The Bardeen-Cooper-Schrieffer Theory Of Superconductivity

Conference Program

October 10-13, 2007

ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

WELCOME

A HISTORY OF BCS—A BRIEF ACCOUNT

"Give it another month, or a month and a half. Wait 'til I get back and keep working. Maybe something'll happen."

With these parting words to Bob Schrieffer, John Bardeen left for Sweden in late November of 1956 to accept the Nobel Prize in Physics, his first, for the discovery of the transistor. Bob, a fourth-year graduate student, along with Leon Cooper, was trying to solve the riddle of superconductivity, a problem that had teased John for over 20 years. Roughly a year earlier, Leon showed that if two opposite-spin electrons, initially outside an otherwise quiescent Fermi sea, feel an attraction, they form a bound state. The attraction Leon envisioned was the phonon-mediated electron-electron interaction delineated by David Pines and John earlier. Thus, by March 1956, the pairing hypothesis originated: pairing all the electrons results in the energy gap of a superconductor. In fact, that an energy gap protects the superconducting state was a key tenet of John's thinking. Nonetheless, precisely how to formulate this mathematically remained elusive.

There must have been something that rang true in John's advice, however, because two months later, while riding on a New York city subway train in late January of 1957, Bob crystallized Leon's pairing hypothesis in the form of a wave function. The next morning he formulated and solved the variational equation for the energy gap. On his return to Urbana, Bob first shared his new result with Leon Cooper who grasped immediately that the wave function enabled a calculational scheme to elucidate the pairing hypothesis. In fact, the next day, John demonstrated using Schrieffer's wave function that the gap in the single-particle spectrum was identical to that entering the ground state energy. The mathematical framework was now clear. Within six months, the full Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity was formulated and its experimental ramifications laid plain. Once the community quickly resolved the subtleties involved in the choice of the electromagnetic gauge, BCS became the benchmark theory of superconductivity. The ensuing years proved fertile, as the theory was applied to collective motion of nucleons, superfluidity in ^{3}He, and the cores of neutron stars. But this was only the beginning. An implicit principle underlying the BCS theory is that of spontaneous symmetry breaking. The unification of electricity and magnetism with the weak interaction is fundamentally rooted in this idea. Indeed, part of the beauty of BCS, aside from its seeming simplicity, is its true universality. This conference celebrates that universality.

P. Phillips

"Give it another month, or a month and a half. Wait 'til I get back and keep working. Maybe something'll happen."

JOHN BARDEEN

ABOUT THE CONFERENCE

The celebration of the 50th anniversary of the 1957 Bardeen-Cooper-Schrieffer (BCS) paper will attempt to meet three goals: 1) highlight a physics discovery unique to the University of Illinois at Urbana-Champaign; 2) stress the intellectual impact of BCS on other areas of physics as well as technology; and 3) raise public awareness of solid state physics.

Each day of this four-day conference will be dedicated to different aspects of superconductivity. The first day will be devoted to the origin of BCS—that is, the history and people behind BCS. Current trends in superconductivity will be featured on the second day, and on the third day the technological impact of BCS will be highlighted. The last day of the conference will feature the impact of BCS on other areas of physics. Also, to help impart to the University of Illinois community the impact of BCS, we intend to hold a public lecture on the quantum magic of superconductivity.

SHUTTLE BUS SCHEDULE

Transportation will be provided to and from the conference banquet on Friday, October 12, 2007. Below is the schedule for pickups. The bus will begin transporting participants from the banquet back to the hotels at 8:30 PM and will continue until 10:00 PM.

Bus Location	Departing Time
Hampton Inn:	5:15 PM and 6:15 PM
Illini Union Hotel (circle drive):	5:25 PM and 6:25 PM
Historic Lincoln Hotel:	5:30 PM and 6:30 PM
Hawthorn Suites:	5:45 PM and 6:45 PM

WEDNESDAY, OCTOBER 10, 2007

8:00 AM Registration Opens

9:00 AM Welcome Ceremony

Philip Phillips, Conference Organizer
Dale Van Harlingen, Head, Department of Physics
Linda Katehi, Provost, University of Illinois at Urbana-Champaign

9:20 AM **NMR and the BCS Theory of Superconductivity**

Charles Slichter, University of Illinois at Urbana-Champaign

9:55 AM **BCS and the Superconducting Energy Gap**

Michael Tinkham, Harvard University

10:30 AM Break

11:00 AM **BCS from 1952–58: A Personal History**

David Pines, Los Alamos National Laboratory

11:25 AM **Origins of the Theory of Superconductivity**

Leon Cooper, Brown University

12:10 PM Lunch at Beckman (provided)

1:30 PM **Theory of Superconductivity**

Robert Schrieffer, Florida State University

2:05 PM **Discovery of Tunneling Between Superconductors**

Ivar Giaever, Rensselaer Polytechnic Institute

2:40 PM **BCS in Russia: The End of '50s–Early '60s**

Lev Gor'kov, Florida State University

3:15 PM Break

3:45 PM **Energy Gap, Mass Gap, and Spontaneous Symmetry Breaking**

Yoichiro Nambu, University of Chicago

4:20 PM **Notes from the Early Days of BCS: Gauge Invariance and the "Higgs" Phenomenon**

Phillip Anderson, Princeton University

6:00 PM BBQ on the Bardeen Quad

THURSDAY, OCTOBER 11, 2007

8:00 AM Registration Opens

9:00 AM **High-Temperature Superconductivity: A Personal View**

Elihu Abrahams, Rutgers University

9:35 AM **Infrared Spectroscopy of High-Tc Superconductors**

Dimitri Basov, University of California, San Diego

10:10 AM Break

10:40 AM **High Temperature Superconductors: BCS or Not BCS?**

J. C. Campuzano, University of Illinois at Chicago

11:15 AM **The Ineluctable Modality of the Visible**

Seamus Davis, Cornell University

11:50 AM Lunch at Beckman (provided)

1:10 PM **NMR of Correlated Electron Superconductors**

Jürgen Haase, Universität Leipzig

1:45 PM **Measuring up the Competition: Neutron Scattering Studies of Antiferromagnetism in Cuprate Superconductors**

John Tranquada, Brookhaven National Laboratory

2:20 PM Break

2:50 PM **Theory Panel Discussion**

Chair and Moderator: P. Phillips
Panelists: P.W. Anderson, S. Chakravarty, A. Chubukov, M.P.A Fisher, S. Kivelson, D. Pines, G. Sawatzky, D. Scalapino, C. Varma, J. Zaanen

5:00 PM **APS Plaque Presentation**

Charles P. Slichter, Professor of Physics
Leo Kadanoff, President, American Physical Society
Richard Herman, Chancellor, University of Illinois at Urbana-Champaign

5:30 PM Dinner at Beckman (provided)

7:30 PM **MillerComm Public Lecture: Lessons from Superconductivity**

Steven Weinberg, University of Texas at Austin

FRIDAY, OCTOBER 12, 2007

8:00 AM Registration Opens

9:00 AM **Josephson Interferometry: Mapping the Pairing Symmetry of Unconventional Superconductors**
Dale Van Harlingen, University of Illinois at Urbana-Champaign

9:35 AM **Superconductivity in Heavy-Fermion Materials**
Joe David Thompson, Los Alamos National Laboratory

