshop will be held from November 16th to 19th, 2010 at Argonne National Laboratory
- Location: Building 223, Auditorium B002
  (The conference room is in the basement of the building)

Coordinators: Valerii Vinokur
Mike Norman
Andreas Glatz

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Website: mti.msd.anl.gov/workshops.html

Schedule

		November 16, Tuesday	November 17, Wednesday	November 18, Thursday	November 19, Friday
am	08:50 - 09:00	*Welcome*			
am	09:00 - 09:50	Allen Goldman	Nandini Trivedi	Peter Armitage	Lev Ioffe
am	09:50 - 10:40	Aviad Frydman	Yonatan Dubi	Saro Fazio	Boris Spivak
am	10:40 - 11:10	*Coffee break*			
am	11:10 - 12:00	Benjamin Sacepe	Paul Goldbart	Vladimir Orlyanchik	Alexander Mirlin
pm	12:00 - 2:00	*Lunch*			
pm	2:00 - 2:50	Tatyana Baturina	Herve Aubin	Gil Refael	Assa Auerbach
pm	2:50 - 3:40	Christoph Strunk	Nadya Mason	Thomas Nattermann	Victor Galitskii
pm	3:40 - 4:10	*Coffee break*			*Closing*
pm	4:10 - 5:00	Dan Shahar	James Valles	Kazushi Kanoda	
pm	5:00 - 5:50	Nikolay Chtchelkatchev	Andreas Glatz	Senthil Todadri	

Program

Tuesday, November 16

Morning Session - Chair: Anand Bhattacharya, ANL	
8:50 - 9:00	*Welcome*
9:00 - 9:50	**Allen Goldman,** University of Minnesota *The role of disorder in insulator-superconductor transitions of ultrathin films*
9:50 - 10:40	**Aviad Frydman,** Bar-Ilan University *Anomalous voltage drop in superconducting InOx nanowires*
10:40 - 11:10	*Coffee Break*
11:10 - 12:00	**Benjamin Sacepe,** CEA Grenoble *Scanning Tunneling Spectroscopy of disordered thin films close to the Superconductor-Insulator Transition*
12:00 - 2:00	*Lunch*
Afternoon Session - Chair: Mike Norman, ANL	
2:00 - 2:50	**Tatyana Baturina,** Institute of Semiconductor Physics, Novosibirsk *Nanopattern-stimulated superconductor-insulator transition in thin TiN films*
2:50 - 3:40	**Christoph Strunk,** University of Regensburg *On insulating and superinsulating states of thin TiN-films*
3:40 - 4:10	*Coffee Break*
4:10 - 5:00	**Dan Shahar,** Weizmann Institute *Disordered superconductors from two to one dimensions*
5:00 - 5:50	**Nikolay Chtchelkatchev,** Institute for High Pressure Physics, Moscow *Low temperature transport in tunnel junction arrays: Cascade energy relaxations*

Wednesday, November 17

Morning Session - Chair: Valerii Vinokur, ANL	
9:00 - 9:50	**Nandini Trivedi,** Ohio State University *Disorder driven pseudogap and emergence of an exotic insulator*
9:50 - 10:40	**Yonatan Dubi,** Tel Aviv University *How phase fluctuations drive the Superconductor-Insulator Transitions*
10:40 - 11:10	*Coffee Break*
11:10 - 12:00	**Paul Goldbart,** University of Illinois at Urbana-Champaign *Weber-blockade view of magnetoresistance oscillations in superconducting strips, and related issues in nanosuperconductivity*
12:00 - 2:00	*Lunch*
Afternoon Session - Chair: Ulrich Welp, ANL	
2:00 - 2:50	**Herve Aubin,** Laboratoire de Physique Quantique, Paris *Nernst effect in disordered superconductors*
2:50 - 3:40	**Nadya Mason,** University of Illinois at Urbana-Champaign *Proximity effects and dissipation in nanostructured superconductors*
3:40 - 4:10	*Coffee Break*
4:10 - 5:00	**James Valles,** Brown University *Cooper Pair Localization in Patterned Amorphous Bi Thin Films*
5:00 - 5:50	**Andreas Glatz,** ANL *Self-organized regular superconducting patterns in thin films*

