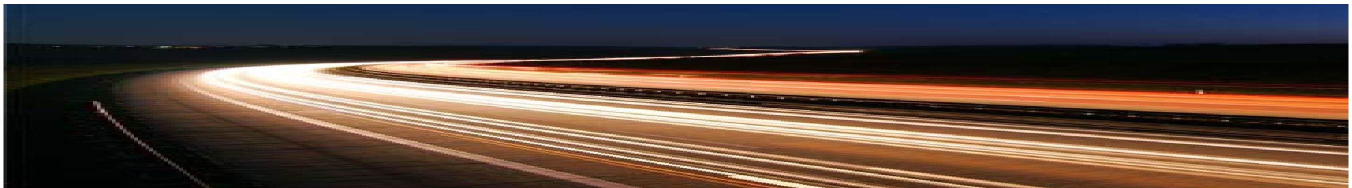

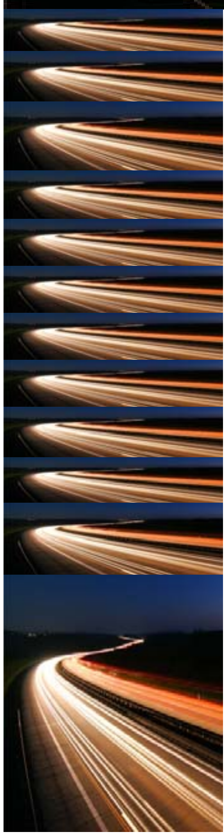

ABSTRACTS

Problem of Super-High-Tc -Superconductivity
Alexei A. Abrikosov
Materials Science Division, Argonne National Laboratory,

A possibility of formulation a general idea for the search of "Super-High-Tc (SHT)" materials is discussed. The approach is based on the idea of enhancement of the basic parameters, entering the BCS formula for Tc: the electron-phonon interaction constant, the density of states and the energy of mediating quasiparticles. The known examples of materials with relatively high Tc are examined. The author's idea of finding a substance forming a "crystal1ine excitonium" phase (1978) is presented.

Since the BCS formula represents only an isotropic model, the role of anisotropy is analyzed within the author's model for high Tc in layered cuprates. The main conclusion is, that anisotropy of the spectrum and the interaction widens the options for obtaining SHT.

<< back

Quantum Criticality and the Itinerant Ferromagnet ZrZn2
Meigan Aronson
University of Michigan

Unconventional superconductivity is often coincident with the suppression of magnetic order at a quantum critical point, in systems as diverse as heavy fermion intermetallics and complex oxides, ferromagnets and antiferromagnets. The underlying magnetic excitations are anomalous at these quantum critical points, and their explication may shed light on the nature of the pairing interactions which are possible. Arguably, the

simplest model system is the itinerant ferromagnet, and we discuss here the magnetic properties of ZrZn2, driven to quantum criticality by Nb doping. A scaling analysis reveals that the mean field behavior is suppressed in the vicinity of the quantum critical point, suggesting that the collapse of ferromagnetism is driven by the increasingly local nature of the electronic interactions. The response of the system is most singular at the quantum critical point, apparently reflecting the divergence in the normal state susceptibility predicted by the Stoner theory. While intrinsic superconductivity has not yet been found near the quantum critical point in ZrZn2, we argue that the critical behavior of this system is consistent with theoretical expectations.

The light elements in combination: Prospects for higher temperature superconductivity*

N.W.Ashcroft
Cornell University

The problem is to induce pairing instabilities in partially filled bands of a periodically inhomogeneous valence electron system, and to achieve these at as high a temperature as possible, eventually even room temperature. The latter was declared to be "pure science fiction" [1] at a time when the maximum transition temperature, Tc, was around 21K. But since then it has been raised by over a factor of 7 with elements in combination, some with considerable polarizabilities. Further, so far as is presently known there are no especially stringent theoretical limits on Tc. The issue therefore eventually devolves on the physical sources of the instabilities and these may originate with electrons themselves (both core and valence) and with the displacive dynamics (the phonon structure) of the ions on which polarizable core electron density resides. If phonon exchange is considered an important contributor to formation of the paired state then light element systems possessing the highest dynamic energy scales should be favored in an otherwise reasonably dense metallic environment. Attention then focusses in this case on combinations of the light elements and especially those containing hydrogen. The role of chemical pre-compression in achieving such systems is clearly important but might well be invoked with constituents which, through their own internal physics, may also contribute to intrinsic pairing.

[1] B.T.Matthias, Physics Today, August 1971, page 23.