10:10 AM Break

10:40 AM **Superconductivity and Electron Correlations in Ruthenates**
Andrew Mackenzie, University of St. Andrews

11:15 AM **Organics Superconductors**
Paul Chaikin, New York University

11:50 AM Lunch at Beckman (provided)

1:10 PM **Predicting New BCS Superconductors**
Marvin Cohen, University of California, Berkeley

1:45 PM **TBA**
Zachary Fisk, University of California, Irvine

2:20 PM **The Ubiquitous SQUID: From Cosmology to Medicine**
John Clarke, University of California, Berkeley

2:55 PM Break

3:25 PM **Two-Dimensional Superconductivity**
Allen Goldman, University of Minnesota

4:00 PM **From BCS through HTS to RTS**
Paul Chu, University of Houston

6:00 PM Banquet at the Champaign Country Club

SATURDAY, OCTOBER 13, 2007

8:00 AM Registration Opens

9:00 AM **Neutron Stars**
Gordon Baym, University of Illinois at Urbana-Champaign

9:35 AM **Nuclear Superfluids**
Ben Mottelson, Nordic Institute for Theoretical Physics in Quark Matter

10:10 AM Break

10:40 AM **Color Superconductivity**
Mark Alford, Washinton University

11:15 AM **Superfluidity and Neutron Star Dynamics**
Ali Alpar, Sabancı Üniversitesi, Orhanlı- Tuzla

11:50 AM Lunch at Beckman (provided)

1:10 PM **Superfluid 3He: The First Unconventional BCS States**
Doug Osheroff, Stanford University

1:45 PM **Application of BCS-like Ideas to Superfluid Helium-3**
Anthony Leggett, University of Illinois at Urbana-Champaign

2:20 PM Break

2:50 PM **BCS-BEC Crossover in Cold Atoms**
Debbie Jin, University of Colorado

3:25 PM **BCS Quantum Hall States**
James Eisenstein, California Polytechnic Institute

4:00 PM **Conference Summary and Looking Ahead**
Malcolm Beasley, Stanford University

Day 1: History

Chair: V. Ambegaokar

Cornell University

8:00 AM–5:00 PM

CONFERENCE REGISTRATION/HELP DESK

BECKMAN INSTITUTE, AUDITORIUM FOYER

9:00 AM

WELCOME CEREMONY

BECKMAN AUDITORIUM

Philip Phillips, Conference Organizer

Dale Van Harlingen, Head, Department of Physics

Linda Katehi, Provost, University of Illinois at Urbana-Champaign

9:20–9:55 AM

NMR AND THE BCS THEORY OF SUPERCONDUCTIVITY

BECKMAN AUDITORIUM

The talk will review the status of superconductivity research in the early 1950s, Bardeen's early thoughts about the role of an energy gap in producing superconductivity, our ideas that NMR experiments might test his ideas, the experimental challenge we had to overcome: how can one do NMR in a perfect diamagnet (which therefore excludes magnetic fields!), the surprising results we found, then the arrival of the BCS theory, and how applying the BCS theory to relate NMR to ultrasonic absorption verifies the essential concept of the theory (the existence of electron pairs).

Presenter: Charles P. Slichter, University of Illinois at Urbana-Champaign

Charles P. Slichter received his AB (1946), MA (1947), and PhD (1949) degrees from Harvard University, all in physics. During World War II, he worked as a research assistant at the Underwater Explosives Research Laboratory at Woods Hole, Massachusetts, while an undergraduate at Harvard. He began research in magnetic resonance as a student with Purcell just two years after the discovery of NMR. Since 1949, he has been a member of the Physics Department at the University of Illinois. In 1961, he was Morris Loeb Lecturer in Physics at Harvard University. In 1970–71 he was a Visiting Scientist at Bell Laboratories in Murray Hill, New Jersey.

He is currently a Center for Advanced Study Professor of Physics and Chemistry Emeritus, and a Research Professor of Physics at the University of Illinois at Urbana-Champaign. His research is in experimental solid state physics, in surface physics, and on the borderline between physics and chemistry, especially involving magnetic resonance. He has been the Ph.D. thesis advisor of 63 students. His book, Principles of Magnetic Resonance, written when he was Loeb lecturer, is now in its third edition.

9:55–10:30 AM

BCS AND THE SUPERCONDUCTING ENERGY GAP

BECKMAN AUDITORIUM

Pre-BCS measurements of electromagnetic absorption by superconductors at near-IR and microwave frequencies had suggested a characteristic photon energy threshold for absorption in the awkward intervening far-infrared wavelength range. Specific heat measurements also suggested a characteristic energy gap of the order of a few kTc. To pursue a spectroscopic measurement of an energy gap of such size, Glover and Tinkham constructed a crude monochromator producing feeble far-IR radiation with which to measure the frequency-dependent transmission of radiation through a very thin superconducting film, compared to the transmission through the film when in the normal state. To their surprise, the transmission in the expected frequency range was greater in the superconducting state, implying that the superconductor was a poorer conductor than in the normal state. This could be understood in terms of a frequency-dependent complex conductivity, with the real part being approximately zero below a "gap energy" $\hbar\omega_g \sim 3k_BT_c$. Subsequent measurements with improved equipment supported this interpretation by finding very good agreement between the measured frequency-dependent real and imaginary components of $\delta(\omega)$, with the functions predicted by the microscopic BCS theory. This agreement was viewed as a major confirmation of the BCS theory: not simply confirming the existence of an energy gap, but also confirming the important "coherence factors" stemming from the detailed structure of the BCS wave functions.

Presenter: Michael Tinkham, Harvard University

A native of Wisconsin, Tinkham received his AB degree from Ripon College, and his MS and PhD from MIT. After a postdoctoral year at the Clarendon Laboratory in Oxford with Professor B. Bleaney, FRS, he spent 11 years at the University of California, Berkeley, before moving to Harvard in 1966. There he has served as Rumford Professor of Physics and Gordon McKay Professor of Applied Physics, recently retiring to emeritus status. Over the years, he has spent sabbatical leaves with P. G. de Gennes at the University of Paris, Orsay, with Brian Pippard at the Cavendish Laboratory, Cambridge, with Albert Schmid at the University of Karlsruhe, with John Clarke at the University of California, Berkeley, and with Hans Mooij at the Technical University of Delft.

He is a Member of the National Academy of Sciences, and a Fellow of the American Academy of Arts and Sciences, the American Physical Society, and the American Association of *the Advancement of Science. Honors from the APS include the Buckley Prize for his research on the electromagnetic properties of superconductors and the Richtmeyer Lectureship. Other honors include an honorary ScD degree from the ETH in Zürich.*

Author of over 300 research publications, he has also written several textbooks: Group Theory and Quantum Mechanics, Superconductivity, *and two editions of* Introduction to Superconductivity. *The latter have been translated into Russian, Japanese, and Chinese.*

10:30–11:00 AM

BREAK

BECKMAN, ROOM 1005

11:00 – 11:25 AM

BCS FROM 1952–58: A PERSONAL HISTORY

BECKMAN AUDITORIUM

This talk will be divided into three parts. In "Before the Creation", Dr. Pines will describe his BCS-related work, adjacent to and with John Bardeen, at a desk in his UIUC office from 1952-55. He will next recall the immediate impact of BCS in Princeton and Copenhagen. In Princeton, news of the breakthrough and a dittoed copy of their not-yet-published PRL arrived in a letter from John in mid-to-late February, and, following an intensive three days spent sorting it out with Elihu Abrahams and Philippe Nozieres, Dr. Pines was able to teach it to his class later that spring of 1957 and show how it was consistent with the famous Matthias rules for the occurrence of superconductivity. In Copenhagen, his lectures on BCS in the course of a visit to the Bohr Institute from June-August 1957 led to its seminal application to nuclear physics. The talk will conclude with a 1958 postscript—working with Bob Schrieffer in Paris and Les Houches to demonstrate its gauge invariance.