Thursday, November 18

Morning Session - Chair: Ken Gray, ANL	
9:00 - 9:50	**Peter Armitage,** Johns Hopkins University *From classical to quantum: Broadband microwave studies of superconducting fluctuations in 2D InO thin films*
9:50 - 10:40	**Saro Fazio,** Scuola Normale Superiore di Pisa *Superfluid-Insulator transition in cavity QED systems*
10:40 - 11:10	*Coffee Break*
11:10 - 12:00	**Vladimir Orlyanchik,** University of Illinois at Urbana-Champaign *Anomalous Noise in the Pseudogap Regime of YBCO films*
12:00 - 2:00	*Lunch*
Afternoon Session - Chair: Anton Andreev, University of Washington & ANL	
2:00 - 2:50	**Gil Refael,** Caltech *The thin film Giaever transformer – vortex drag in a superconductor thin-film bilayer*
2:50 - 3:40	**Thomas Nattermann,** University of Cologne *Phase Diagram of Electron Systems near the Superconductor-Insulator Transition*
3:40 - 4:10	*Coffee Break*
4:10 - 5:00	**Kazushi Kanoda,** University of Tokyo *Superconductivity emerging from antiferromagnet and spin liquid in organics*
5:00 - 5:50	**Senthil Todadri,** MIT *Superconductor - Mott insulator transitions*

Friday, November 19

Morning Session - Chair: Andreas Glatz, ANL	
9:00 - 9:50	**Lev Ioffe,** Rutgers University *Exact solution of a simple model for disorder-driven superconductor-insulator transition*
9:50 - 10:40	**Boris Spivak,** University of Washington *Theory of quantum normal metal-superconductors transitions and the Weakly Coupled Pfaffian as a Type I Quantum Hall Liquid*
10:40 - 11:10	*Coffee Break*
11:10 - 12:00	**Alexander Mirlin,** Karlsruhe Institute of Technology *Multifractality and electron-electron interaction at metal-insulator, quantum Hall, and superconductor-insulator transitions*
12:00 - 2:00	*Lunch*
Afternoon Session - Chair: Kostya Matveev, ANL	
2:00 - 2:50	**Assa Auerbach,** Technion *Conductivity of 2D Lattice Bosons*
2:50 - 3:40	**Victor Galitskii,** University of Maryland *Non-Perturbative Theory of Quantum Superconducting Fluctuations in a Disordered Superconductor*
3:40	*Closing*

Abstracts

Peter Armitage

From classical to quantum: Broadband microwave studies of superconducting fluctuations in 2D InO thin films

We apply a new broadband microwave `Corbino' technique to the study of 2D disordered superconducting InO_x thin films across the superconductor insulator transition. Explicit frequency dependency of the superfluid stiffness and complex conductivity are obtained down to 290mK from 10MHz to 20GHz. AC measurements such as these ones are explicitly sensitive to the time scales of various superconducting fluctuation modes. We discuss various regimes of classical fluctuations and evidence for quantum superconducting fluctuations as the system is driven with increasing disorder across the 2D superconductor-insulator transition and into the unconventional insulating state.

Herve Aubin

Nernst effect in disordered superconductors

In amorphous superconducting thin films, the signal due to superconducting fluctuations dominates the Nernst response on a large range of temperature and magnetic field. In the vicinity of the critical temperature and in the zero-field limit, the magnitude of the signal is in quantitative agreement with what is theoretically expected for Gaussian fluctuations of the superconducting order parameter. At higher temperatures and finite magnetic field, the Nernst coefficient is set by the size of superconducting fluctuations. The Nernst coefficient emerges as a direct probe of the ghost critical field, the normal-state mirror of the upper critical field. I will summarize our work on amorphous compounds of $Nb_{0.15}Si_{0.85}$ and InO_x. In this context of superconductor-insulator transitions, I will present recent developments in the preparation of metallic nanocrystals films with electric field tunable conductance.