*** Supported by the National Science Foundation**

<< back

Artificial superlattices grown by MBE: can we design novel superconductors?

Ivan Bozovic and G. Logvenov
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We wish to stress upfront that regrettably our group does not know (yet!) how to synthesize a room temperature superconductor. What we know how to do is to deposit atomically smooth layers of various complex oxides, using atomic-layer Molecular Beam Epitaxy (MBE).1 So far, we have worked with cuprates, manganites and titanates, but the extension at many other oxides should be straightforward, since the hardware is in place and much of the experience seem transferable.

Some (many!) oxides can be grown nicely (i.e., epitaxially) one-on-top-of-another, and this enables us to stack layers of different oxides, with disparate physical properties, on an extremely fine (sub-nanometer) scale, and form precise superlattices.1 [We will show some examples in this talk.] In this way, we can synthesize novel, artificial materials that do not exist in Nature (i.e., which are only metastable), and which could have novel and interesting properties.

Now, oxides exhibit an enormously wide range of properties, including extremes such as the strongest dielectrics, ferroelectrics, ferromagnets – and, last but not least, the strongest known superconductors with the highest Tc above 160 K – and hence the range of possible combinations is very large. Thus we need some theoretical guidance here – which pairs to try (first). One possible choice is for one constituent to be a metal and the other to be an insulator in which excitons can live; with such a superlattice we could achieve a physical realization of the 40-year old theoretical model of V. L. Ginzburg which he suggested2 could provide a (quasi-2D) excitonic superconductor – with a very high Tc.

1 I. Bozovic et al., Phys. Rev. Lett. 89, 107001 (2002); Nature 421, 873 (2003); Phys. Rev. Lett. 93, 157002 (2004); P. Abbamonte et al., Science 297, 581 (2002).

2 V. L. Ginzburg, Phys. Lett. 13, 101 (1964), Sov. Phys. JETP 20, 1549 (1965); Rev. Mod. Phys. 76, 981, 2004.

<< back

Superconductivity Among Lightweights: Basic Properties of Pure, Doped and Damaged MgB2

Paul C. Canfield
Ames Laboratory and Iowa State University

The discovery of Tc ~ 40 K superconductivity in MgB2, a simple, cheap, binary compound was akin to finding the Holy Grail in intermetallic superconductivity. This was the compound that researchers had quested for during the second half of the 20th century. The announcement of this discovery in January of 2001 set of a flurry of basic and applied research that has resulted in a remarkable understanding of this materials's rather extreme form of BCS superconductivity. In this talk I will present an overview of our current understanding of the superconducting and normal state properties of MgB2 with particular emphasis on the novelty and implications of the two superconducting gaps found in this material. (Note: for those interested in reading ahead please refer to the March 2003 issue

of Physics Today or the April 2005 issue of Scientific American.)

<< back

Possible Room Temperature Superconductivity via a Negative Static Dielectric Constant?

C. W. Chu
University of Houston
Hong Kong University of Science and Technology

After extensive debates, many now accept that a negative dielectric constant can exist without the violation of the causality and stability requirements. In a medium with a negative dielectric constant, electrons are expected to attract. If instabilities, such as charge density waves, can be arrested, superconductivity may occur. No negative static dielectric constant has been reported. However, very recently, a negative static dielectric constant has been observed by us in nano-particle aggregates under a dc biased field at room temperature. The polarity of the accumulated charge in the sample is also observed to be opposite to that of the electric field applied when the dielectric constant is switched to negative. The implications of the observations to the possible existence of a novel state and/or high temperature superconductivity and to wave propagation will be explored. The challenge in the detection of superconductivity in such a system, if exists, will also be discussed.

<< back

Oxides and interfaces in the search for high-temperature superconductivity*

A.J. Freeman, R. Saniz, S.H. Rhim, and Jaejun Yu**
Northwestern University
*****CSCMR and School of Physics, SeoulNationalUniversity, Seoul 151-747, Korea***

The search for higher critical temperature superconductors has often led researchers to try to find materials presenting conditions for alternative pairing mechanisms. In this presentation, we analyze first-principals density functional calculations of the electronic structures of two such systems, and discuss their bearing upon superconductivity: (i) We first consider the so-called beta-pyrochlore Os oxides (AOs_2O_6, A-alkali metal), which are claimed to be "unconventional" superconductors by some researchers [1]. (ii) Then we focus on the CuCl/Si(111) interfacial system, which many years ago was found to show signs of a nearly ideal diamagnetic response between 60 K and 180 K[2], and was presented as a possibly candidate for excitonic superconductivity. In case (i), our studies show that the observed trends regarding Tc, upon substitution of the alkali metal and under applied hydrostatic pressure, can be understood within a phonon-mediated picture with important contributions from spin fluctuations, In case (ii), we find, interestingly, that the system is metallic at the interface with a strong two-dimensional character. However, if indeed there is high-temperature superconductivity, our estimates of Tc (< 2 K) based on electron-phonon coupling theory show that the phonon-mediated

pairing mechanism alone would be too weak to account for it.