Presenter: David Pines, Los Alamos National Laboratory

David Pines is the founding co-director of the Institute for Complex Adaptive Matter (a multi-campus research program of the University of California with 49 branches in the United States and overseas), a Distinguished Professor of Physics at UC Davis, Research Professor of Physics and Professor Emeritus of Physics and Electrical and Computer Engineering in the Center for Advanced Study, University of Illinois at Urbana-Champaign, and a staff member in the office of the Materials Physics and Applications Division at Los Alamos. His seminal contributions to the theory of many-body systems and to theoretical astrophysics have been recognized by two Guggenheim Fellowships; the Feenberg Medal, Friemann, Dirac, and Drucker prizes; and by his election to the National Academy of Sciences, American Philosophical Society, American Academy of Arts and Sciences, Russian Academy of Sciences, and Hungarian Academy of Sciences; and Visiting Professorships at Caltech, College de France, Trinity College, University of Cambridge, University of Leiden, and Université de Paris.

He is the founding director of the Center for Advanced Study, UIUC (1968–70), was vice president of the Aspen Center for Physics (1968–72), and was the founding co-chair of the US-USSR Cooperative Program in Physics (1968–89). He is a co-founder of the Santa Fe Institute and served as its vice president, chair of the Board of Trustees and co-chair of its Science Board and Science Steering Committee during the years 1982–96. He has been the organizer or co-organizer of sixteen workshops and two summer schools. He currently serves as an honorary trustee of the Aspen Center for Physics, a member of the Science Board of the Santa Fe Institute, and of the Board of Overseers, Sabanci University, Istanbul.

11:25 AM–12:00 PM

ORIGINS OF THE THEORY OF SUPERCONDUCTIVITY

BECKMAN AUDITORIUM

Dr. Cooper will give a, somewhat, personal account of events that led to The Theory of Superconductivity, as well as share some thoughts about their continuing significance.

Presenter: Leon Cooper, Brown University

Leon N. Cooper was born in 1930 in New York, where he attended Columbia University (AB 1951, AM 1953, PhD 1954). He became a member of the Institute for Advanced Study (1954–55), after which he was a research associate at the University of Illinois (1955–57), and later an assistant professor at Ohio State University (1957–58). Professor Cooper joined Brown University in 1958, where he became Henry Ledyard Goddard University Professor (1966–74) and where he is currently the Thomas J. Watson, Sr. Professor of Science (1974–) and Director of the Institute for Brain and Neural Systems.

In 1972 Professor Cooper received the Nobel Prize in Physics (with J. Bardeen and J.R. Schrieffer) for his studies on the theory of superconductivity. In 1968, he was awarded the Comstock Prize (with J.R. Schrieffer) of the National Academy of Sciences. Cooper has also been awarded The Award of Excellence from Graduate Faculties Alumni of Columbia University, the Descartes Medal from Academie de Paris, Université René Descartes, and the John Jay and Alexander Hamilton awards from Columbia University.

He is a Fellow of the American Physical Society, the American Academy of Arts and Sciences, the American Association for Advancement of Science, Phi Beta Kappa, and Sigma Xi. He is a member of the American Philosophical Society, the National Academy of Sciences, and the Society for Neuroscience.

Professor Cooper's research interests include the foundations of Quantum Theory, the cellular and molecular basis for learning and memory storage, synaptic plasticity, and neural networks.

12:10–1:30 PM

LUNCH AT BARDEEN

BECKMAN EAST/CENTER ATRIUM

(Additional seating available in rooms 1005 and 1237)

Chair: G. Boebinger, National High Magnetic Field Laboratory

1:30–2:15 PM

THEORY OF SUPERCONDUCTIVITY

BECKMAN AUDITORIUM

Presenter: Robert Schrieffer, Florida State University

2:05–2:40 PM

DISCOVERY OF TUNNELING BETWEEN SUPERCONDUCTORS

BECKMAN AUDITORIUM

Ivar Giaever received a Nobel Prize in Physics for using electron tunneling to measure the energy gap in superconductors. In this talk, he will recollect some of the events that led to this discovery and, hopefully, will be able to convey to the audience some of the fun and excitement of that area. He counts his great fortune as being in the right place at the right time, where he had access to outstanding and helpful physicists. Those who wish may find a written version in his Nobel Prize talk: "Electron Tunneling and Superconductivity Science"183, 1253-1258 1974 or Reviews of Modern Physics 46 (2): 245-250 1974, or look up the talk at the Web site: www.nobelprize.org.

Presenter: Ivar Giaever, Rensselaer Polytechnic Institute

Dr. Ivar Giaever received his Mechanical Engineering degree from the Norwegian Institute of Technology in 1952, and a PhD in theoretical physics from Rensselaer Polytechnic Institute in 1964. Early experience includes one year as an engineer in the Norwegian Army and one year as a patent examiner for the Norwegian Government. In 1954, Dr. Giaever immigrated to Canada and joined Canadian General Electric's Advanced Engineering Program. He immigrated to the USA in 1956 and worked as an applied mathematician for General Electric Company before joining the Research and Development Center in 1958. From 1958 to 1970, Dr. Giaever worked in the fields of thin films, tunneling, and superconductivity. In 1970, he was awarded a Guggenheim Fellowship and spent one year in Cambridge, England, studying biophysics. Upon his return to the Research and Development Center in 1971, Dr. Giaever began his current efforts of studying the behavior of organic molecules at solid surfaces, and the interaction of cells with surfaces. During a sabbatical in 1975, he served as an adjunct professor at the University of California, San Diego and a visiting professor at the Salk Institute for Biological Studies at La Jolla. He was an Institute Professor of Science at Rensselaer Polytechnic Institute from 1988 until he became a Professor Emeritus when he retired in 2004. He is currently Professor-at-Large at the University of Oslo and President of Applied BioPhysics, Inc., a company he founded with C. Keese in 1991.

Dr. Giaever received the Oliver E. Buckley Prize in 1965 from the American Physical Society. In October 1973, he shared the Nobel Prize in Physics with L. Esaki and B. D. Josephson. In 1974, he received the Vladimir K. Zworykin Award from the National Academy of Engineering. In 2003, he received the Onsager Medal from NTNU, Norway. He is a recipient of numerous honorary degrees.

In 1974, Dr. Giaever was elected to the National Academy of Sciences and to the American Academy of Arts and Sciences. In 1975, he was elected to the United States National Academy of Engineering. In addition, he is a member of the Korean Academy of Science, the Norwegian Academy of Sciences, and the Swedish Academy of Engineering. He is also an honorary member of the Norwegian Academy of Technology and the American Society of Mechanical Engineers.