Assa Auerbach

Conductivity of 2D Lattice Bosons

tba

Tatyana I. Baturina

Nanopattern-stimulated superconductor-insulator transition in thin TiN films

That a thin film of the same material can be a superconductor but can very well turn an insulator, is one of the most remarkable aspects of disordered superconductors. The engine driving the transition between the superconducting and insulating states is disorder the action of which can be enhanced by the proper choice of the system geometry. In this talk we will present the results of the comparative study of the transport properties of continuous and nanoperforated TiN films [1]. We will show that patterning into a square array of nanoscale holes turns a thin TiN film into an array of superconducting weak links and stimulates both, the disorder- and magnetic field-driven superconductor-to-insulator transitions, pushing them to the lower degree of microscopic disorder. Depending on the original degree of disorder the nanopatterning either *suppresses the critical temperature, or drives the initially superconducting film into an insulating state, or else, transforms the originally insulating film into an even more pronounced insulator.*

[1] T. I. Baturina, V. M. Vinokur, A. Yu. Mironov, N. M. Chtchelkatchev, D. A. Nasimov, A. V. Latyshev, preprint arXiv:1011.1592

Nikolay Chtchelkatchev

Low temperature transport in tunnel junction arrays: Cascade energy relaxations

An array of tunnel junctions is a generic model for a wealth of the diverse physical system ranging from the actual Josephson junction arrays to granular and strongly disordered systems, which demonstrate superconductor-insulator transition. We study electronic transport at the insulating part of the transition and develop a theory of the far-from-equilibrium charge transfer. We show that at low temperatures the energy relaxation ensuring the tunneling processes and thus mediating the charge transfer can become a cascade two-stage process: charge carriers lose their energy to a bosonic environment (electromagnetic fluctuations or electron-hole pairs), which, in its turn, relaxes the energy to the thermostat. We derive the current-voltage characteristics for the arrays and demonstrate that opening the energy gap in the environmental excitations spectrum completely suppresses the tunneling current. The consequences of the cascade relaxation for transport in the physical systems in the close proximity to superconductor-to-superinsulator transition and related effects are discussed.

Yoni Dubi

How phase fluctuations drive the Superconductor-Insulator Transitions

The superconductor-insulator transition (SIT) in disordered thin films, driven by changing thickness or magnetic field, has been puzzling the community for over two decades and still challenges our understanding of the interplay between superconductivity, disorder and reduced dimensionality. I will show that much of the experimental findings, including the field- and thickness-driven SIT, the huge magneto-resistance peak, local gap variations and the recently observed increase of T_c with parallel field can all be explained within a single framework, as resulting from phase fluctuations in the presence of a spatially non-uniform order-parameter. The SIT is explained as interplay of phase-fluctuations and percolation (for the field-induced transition) and due to scaling of the phase-stiffness (for the thickness-induced SIT). The theory gives excellent agreement with various experimental data (e.g. dependence of Tc on thickness) and provides various predictions which can

Rosario Fazio

Superfluid-Insulator transition in cavity QED systems

Coupled quantum electrodynamics (QED) cavities have been recently proposed as new systems to simulate a variety of equilibrium and non-equilibrium many-body phenomena. I will give a brief review of their main properties together focusing on the possibility to observe superfluid-insulator transition be tested experimentally.

Aviad Frydman

Anomalous voltage drop in superconducting InO_x nanowires

In recent years, experimental studies on thin superconducting films of InO_x and TiN have yielded a number of non trivial findings such as a giant MR peak, large inhomogeneity, non uniform energy gap, discontinuous I-V characteristics and signatures for superconductivity above T_c. These results have stimulated some theoretical ideas, including inherent electronic granularity and the presence of non-coherent preformed pairs, designed to explain the nature of the disorder-induced superconductor-insulator-transition in these materials. Up to date, a comprehensive understanding of the superconductivity in these materials is absent and more experimental results are needed to shed light on the relevant issues.In my talk I will discuss experimental results obtained on InO_x nanowires with widths comparable to the coherence length. These wires show a transition from an insulator to a superconductor as a function of disorder – controlled by low temperature annealing. In the intermediate disorder regime the resistance of the wires saturates at a finite value as the sample is cooled below the bulk T_c. At the same time, a large spontaneous voltage develops along the wire. This voltage is anti-symmetric in magnetic field and exhibits a quasi periodic oscillation with perpendicular field. I will discuss these findings and suggest that they may reflect a spontaneous thermopower and Nernst effect originating from NS interfaces present in the disordered superconductor.