[1] T. Muramatsu et al., cond-mat/0502490.

[2] B.L. Mattes and C.L. Foiles, Physica 135B, 139 (1985).

*** Supported by the DOE (Grant No. DE-FG02-88ER 45372/A021).**

Andreev Reflection at the CeCoIn5 Heavy Fermion Superconductor Interface
Laura H. Greene
University of Illinois at Urbana-Champaign

The dynamic conductance across nano-scale junctions consisting of a heavy-fermion superconductor (HFS) and normal-metal (N) is measured over a wide range of temperature (60 K to 400 mK). [W. K. Park et al., cond-mat/0409090] The HFS/N (CeCoIn5/Au) contact is shown to be in the Sharvin limit. The background conductance develops a gradual asymmetry with decreasing temperature starting at the heavy-fermion liquid coherence temperature, T* (~45K), to the onset of superconducting coherence, Tc (2.3K). The enhanced sub-gap conductance observed below Tc arises from Andreev reflection. This enhancement is an order of magnitude smaller (~13.3 % at 400 mK) than that observed for N/conventional superconductors but consistent with other N/HFS data reported. Attempts to fit to the full conductance curve as a function of temperature with extended Blonder-Tinkham-Klapwijk models, including those that account for the breakdown of the Andreev approximation and re-normalizations of the Fermi momenta, clearly show that existing models cannot account for our data. We provide a theoretical framework for understanding the N/HFS Andreev conversion process.

<< back

Electronic Structure, Magnetism Properties and Superconductivity in Na_xCoO_2
I. Mazin (NRL), M. Johannes (NRL), D.J. Singh (Oak Ridge)
US Naval Research Lab

I will discuss the experimental and theoretical result regarding the electronic properties of NaxCoO2 based materials, both magnetic and (hydrated) superconducting. I will emphasize the following issues: (1) Are relevant correlations Hubbard-like ("LDA+U") or related to critical magnetic frluctuations? (2) What is the role of magnetic fluctuations in superconductivity and which superconducting symmetries are consistent with the experiment and with the theory (3) What determines the magnetic ordering in the parent compound?

<< back

Collective modes in multilayered junctions
S. E. Shafranjuk and J. B. Ketterson

Northwestern University

Collective modes involving the gap amplitude and phase in a multilayered superconducting junction are considered. The junction is formed by a sequence of "clean" superconducting layers S separated by insulating barriers I. Using the quasiclassical Green function method, we derive the self-consistent linear equations describing the collective amplitude and phase oscillations. We find that the amplitude and phase modes in "clean" multilayered Josephson junctions may be stabilized at certain magnitudes of the barrier transparency and Cooper coupling strength. We also find that the frequency of the resonances in a multilayered junction can be tuned by applying a bias supercurrent across the adjacent subjunction.

The collective oscillations of the superconducting gap amplitude and phase in "clean" multilayered Josephson junctions may be stabilized at certain magnitudes of the barrier transparency D and Cooper coupling constant. In a multilayered junction the frequencies of these sharp resonances may be tuned by applying a bias supercurrent across the adjacent subjunction. Clearly this flexibility might hold promise for designing of new types of qubits and qubit gates. In the talk we discuss a two qubit gate based on an SISIS type junction with intrinsic proximity interqubit coupling. We derive the two qubit Hamiltonian and evaluate major qubit characteristics, including the interlevel splitting, interqubit coupling, and the decoherence time.

<< back

Thoughts on Why MgB2 is Such a Pathetic Superconductor
Warren E. Pickett
University of California Davis

The discovery of superconductivity at 40 K in MgB2 brought immediate amazement, which has not yet fully abated even though understanding of its mechanism has emerged quite rapidly. For phonon superconductors, MgB2 breaks all the "Matthias rules": it is not a transition metal compound, it does not have a large Fermi level density of states, and it is not cubic. Its seriously non-cubic structure is central to its success.