2:40–3:15 PM

BCS IN RUSSIA: THE END OF '50S–EARLY '60S

BECKMAN AUDITORIUM

There was a delay before the BCS theory reached Russia. It was immediately recognized as the crucial theoretical step that proved the long-anticipated gapped spectrum for new excitations. For many Russians, well aware of the strong anisotropy of electronic spectra in metals, the question of a detailed fit to experiment was not the decisive factor (actually, the agreement, we know, fit exceedingly well for the isotropic model!). As to the Cooper instability underlying the theory, it was accepted as the qualitative key idea that would finally allow answering the long-standing question of why superconductivity (SC) is so common a phenomenon in metals.

The variational approach chosen in the BCS paper for finding the ground state wave function needed modifications, and a considerable progress in this direction has been achieved in Russia.

Among the urgent theory problems there was the need to establish the symmetry order parameter governing the SC transition, as well as to reformulate the theory in the gauge-invariant manner that would allow treating nonlinear or inhomogeneous SC properties. These goals have mainly been achieved by applying the approaches borrowed from the Quantum Field Theory, most importantly, by making use of the new methods in the Quantum Statistics at finite temperatures specially elaborated for the purpose.

The Cooper pair wave function has been identified as the order parameter. With its use the phenomenological Ginzburg-Landau (GL) equations have been rigorously derived from the microscopic theory (with the doubled charge, 2e!). Together with the remarkable findings from the GL phenomenology and with the new theory for the SC alloys, the microscopic results comprised the broadly acclaimed GLAG- theory.

These and some other results, including the so-called "gapless SC" in alloys containing paramagnetic impurities, will be briefly discussed in the talk.

Presenter: Lev Gor'kov, National High Magnetic Field Laboratory, Florida State University

Lev Gor'kov received an MS Engineering diploma from Moscow University, then the Moscow Mechanical Institute (1953); a PhD ("Candidate of Sciences") at the L.D.

Landau Theory Department, the Kapitza Institute for Physical Problems, the USSR Academy of Sciences, (1955); and a Doctor of Sciences from the Ioffe Institute Physical Technical Institute, the USSR Academy of Sciences (1960).

From 1955 to 1964, he was with the Landau theory group at the Kapitza Institute as a scholar. After L.D. Landau's tragic car incident in 1962, Gor'kov, together with three of Landau`s pupils, co-founded the L.D. Landau Institute for Theoretical Physics and served as Department Head and Chairman of the Educational Landau Theory Department at the Moscow Institute for Physics and Technology from 1965 to1992. He was the George A. Miller Visiting Professor at the University of Illinois at Urbana-Champaign from 1991–92 and is currently serving as Program Director/Professor at the National High Magnetic Field Laboratory at Florida State University in Tallahassee.

Gor'kov is a member of the Soviet Academy of Sciences; the National Academy of Sciences, USA; the American Academy of Arts and Sciences; and an APS fellow. His scientific interests and published papers are in quantum electrodynamics; hydrodynamics and acoustics; quantum mechanics and quantum statistics and thermodynamics; liquid helium etc. His main interests are in condensed matter physics; superconductivity, including high Tc cuprates; heavy fermions; disorder in low dimensions; organic materials; and manganites.

3:15–3:45 PM

BREAK

BECKMAN, ROOM 1003

3:45–4:20 PM

ENERGY GAP, MASS GAP, AND SPONTANEOUS SYMMETRY BREAKING

BECKMAN AUDITORIUM

Dr. Nambu will give a historical overview of how the BCS theory has migrated to particle physics and has helped solve its problems.

Presenter: Yoichiro Nambu, University of Chicago

Dr. Nambu studied physics at the University of Tokyo in the early 1940s. After serving in the army during the war, he returned to Tokyo as a postdoctoral researcher and came in contact with Tomonaga and his group, who were developing the renormalization theory at another university nearby. He held a faculty position at Osaka City University for a few years and then was invited to the Institute for Advanced Study at Princeton in 1952.

Since 1954, Dr. Nambu has been with the University of Chicago. His theoretical work has been mainly in particle physics, (chiral symmetry and mass generation, quark color, hadron string model, etc.), but it has also ranged over condensed matter and nuclear physics. He has been particularly interested in cross-fertilization among the different subfields of physics through general principles and concepts.

4:20–4:55 PM

NOTES FROM THE EARLY DAYS OF BCS: GAUGE INVARIANCE AND THE "HIGGS" PHENOMENON

BECKMAN AUDITORIUM

A spectrum of theorists questioned the BCS theory because of its apparent violation of gauge invariance. At first incomprehensibly, and then with increasing coherence, I answered those criticisms and in the process discovered the Higgs phenomenon. I describe this development and some amusing difficulties of communication that arose.

Presenter: Philip W. Anderson, Princeton University

6:00–9:00 PM

BBQ ON THE BARDEEN QUAD

Join us for BBQ and beer on the Engineering Quad (southwest of Beckman Institute). Just look for the orange and blue tent!

****This activity is complimentary to those who have paid the conference registration fee. A limited number of tickets for guests, graduate students, and UIUC personnel will be available for purchase at the conference registration desk.**

Day 2: Current Trends

Chair: Michael Norman

University of California, San Diego

8:00 AM–5:00 PM

REGISTRATION/HELP DESK

BECKMAN AUDITORIUM FOYER

9:00–9:35 AM

HIGH-TEMPERATURE SUPERCONDUCTIVITY: A PERSONAL VIEW

BECKMAN AUDITORIUM

A number of interesting issues involving both theory and experiment for the cuprate high-temperature superconductors will be discussed. An exhaustive survey will not be given.

Presenter: Elihu Abrahams, Rutgers University

Elihu Abrahams received his AB (1947) and PhD (1952) degrees from the University of California, Berkeley, both in physics. While an undergraduate at UC Berkeley, he was enrolled in the US Navy V-12 program. He began research in theoretical condensed matter physics as a student with C. Kittel in 1950 and in 1953, continued his research work as a postdoctoral associate and research assistant professor at the University of Illinois at Urbana-Champaign. Since 1956, he has been a member of the Physics Department of Rutgers University, where he is now Bernard Serin Professor (Emeritus) and Director of the Center for Materials Theory. He has been a visiting professor at ENS, Paris (1959–60, 1969–70), at the Université de Paris VI (1994) and at the Collège de France (1986). He has been a Guggenheim Fellow and is a member of the American Academy of Arts and Sciences and the National Academy of Sciences. His research is on the quantum many body problem, with emphasis on systems of strongly correlated electrons.

9:35–10:10 AM

INFRARED SPECTROSCOPY OF HIGH-TC SUPERCONDUCTORS

BECKMAN AUDITORIUM

The pioneering experiments of Prof. M. Tinkham and his collaborators [1] carried out both before and after the advent of the BCS theory have established infrared spectroscopy as a premier experimental tool for exploring superconductivity. Not surprisingly, infrared methods have been extensively applied to high-Tc cuprates and have helped to elucidate many important aspects of these exceptionally complex materials [2]. In this talk, Dr. Basov will review a series of recent experiments aimed at understanding the formation of a conducting state in parent insulating compounds, the search for an elusive "glue" which may mediate superconducting pairing, as well as infrared studies of the energetics of the superconducting state.