Victor Galitski

Non-Perturbative Theory of Quantum Superconducting Fluctuations in a Disordered Superconductor

In this talk, I will consider an anisotropic-gap superconductor in the vicinity of the quantum critical point, where the transition temperature is suppressed to zero by disorder. The quantum critical theory for this transition can be derived from the first principles and corresponds to a marginal case in two dimensions, being formally equivalent to the theory of an antiferromagnetic quantum critical point. This allows us to use asymptotically-exact methods to calculate the non-perturbative effect of quantum superconducting fluctuations on thermodynamic properties of the superconducting film. Another important phenomenon is due mesoscopic disorder fluctuations, which lead to spatial variations of a local pairing temperature and to formation of superconducting islands above the mean-field transition. These mesoscopic effects give way to a Griffiths phase, which can be visualized as a network of superconducting islands and strongly-fluctuating metallic regions with a strongly suppressed density of states. Experimental manifestations of the proposed state will be discussed.

Andreas Glatz

Self-organized regular superconducting patterns in thin films

The interplay between the superconducting order parameter and elastic fields, which are intimately connected to the very existence of the superconductivity itself, can result in a novel superconducting state: a regular self-organized texture of superconducting islands. In this talk the formation of these islands in a system of a thin superconducting film coupled elastically to a more rigid substrate as well as the phase diagram below the superconducting critical temperature depending *on the elastic coupling constant of both subsystems is presented. The fact that this pattern is a result of the Ginzburg-Landau description of superconductivity indicates that the formation of regular structures may be a common feature of the superconductor transition in the presence of an external long-range field.*

Paul M. Goldbart

Weber-blockade view of magnetoresistance oscillations in superconducting strips, and related issues in nanosuperconductivity

Recent experiments by the Shahar group on the electrical conductance of thin, narrow superconducting strips found periodic fluctuations, as a function of the perpendicular magnetic field, having a period corresponding to approximately two flux quanta per strip area [A. Johansson et al., Phys. Rev. Lett. 95, 116805 (2005)]. I shall discuss these experiments from the viewpoint of vortex motion, and argue, in particular, that the superconducting strip behaves as the dual of a quantum dot, with the vortices, magnetic field, and bias current respectively playing the roles of the electrons, gate voltage and source-drain voltage. This analogy suggests that the strip conductance oscillations are a reflection of "Weber-blockade" diamonds (i.e., analogs of Coulomb-blockade diamonds) in the bias-current/magnetic-field plane, which give electrical resistance maxima that, for small bias-currents, correspond to the fields at which strip states of N and N+1 vortices have equal energy. If time permits, I shall also discuss various related issues in nanosuperconductivity. This talk is based on work done with David Pekker and Gil Refael [arXiv:1010.4799v1].

Allen Goldman

The role of disorder in insulator-superconductor transitions of ultrathin films

Historically there have been two types of thickness-tuned transitions found in ultrathin films grown in situ on substrates cooled to liquid helium temperatures. When films are deposited onto substrates without underlayers of amorphous Sb or Ge, curves of R(T) at different thicknesses exhibit local minima at values of thickness near, but shy of the critical thickness for global superconductivity. Such films also exhibit Arrhenius activated behavior at temperatures below the local minimum, with a dependence of the activation energy on $k_F l$ *that agrees with the theory of Feigel'man et al. On the other hand in the case of films that are grown with underlayers, the insulator-superconductor transition is direct and there is no regime of Arrhenius activated behavior. The distinction between the two film morphologies produced using these different procedures, and usually designated as granular and homogenous, appears to be explainable by subtle differences between their geometries. Recent results correlating ex situ AFM studies and the quantitative analysis of observed film structure with electrical properties at low temperatures will be reported.*

Lev Ioffe

Exact solution of a simple model for disorder-driven superconductor-insulator transition

tba

Kazushi Kanoda

Superconductivity emerging from antiferromagnet and spin liquid in organics

The layered organic systems k-(ET)2X with X a variety of anions provide playgrounds for Mott physics in two dimensions. Because the conducting layer consists of anisotropic triangular lattice with the anisotropy varied by X, spin frustration as well as electron correlation plays an important role in the nature of ground state. In half-filled band systems, an antiferromagnetic state (for X=Cu[N(CN)2]Cl) competes with a spin liquid state (for X=Cu2(CN)3) and both give way to superconducting states under pressure. The 10% hole-doped system k-(ET)4Hg2.89Br4 is an inhomogeneous (possibly phase-separated) superconductor at ambient pressure; however, it gets homogenous with a dome of T_c as a function of pressure. In this workshop, I present NMR and transport studies on the Mott insulators with different natures and pressure- or doping-induced superconductivity.