So while it is easy to marvel at MgB2 -- a remarkable high Tc class with only a single member -- it is provocative and perhaps useful to take the glass-half-full viewpoint: why isn't MgB2 a much better superconductor than it is? Why only 40 K, why not 75 K, why not room temperature?

I will address first the general characteristics that give rise to 40 K superconductivity, and extend the parameters in this class of materials to speculate about the maximum Tc such materials might support. At the simplest level this requires identifying structural instability arising from the ultrastrong el-ph coupling. Further considerations involve nonadiabaticity and anharmonicity. These questions will be considered within the context of the recently discovered superconductivity in B-doped diamond, which may be said to the second member of the MgB2 class (albeit three dimensional).

<< **back**

RVB Theory of Superconductivity in the High Tc Cuprates
Mohit Randeria
Physics Department, The Ohio State University

We use a variational wavefunction approach to gain insight into the strongly correlated d-wave superconducting state of the high Tc cuprates. We show that Mott physics leads to qualitatively different trends in pairing and phase coherence: the pairing scale decreases monotonically with hole doping x while the SC order parameter shows a non-monotonic ``dome''. We obtain detailed results for the doping-dependence of a large number of experimentally observable quantities including the Fermi surface, nodal quasiparticles, energy gap, optical spectral weight, and superfluid density. Our results are either in remarkable semi-quantitative agreement with existing data or have been subsequently verified. At small hole doping we discuss the tendencies toward various competing orders including antiferromagnetism. Finally we discuss sum rules for one-particle spectroscopies, which shed light on the striking asymmetry in the tunneling spectra in doped Mott insulators and are useful in estimating the local doping variations in inhomogeneous materials.

<< **back**

Tuning unconventional f-electron superconductors
J.L. Sarrao
Los Alamos National Laboratory

We discuss recent studies of the CeMIn$_5$ and PuMGa$_5$ families of superconductors and argue that there are several "knobs" that can be used to maximize superconducting transition temperature T$_c$. In particular, the evolution of T$_c$ with structural anisotropy (as measured by the ratio of the tetragonal lattice constants c/a) [Bauer et al., PRL (2004)] and the evolution of T$_c$ with spin fluctuation energy scale (T$_{sf}$) [Curro et al., Nature (2005)] are emphasized. Prospects for extending these studies to other systems and thereby further enhancing T$_c$ will be considered.

<< **back**

Artificial superlattices grown by MBE: can we design novel superconductors? A Possibility of Room Temperature Superconductivity
Masashi Tachiki
Research Organization for Information Science and Technology
National Institute for Materials Science

The high temperature superconductivity of layered copper oxides is

explained in the following way. The recent neutron and photon scattering experiments show that the dispersion of in-plane Cu-O bond-stretching longitudinal optical phonon is strongly softened with doping near the zone boundary. We suggest that it can be described with a negative electric dielectric function that results in an overscreening of the intersite Coulomb interaction due to phonon-induced charge transfer and vibronic electron-phonon resonance. We propose that such a strong electron-phonon coupling of specific modes can form a basis for the phonon mechanism of high temperature superconductivity. With the Eliasberg theory using the experimentally determined electron dispersion and dielectric function, we demonstrate the possibility of the superconductivity with the order parameter of the and the transition temperature well in excess of 100K. From the above results, we propose that room temperature superconductivity is realized in compounds with relatively small carrier concentrations and thus with the strong vibronic electron-phonon interaction.

<< back

Tunneling Spectroscopy and the Electron-Boson Interaction in High Tc Superconductors

John Zasadzinski

Electron spectroscopies of high Tc superconductors can be understood within an Eliashberg framework, appropriately modified for d-wave symmetry. An analysis of break junction and STM tunneling spectra on $Bi_2Sr_2CaCu_2O_{2+\delta;}$ (Bι2212) reveals that the spectral dip feature is directly linked to strong electronic coupling to a narrow boson spectrum, evidenced by a large peak in a α^2F (ω). For optimal doped Bi2212 the resulting self-energy is consistent with ARPES along the nodal direction. The tunneling dip feature remains robust in the overdoped regime of Bi2212 with bulk Tc values of 56K-62K. This is contrary to recent optical conductivity measurements of the self-energy that suggest the narrow boson spectrum disappears in overdoped Bi2212 and therefore cannot be essential for the pairing mechanism. The discrepancy is resolved by considering the way each technique probes the electron self-energy, in particular, the unique sensitivity of tunneling to the off-diagonal or pairing part of the self-energy. Electronic coupling to higher energy excitations, observed in optical conductivity, do not appear to be relevant to superconductivity.

<< back