[1] M.Tinkham, Reviews of Modern Physics 46, 587 (1974).

[2] D.N.Basov and T.Timusk, Reviews of Modern Physics 77, 721 (2005).

Presenter: Dimitri Basov, University of California, San Diego

Dimitri Basov received his PhD in 1991 in experimental physics from the Lebedev Institute, Russian Academy of Sciences. From 1992–96, he was a postdoc at McMaster University. He served one year at the Brookhaven National Laboratory as an Assistant Physicist before leaving in 1997 to become Assistant, then Associate Professor at the University of California, San Diego. He has been a full Professor at that institution since 2001.

Dr. Basov has been honored with the NSF Career Award, the Sloan Fellowship, the Cottrell Fellowship, the Ludwig Genzel Prize, and is an APS Fellow. His research interests include superconductivity, and optical properties of complex electronic and magnetic materials.

10:10–10:40 AM

BREAK

BECKMAN, ROOM 1005

10:40–11:15 AM

HIGH TEMPERATURE SUPERCONDUCTORS: BCS OR NOT BCS?

BECKMAN AUDITORIUM

Presenter: J. C. Campuzano, University of Illinois at Chicago

11:15–11:55 AM

THE INELUCTABLE MODALITY OF THE VISIBLE: IMAGING THE GENESIS OF CUPRATE SUPERCONDUCTIVITY IN THE CORRELATED STATES OF THE HOLE-DOPED CUO2 INSULATOR

BECKMAN AUDITORIUM

Within the BCS theory of superconductivity, the Fermi liquid state is susceptible to pair formation due to phonon mediated attractive electron-electron interactions. By contrast, pairing in cuprate superconductors emerges when holes are doped into a 2-d antiferromagnetic Mott insulator. Thus, it is strong repulsive electron-electron interactions within a single non-degenerate band of the CuO_2 plane which may actually provide the foundation upon which the superconductivity is built. But there is still no consensus on either the structure of the cuprate many-body state, or the electron pairing mechanism.

Tunneling spectroscopy, which was critical to studies of BCS superconductivity, is now beginning to play an important but quite different role in studies of cuprates. We focus on atomic-resolution determination of the structure of excited state spectrum using the techniques of Spectroscopic Imaging STM (SI-STM) [i]. Two major families of cuprates are studied: $Ca_{1-x}NxCuO_2Cl_2$ and $Bi_2Sr_2CaCu_2O_{8+x}$.

The basic density-of-states as derived from the tunneling spectrum is highly consistent with d-wave BCS superconductivity [ii] (at least near the hole-density p associated with maximum T_c). However, the evolution of the excitation spectrum with *p* is not. The primary energy gap Δ grows approximately linearly with falling p [iii] even as the T_c diminishes to zero. This energy gap turns out to be heterogeneous on the ~3nm scale [iv], an effect triggered primarily by the randomly distributed non-stoichiometric dopant atoms [v]. Spatial fluctuations in the pair energy[vi] provide a consistent explanation for this electronic disorder near E~Δ. Nevertheless we always find a lower energy Δ_0 below which the electronic structure is spatially homogeneous4 [vii].

An obvious way to access the underlying many-body state is to suppress the superconductivity. When this is done at the center of a vortex core [viii], at temperatures above [ix] T_c, and at *p* below the critical hole-density [x],[xi], the effects observed are startling Strong spatial modulation in the density-states with periodicities near 4-unit cells typically in 'checkerboard' patterns are detected; an apparently equivalent modulation of the spin excitations is seen by inelastic neutron scattering. It is as if the cuprate "normal" state at low *p* consists of electronic states better defined in real-space (***r***-space) rather than in ***k***-space. To identify the underlying many-body state, simultaneous determination of ***r***-space and ***k***-space electronic structure may therefore be required.

To meet this challenge, we introduced the technique of 'Quasiparticle Interference Imaging' (QPI)[7]. We image the Friedel oscillations of d-wave Bogoliubov quasiparticles, identify their wavevectors, and then deduce both the energy and ***k***-space locations of the quasiparticles undergoing scattering. This allows the superconducting energy gap $\Delta(\boldsymbol{k})$ to be determined simultaneously with the ***r***-space density-of-states. At energies less than Δ_0 we see beautifully coherent d-wave BCS quasiparticles—consistent with the ARPES results[xii]. When E reaches Δ_0, we find that the associated ***k***-space states have just reached the antiferromagnetic Brillouin zone (BZ) boundary, and here the interference patterns disappear. Above Δ_0, the states become quasi-localized and patterned in a new fashion; their ***r***-space structure was recently revealed [xiii] to be a Cu-O-Cu bond-centered pattern with disperse $4a_0$-wide unidirectional domains.

A possible explanation could be that states inside the antiferromagnetic BZ are coherent Bogoliubov excitations from the superfluid ground state, while those outside this region are quasi-localized and not excitations from the phase coherent superfluid. If this is the case then, although the pairing gap increases with diminishing *p*, the number of ***k***-space eigenstates available to undergo Cooper pairing diminishes rapidly and the quasi-localized states increasingly predominate—driving T_c to zero as $p \rightarrow 0$.

Acknowledgements: This work is part of a long-term collaboration between the Davis Group (Cornell), Prof. S. Uchida (Tokyo), Prof. Dung-Hai Lee (UC Berkeley), Prof. H. Takagi (RIKEN), Prof. K. McElroy (Colorado) and Prof. P. Hirschfeld (U. Florida)

Presenter: J. C. Séamus Davis, Cornell University

B.Sc., 1983, National University of Ireland, Cork. Ph.D., 1989, University of California, Berkeley. Research Assistant, University of California, Berkeley, 1984-1989. Postdoctoral Research Associate, University of California, Berkeley, 1990-1993. Assistant Professor, Physics, University of California, Berkeley, 1993-1997 . Faculty Physicist, L. Berkeley National Laboratory, 1998-2002 . Associate Professor, Physics, University of California, Berkeley, 1998-2000. Professor, Physics, University of California, Berkeley, 2001-2002 . Professor, Physics, Cornell University, 2003- present. NSF National Young Investigator Award, 1994. Packard Fellow in Science and Engineering, 1994. Alfred P. Sloan Research Fellow, 1996. Miller Research Professor, 2000. Outstanding Performance Award, L. Berkeley National Laboratory, 2001. Ehrenfest Lecturer, University of Leiden, Holland, 2002, Fellow of the Institute of Physics, 2002, Fellow of the American Physical Society, 2005, Fritz London Memorial Prize 2005.

Dr. Davis's research interests are in the application of experimental techniques of high precision low temperature physics to questions of fundamental significance. At present, these include (i) studies of atomic scale electronic phenomena in transition metal oxides including the high temperature superconductors using Spectroscopic Imaging STM, (ii) studies of superfluid Quantum Nanofluidics, (iii) exploration of possible Bosonic Supersolid Phases both in electronic systems and in 4He and, (iv) studies of the ultimate Force sensitivity limits of mechanical systems.

11:50 AM–1:10 PM

LUNCH AT BECKMAN

BECKMAN CENTER/EAST ATRIUM

(Additional seating available in Rooms 1005 and 1237.)