Nadya Mason

Proximity effects and dissipation in nanostructured superconductors

Decoherence due to dissipative coupling to an environment is a topic of both fundamental and practical interest. To study the interplay between coherence and dissipation, we have fabricated planar arrays of proximity-coupled superconducting islands on metallic substrates. The superconducting islands are well-understood coherent systems with long-range order, while the intervening normal metal channels introduce known dissipation into the system. This sample configuration allows us to study proximity effects in a tunable, phase-separated system. We perform low-temperature transport measurements of these systems to analyze proximity effects and the effects of dissipation by changing the island sizes and spacings.

Alexander Mirlin

Multifractality and electron-electron interaction at metal-insulator, quantum Hall, and superconductor-insulator transitions

Multifractality of wave functions is a remarkable property of Anderson localization-delocalization transitions. We explore the impact of multifractality in problems with short-range electron-electron interaction:(i) Metal-insulator and quantum Hall transitions in interacting systems. Multifractality governs dephasing rate and therefore determines the dynamical exponent controlling the scaling of the transition width with temperature. We combine an analytical treatment (that includes the identification of operators responsible for dephasing in the formalism of the non-linear sigma-model (NLSM) and the corresponding renormalization-group (RG) analysis in $2 + \varepsilon$ dimensions) with numerical simulations on the Chalker-Coddington network model of the quantum Hall transition.(ii) Superconductor-insulator transition. We perform the RG analysis in the framework of the NLSM and analyze the interplay of interactions in the spin-singlet, triplet and Cooper channels with the multifractality induced by disorder. Specifically, we consider 2D diffusive systems with relatively low conductivity, as well as 2D systems with strong spin-orbit interaction and 3D systems near the Anderson localization transition. In all these cases it is found that the multifractality strongly enhances the superconductor-insulator transition *temperature.*

Thomas Natterman

Phase Diagram of Electron Systems near the Superconductor-Insulator Transition

The zero temperature phase diagram of Cooper pairs exposed to disorder and magnetic field is found to exhibit four distinct phases: a Bose and a Fermi insulating, a metallic and a superconducting phase, respectively. The results explain the giant negative magneto-resistance found experimentally in In-O, TiN, Bi and high-Tc materials.

Vladimir Orlyanchik

Anomalous Noise in the Pseudogap Regime of YBCO films

It is widely believed that symmetry-breaking electronic correlations are present in the pseudogap regime of high-Tc superconductors. If such correlations (e.g. stripes) are partially static, one would expect low-frequency noise from thermal switching among different configurations. We have found anomalous noise below a temperature of about 240 K in the normal state of underdoped YBCO and Ca-YBCO films. This noise regime, unlike the more typical noise above 240 K, has features expected for a symmetry-breaking collective electronic state. However, the onset temperature seems to be independent of doping, unlike other pseudogap effects. We speculate on a model involving coupling between stripes and impurities with thermally activated motion.

Gil Refael

The thin film Giaever transformer – vortex drag in a superconductor thin-film bilayer

The normal-field induced superconductor-insulator transition in amorphous thin films, and the possible intervening metallic state, can be qualitatively explained within two paradigms: as vortex condensation, or as a percolation transition between the competing normal and superconducting phases. An experiment that may qualitatively distinguish these two paradigms is a drag experiment on a bilayer system, consisting of two parallel films, where a voltage response in one layer to current in the other is measured. The drag due to vortices is expected to dramatically exceed the Coulomb drag that may arise from the charge carriers in the percolation scenario. In my talk, I will present recent results estimating the drag response within the vortex and percolation paradigms, in the limit of no tunneling between the layers.

Benjamin Sacepe

Scanning Tunneling Spectroscopy of disordered thin films close to the Superconductor-Insulator Transition

Disordered thin films close to the superconductor-insulator transition (SIT) offer a perfect testing ground for the study of the superconducting state subject to reduced-dimensionality and strong disorder. Although localization and superconductivity have been clearly evidenced on the macroscopic scale by transport measurements, very little is known about the microscopic details of *their interplay. In this talk, we present a scanning tunneling spectroscopy study preformed on ultra-thin films of TiN which undergo a disorder-tuned SIT. When the samples approach the critical disorder of the SIT, we observed that the superconducting gap fluctuates spatially leading to an inhomogeneous superconducting state. In addition, the gap to T_c ratio, Δ/T_c, becomes anomalously large and increases upon an increase in the disorder. Such a non-vanishing spectral gap suggests the persistence of local superconducting pairing across the disorder-tuned SIT. On the other hand, our measurements reveal the presence above T_c of a significant pseudogap in the density-of-states. We demonstrate that this pseudogap results from the presence of short-lived Cooper pairs that appear well above T_c. We will discuss the consequences of our findings on the physics of the SIT as well as the general role played by the disorder and reduced-dimensionality in the formation of superconducting inhomogeneities and of superconductivity-related pseudogap in conventional superconductors.*

Dan Shahar

Disordered superconductors from two to one dimensions

tba

Boris Spivak

Theory of quantum normal metal-superconductors transitions and the Weakly Coupled Pfaffian as a Type I Quantum Hall Liquid

We study suppression of superconductivity by disorder in superconductors. I the case of d-wave superconductors there are two sequential low temperature transitions as a function of disorder: a d-wave to s-wave, and then an s-wave to metal transition. In the case of p-wave superconductors there only one superconductor-metal transition. The Pfaffian phase of electrons in the proximity of a half-filled Landau level is understood to be a p+ip superconductor of composite fermions. We consider the properties of this paired quantum Hall phase when the pairing scale is small, i.e. in the weak-coupling, BCS, limit, where the coherence length is much larger than the charge screening length. We find that, as in a Type I superconductor, the vortices attract so that, upon varying the magnetic field from its magic value at $\nu = 5/2$, the system exhibits Coulomb frustrated phase separation. We propose that the weakly and strongly coupled Pfaffian states exemplify a general dichotomy between Type I and Type II quantum Hall fluid.

Christoph Strunk

On insulating and superinsulating states of thin TiN-films

Recently a transition from an insulating state with a sheet resistance ~1 MOhm to a much more strongly insulating state with an unmeasurably small linear conductance was observed in strongly disordered TiN thin films [1]. It was suggested that this transition may be interpreted as the charge analog of the familiar vortex Berezinskii-Kosterlitz-Thouless (BKT) transition, resulting from a granularity within the electronic system [2]. We present new data on the linear and non-linear conductance of such films, which allow a separation of competing *heating instabilities in the strongly insulating state from the non-linearities typical for the BKT transition. At very low temperatures, we observe power laws $I \sim V^{\alpha}$ in the dc IV-characteristics with a strongly temperature dependent exponent \alpha, which is a hallmark of a BKT -like charge/anticharge unbinding process [3]. In addition, a size dependence of the insulating properties is found that points towards the importance of long-range interactions in these films.*

[1] T. Baturina et al., PRL 99, 257003 (2007).
[2] V. Vinokur et al. Nature 452, 613 (2008).
[3] D. Kalok et a., arXiv:1004.5153

Senthil Todadri

Superconductor - Mott insulator transitions

tba

Nandini Trivedi

Disorder driven pseudogap and emergence of an exotic insulator"

We have discovered a new phase-disordered insulator arising from the interplay of superconductivity and localization. We further predict that even in a weak coupling BCS superconductor a disorder-driven pseudogap with suppressed low energy spectral weight isformed sandwiched between a pairing temperature scale T that grows with disorder and a coherence scale T_c hat ultimately vanishes at the superconductor-insulator transition. Calculations of the spectral functions using determinantal quantum Monte Carlo and maximum entropy methods give insights into the coherence peaks as well as the evolving asymmetries in the spectral functions as thermal and quantum fluctuations are increase.*

James Valles

Cooper Pair Localization in Patterned Amorphous Bi Thin Films

Ultrathin films near the Superconductor-Insulator Transition (SIT) can exhibit Cooper pair transport in their insulating phase. This Cooper Pair Insulator state is achieved in amorphous Bi films patterned with a Nanohoneycomb array of holes. Here we present evidence suggesting the Cooper pairs in these films are localized by regions of increased film thickness $\sim\xi$ connected by weak links of thinner material. The thickness variations serve to localize the Cooper pairs to islands that are separated by regions of normal film, and the properties of the weak links connecting the islands control the SIT. We will discuss these findings in terms of currently proposed models for this SIT.