Chair: N. Bontemps, ESPCI-CNRS

1:10–1:45 PM

NMR OF CORRELATED ELECTRON SUPERCONDUCTORS

BECKMAN AUDITORIUM

As a bulk probe with atomic scale resolution, NMR is a powerful tool for the investigation of the chemical and electronic structure of modern materials. Basic findings from NMR on correlated electron superconductors will be reviewed. The emphasis will be on high-temperature superconductors, for which we also reveal new NMR data that contradict the single-component picture suggested by early NMR experiments, which influenced much of the thinking about these materials. We introduce a two-component model and deduce the hyperfine couplings of the particular nuclei with these two components and discuss the temperature dependences of the related spin susceptibilities together with possible scenarios.

Presenter: Jürgen Haase, Universität Leipzig

Dr. Jürgen Haase received his Study of Physics (1984) and PhD (1987) from the Department of Physics at the Universität Leipzig in Germany. He was a research assistant there until 1989, when he became a postdoctoral research associate in the Department of Chemistry at the University of Illinois at Urbana-Champaign. He has also been a member of the faculty at Washington University, St. Louis (1993), Universität Leipzig (1994–96), University of Illinois at Urbana-Champaign (1997–2000), and Universität Stuttgart, Germany (2000–02). He was a staff scientist at the Max Planck Institute for the Chemical Physics of Solids (2003–04) and at the Leibniz Institute for Solid State and Materials Research (2004–06), both in Dresden, Germany. Since 2006, he has been full professor of Solid State Physics at the Universität Leipzig.

His research activities include a broad NMR methodological background in physics and physical chemistry, physics of correlated electronic materials (high-temperature superconductivity), and ultra-high-field NMR in pulsed magnets.

1:45–2:20 PM

MEASURING UP THE COMPETITION: NEUTRON SCATTERING STUDIES OF ANTIFERROMAGNETISM IN CUPRATE SUPERCONDUCTORS

BECKMAN AUDITORIUM

High-temperature superconductivity in the cuprates is obtained by doping charge carriers into a parent compound that is an antiferromagnetic insulator with a strong magnetic interaction between Cu moments within the copper-oxide planes. A small density of positive charge carriers (holes) is sufficient to destroy the antiferromagnetic order; nevertheless, local antiferromagnetic correlations survive. Neutron scattering is an essential tool for characterizing these spin fluctuations. While antiferromagnetic order competes with superconductivity, local spin correlations may be relevant to the pairing mechanism. I will review the progress that has been made over the last 20 years and give my own biased perspective on the nature and doping dependence of spin correlations in the cuprates. A more detailed review is given in [1].

Work at Brookhaven is supported by the Office of Science, U.S. Department of Energy, under Contract No. DE-AC02-98CH10886.

[1] J. M. Tranquada, Handbook of High Temperature Superconductivity, edited by J. R. Schrieffer and J. S. Brooks (Springer, New York, 2007), pp. 257-298; cond-mat/0512115.

Presenter: John Tranquada, Brookhaven National Laboratory

Dr. John M. Tranquada is presently a Senior Physicist and group leader for Neutron Scattering in the Condensed Matter Physics & Materials Science Department at Brookhaven National Laboratory (BNL). He graduated cum laude from Pomona College in 1977 with a BA in Physics, and received a PhD in Physics from the University of Washington in 1983. In 1986, after a postdoctoral position with a participating research team on an x-ray spectroscopy beam line at the National Synchrotron Light Source, he joined the Physics Department at Brookhaven. With the discovery of high-temperature superconductivity that year, he was in a good position to do early x-ray spectroscopic studies of the electronic character of the charge carriers in the cuprates. Tranquada moved to the Neutron Scattering Group in 1987, where his first experiment resulted in the discovery of the antiferromagnetic order in YBa2Cu3O6.15, the parent compound of one of the first reported families of superconductors. Working at Brookhaven's High Flux Beam Reactor (HFBR), he discovered spin and charge stripe order in a special cuprate, La1.48Nd0.4Sr0.12CuO4, in 1995. With the demise of the HFBR in 1999, Tranquada has continued his neutron scattering studies at top national and international facilities, looking into anomalous lattice vibrations, as well as spin fluctuations, especially in connection with stripe correlations. He has published more than 150 peer-reviewed journal articles, has presented over 150 invited lectures, and is co-author of a book on neutron scattering techniques.

Tranquada is an elected Fellow of the American Physical Society (APS, 1997), the American Association for the Advancement of Science (AAAS, 2006), and the Neutron Scattering Society of America (NSSA, 2007). He is a Divisional Associate Editor for Physical Review Letters (2001–07) and a member of the Executive Committee of the Division of Materials Physics of the APS (2006–08). He serves on advisory committees for the Neutron Scattering Sciences Division at Oak Ridge National Laboratory (2006–09) and the NIST Center for Neutron Research (2001–07), is a member of the steering committee for the US-Japan Cooperative Research Program on Neutron Scattering (since 1999), and has served numerous times as a peer reviewer and on review committees for the Basic Energy Sciences Division of the Department of Energy (DOE), as well as for organizations in France and Japan. He has been honored with the DOE Award for Outstanding Scientific Accomplishment in Solid State Physics (1988), the BNL Research & Development Award (1995), and the Sustained Research Prize of the NSSA (2006).

2:20–2:50 PM

BREAK

BECKMAN, ROOM 1005

2:50–4:30 PM

THEORY PANEL DISCUSSION

BECKMAN AUDITORIUM

Chair and Moderator: P. Phillips

Panelists: P.W. Anderson, S. Chakravarty, A. Chubukov, M.P.A Fisher, S. Kivelson, D. Pines, G. Sawatzky, D. Scalapino, C. Varma, J. Zaanen

5:00–5:30 PM

APS PLAQUE PRESENTATION

BECKMAN AUDITORIUM

Charles P. Slichter, Professor of Physics

Leo Kadanoff, President, American Physical Society

Richard Herman, Chancellor, University of Illinois at Urbana-Champaign

5:30–7:00 PM

DINNER AT BECKMAN

BECKMAN CENTER/EAST ATRIUM

(provided to all paid registrants).

7:30 PM

MILLERCOMM PUBLIC LECTURE: LESSONS FROM SUPERCONDUCTIVITY

ALICE CAMPBELL ALUMNI CENTER

Reception to follow.

Presenter: Steven Weinberg

Steven Weinberg holds the Josey Regental Chair in Science at the University of Texas at Austin, where he is a member of the Physics and Astronomy Departments. His research on elementary particles and cosmology has been honored with numerous prizes and awards, including in 1979 the Nobel Prize in Physics and in 1991 the National Medal of Science. In 2004 he received the Benjamin Franklin Medal of the American Philosophical Society, with a citation that said he is "considered by many to be the preeminent theoretical physicist alive in the world today." He has been elected to the US National Academy of Sciences and Britain's Royal Society, as well as to the American Philosophical Society and the American Academy of Arts and Sciences.

He is the author of over 300 articles on elementary particle physics. His books include Gravitation and Cosmology—Principles and Applications of the General Theory of Relativity *(1972);* The First Three Minutes *(1977);* The Discovery of Subatomic Particles *(1983, 2003);* Elementary Particles and The Laws of Physics *(with R.P. Feynman) (1987);* Dreams of a Final Theory—The Search for the Fundamental Laws of Nature *(1993); a trilogy,* The Quantum Theory of Fields *(1995, 1996, 2000);* Facing Up—Science and its Cultural Adversaries *(2002); and most recently* Glory and Terror—The Growing Nuclear Danger *(2004). Articles of his on various subjects appear from time to time in The New York Review of Books.*

He has served as consultant at the U. S. Arms Control and Disarmament Agency, President of the Philosophical Society of Texas, and member of the Board of Editors of Daedalus magazine, the Council of Scholars of the Library of Congress, the JASON group of defense consultants, and many other boards and committees.

Educated at Cornell, Copenhagen, and Princeton, he also holds honorary doctoral degrees from sixteen other universities, including Chicago, Columbia, McGill, Padua, Salamanca, and Yale. He taught at Columbia, Berkeley, M.I.T., and Harvard, where he was Higgins Professor of Physics, before coming to Texas in 1982.

Day 3: Novel Superconductors and Applications

Chair: Miles Klein

University of Illinois at Urbana-Champaign

8:00 AM–4:30 PM

REGISTRATION/HELP DESK

BECKMAN AUDITORIUM FOYER

9:00–9:35 AM

JOSEPHSON INTERFEROMETRY: MAPPING THE PAIRING SYMMETRY OF UNCONVENTIONAL SUPERCONDUCTORS

BECKMAN AUDITORIUM

One of the significant testable predictions of the BCS theory of superconductivity was the presence of an energy gap and all conventional superconductors were found to exhibit a nearly-isotropic "s-wave" pairing symmetry. However, the discovery of the heavy fermion and high-temperature superconductors in the 1980's revealed the existence of materials with order parameters that were strongly anisotropic in magnitude and/or phase. Thermodynamic and transport measurements suggested the presence of nodes in the order parameter but the determination of the pairing symmetry remained elusive for several years. A breakthrough came with the pioneering of a new class of phase-sensitive experiments based on directional Josephson tunneling and phase interference.

In this talk, I will describe the technique of Josephson interferometry and review how it was implemented in several manifestations to verify the $d_{x^2-y^2}$ pairing symmetry of the cuprates. I will then outline recent and on-going work to apply this technique to other materials suspected to be unconventional, particularly the ruthenate superconductor Sr_2RuO_4, which has recently been confirmed to have a dynamical chiral p-wave order parameter domains of the form $p_x \pm ip_y$, and the heavy fermion superconductor UPt^3 which exhibits two superconductor phases, one of which is believed to be odd-parity and complex.

Presenter: Dale Van Harlingen, University of Illinois at Urbana-Champaign

Dale J. Van Harlingen is a Center for Advanced Study Professor of Physics, the Donald Biggar Willett Professor of Engineering, and the Head of the Department of Physics at the University of Illinois at Urbana-Champaign. Van Harlingen received his bachelor's degree in physics in 1972 and his Ph.D. in physics in 1977 from The Ohio State University. After a year as a NATO postdoctoral fellow in the Cavendish Laboratory at the University of Cambridge, England, he held a postdoctoral research position at the University of California at Berkeley. He joined the Physics faculty at the University Illinois as an assistant professor in 1981and has spent his entire professional career there.

Van Harlingen is a long time Principal Investigator in the Frederick Seitz Materials Research Laboratory where he conducts experimental low temperature research on superconductor materials and microfabricated superconductor devices. His work focuses on studying quantum phenomena and phase coherence and dynamics in a wide variety of superconducting structures using transport measurements, Josephson tunneling, and scanning probe microscopy. Current interests include determination of the pairing symmetry of unconventional superconductors, exploration of the dynamics of π-Josephson junctions, development of instrumentation for scanning SQUID microscopy, and characterization of electronic transport in nanoscale superconducting structures.

Van Harlingen became a member of the American Physical Society in 1975 and an APS Fellow in 1996. He received the Oliver E. Buckley Prize in Condensed Matter Physics from the APS in 1998 and was elected a member of the American Academy of Arts and Sciences in 1999 and to the National Academy of Sciences in 2003. He was named a Professor in the Center for Advanced Study at Illinois in 2004 and became Head of the Department of Physics in 2006.

9:35 – 10:10 AM

SUPERCONDUCTIVITY IN HEAVY-FERMION MATERIALS

BECKMAN AUDITORIUM

The surprising discovery of superconductivity in $CeCu_2Si_2$, with its dense array of strongly paramagnetic Ce ions, opened the field of heavy-fermion superconductivity. In their 1979 paper, Steglich and coworkers observed in $CeCu_2Si_2$ the hallmarks characteristic of all subsequent examples: the low temperature specific heat γT is very large due to "very heavy fermion quasiparticles"; the size of the specific heat jump at the superconducting transition temperature Tc is proportional to γT_c, suggesting that Cooper pairs are formed by these heavy fermions; T_c is less than but comparable to the degeneracy temperature of the heavy fermions, which, in turn, is much lower than the Debye temperature of phonons, making $CeCu_2Si_2$ a "high-temperature superconductor"; and, the superconductivity, though conceptually that of Bardeen, Cooper and Schrieffer, probably requires a mechanism for Cooper pair formation other than electron-phonon coupling. Remarkably, during the subsequent three years, this work was cited only 18 times. But, this course soon changed with the discovery of heavy-fermion superconductivity in UBe_{13} and UPt_3, which established that superconductivity in a nearly magnetic material, such as $CeCu_2Si_2$, was not a singularity of Nature. Some 20 plus years later, we have nearly 20 examples of heavy-fermion superconductivity in Ce-, U-, and even Pu- and Np-based intermetallics, but despite substantial experimental and theoretical study, conclusive evidence for the mechanism of heavy-fermion superconductivity remains elusive. Among these examples, the isostructural family $CeMIn_5$ (M=Co, Rh, Ir) may exemplify most cleanly the complexity of the problem posed by heavy-fermion superconductivity that, when answered, will reveal much more than just the mechanism of superconductivity. Using $CeMIn_5$ as a case study, this talk reviews briefly what is known and what needs to be learned to make progress on the heavy-fermion superconductivity problem.

** Work at Los Alamos was performed under the auspices of the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, and supported by the Los Alamos Laboratory Directed Research and Development program.*

Presenter: Joe David Thompson, Los Alamos National Laboratory

10:10–10:40 AM

BREAK

BECKMAN, ROOM 1005

10:40–11:15 AM

SUPERCONDUCTIVITY AND ELECTRON CORRELATIONS IN RUTHENATES

BECKMAN AUDITORIUM

Dr. Mackenzie will review the physics of ruthenate superconductivity, a field which was kick-started by the experimental discovery of Yoshiteru Maeno and colleagues in 1994 and further fueled soon afterwards by the inspired suggestions by Rice, Sigrist, and (independently) Baskaran that Sr_2RuO_4 was a candidate for spin triplet pairing. He will discuss the evidence that has accumulated supporting that hypothesis, and try to give an objective assessment of the current state of knowledge regarding the gap symmetry. He will particularly emphasize the advances in crystal growth, led by Maeno, that have underpinned this field. If time permits there will also be some remarks on the quest to understand the mechanism of superconductivity and the fascinating correlated electron physics that can be explored in the broader ruthenate family.