Participants

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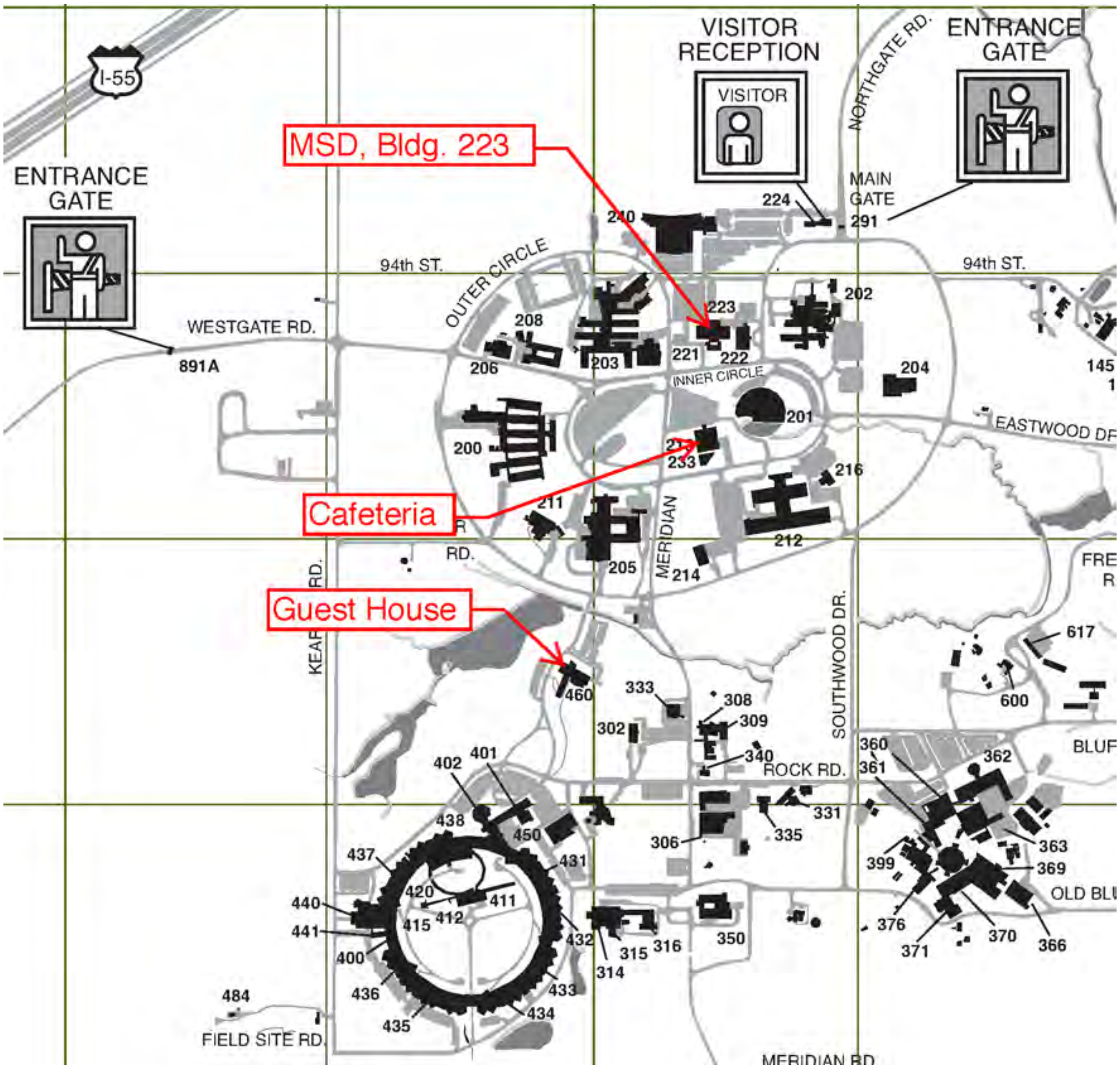
Argonne Map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