Selection of references

The superconductivity of Sr2RuO4 and the physics of spin-triplet pairing

A.P. Mackenzie and Y. Maeno, Rev. Mod. Phys. 75, 657 (2003).

Odd-parity superconductivity in Sr2RuO4

K.D. Nelson et al., Science 306, 1151 (2004).

Superfluid 3He has a partner

T.M. Rice, Science 306, 1142 (2004).

Dynamical superconducting order parameter domains in Sr2RuO4

F. Kidwingra et al., Science 314, 1267 (2004).

High resolution polar Kerr effect measurements of Sr2RuO4: Evidence for broken time-reversal superconductivity in the superconducting state

J. Xia et al., Phys. Rev. Lett. 97, 167002 (2006).

Upper limit on spontaneous supercurrents in Sr2RuO4

J. Kirtley et al., arXiv:0704.3364

Presenter: Andrew Mackenzie, University of St. Andrews

Andrew Peter Mackenzie is currently a professor of condensed matter physics at the University of St. Andrews in Scotland. He earned a BSc (1st class Hons.) in Physics from the University of Edinburgh in 1986 and a PhD in Physics from the University of Cambridge in 1991.

He is the recipient of the Royal Society University Research Fellowship (1993), Mott Lecturer at the Condensed Matter and Materials Physics conference of the UK Institute of Physics (1999), Fellow of the Royal Society of Edinburgh (2004), and recipient of the Daiwa-Adrian Prize for collaborative UK-Japanese research achievement (co-team leader with Prof. Y. Maeno of Kyoto University, 2004).

11:15–11:50 AM

ORGANICS SUPERCONDUCTORS

BECKMAN AUDITORIUM

Presenter: Paul Chaikin, New York University

11:50 AM–1:10 PM

LUNCH AT BECKMAN

BECKMAN CENTER/EAST ATRIUM

(Additional seating available in Rooms 1005 and 1237.)

Chair: J. Tucker

1:10–1:45 PM

PREDICTING NEW BCS SUPERCONDUCTORS

BECKMAN AUDITORIUM

Assuming phonon induced pairing of electrons, what do current calculations yield in the way of explanations and predictions of superconducting properties and the prediction of new superconductors? I will discuss this question starting with the BCS model that yielded a simplified solution to the BCS gap equation and an expression for Tc that stimulated a hunt for materials with high frequency phonons and a large density of states at the Fermi level. I'll describe the evolution of this hunt and the current status of ab initio calculations based on Eliashberg theory including the recently developed Wannier method for exploring electron-phonon interactions and the "electron spring constant" view for increasing Tc.

Presenter: Marvin Cohen, University of California, Berkeley

Marvin L. Cohen was born in Montreal and moved to San Francisco when he was 12 years old. He was an undergraduate at the University of California at Berkeley and completed graduate studies at the University of Chicago in 1963 (Ph.D. 1964). After a one year postdoctoral position with the Theory Group at Bell Laboratories (1963–64), he joined the Berkeley Physics Faculty. He became University Professor in1995. He has also been a Senior Faculty Scientist at the Lawrence Berkeley National Laboratory since 1965.

Cohen's current and past research covers a broad spectrum of subjects in theoretical condensed matter physics. He is best known for his work with pseudopotentials with applications to electronic, optical, and structural properties of materials, superconductivity, semiconductor physics, and nanoscience.

Cohen is a recipient of the National Medal of Science, the APS Oliver E. Buckley Prize for Solid State Physics, the APS Julius Edgar Lilienfeld Prize, the Foresight Institute Richard P. Feynman Prize in Nanotechnology, and the Technology Pioneer Award from the World Economic Forum. He received the Department of Energy Award for Outstanding Accomplishment in Solids State Physics, the DOE Award for Sustained Outstanding Research, the Lawrence Berkeley Laboratory Certificate of Merit and Outstanding Performance Award, was Faculty Research Lecturer, University of California, Berkeley and Loeb Lecturer, Harvard University, was awarded Doctorat Honoris Causa, University of Montreal. Cohen has contributed more than 700 technical publications.

Cohen is a Fellow of the American Physical Society, a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and a Fellow of the American Association for the Advancement of Science.

In 2005, Cohen was President of the American Physical Society (APS), an organization representing more than 44,000 physicists in universities, industry and national laboratories. He has served as a member and then chair of the Executive Council of the Division of Condensed Matter Physics of the APS; as the U.S. representative on the IUPAP Semiconductor Commission; a member of the National Academy of Sciences Government-University Industry Research Roundtable; Member, U.S. Delegation to Bilateral Dialog for Research and Development in the US and Japan; Member, Science Policy Board of the Stanford Synchrotron Radiation Laboratory and the Science Policy Committee of SLAC. He was a Member of the Governing Board of the American Institute of Physics.

Cohen served on a variety of national and international boards and committees as an advisor and advocate for science education. He was Vice Chair of the NAS-GUIR Working Group on Science and Engineering Talent emphasizing the recruitment of women and minorities. He was a featured speaker for the Electron Birthday Project (televised to US high schools) and is currently active in lecturing to lay audiences, K-12 students, and industrial groups.

1:45 – 2:20 PM

TBA

Presenter: Zachary Fisk, University of California, Irvine

2:20–2:55 PM

THE UBIQUITOUS SQUID: FROM COSMOLOGY TO MEDICINE

BECKMAN AUDITORIUM

SQUIDs (Superconducting QUantum Interference Devices) were first realized about six years after the BCS theory. A brief history of their evolution is presented. The SQUID combines the phenomena of flux quantization and Josephson tunneling to make an ultrasensitive detector of magnetic flux. Low-transition temperature (T_c) SQUIDs configured as voltmeters can achieve a voltage noise as low as 10^{-15} $VHz^{-1/2}$; coupled to a superconducting flux transformer to form a magnetometer, they achieve a typical magnetic field noise of 10^{-15} $THz^{-1/2}$. SQUIDs find a wide range of applications, which are briefly reviewed. A recent development is the use of multiplexed SQUIDs to read out ultrasensitive bolometers—based on superconductors biased at their resistive transition—that are being used in far infrared astronomy, for example, to search for galaxy clusters. SQUID magnetometers, together with prepolarization of the nuclear spins, are used to obtain magnetic resonance images (MRI) in a magnetic field of 132 microtesla, corresponding to a proton Larmor frequency of 5.6 kHz—four orders of magnitude lower than in conventional MRI. The spatial resolution is typically 1 mm. At these very low fields, different tissue types can be distinguished with relaxation time (T_1)-weighted contrast imaging with much better sensitivity than at high fields. Possible clinical applications are discussed.

Presenter: John Clarke, University of California, Berkeley

John Clarke is a Professor of Physics at the University of California, Berkeley, and a Faculty Senior Scientist at Lawrence Berkeley National Laboratory. He received his BA in 1964 and his PhD in 1968, both from Cambridge University. He arrived at UC Berkeley as a postdoctoral scholar in 1968, and has been on the faculty since 1969. His research has been mostly on the fundamental science and applications of superconductivity, especially SQUIDs—Superconducting Quantum Interference Devices—fabricated from both low- and high-transition temperature superconductors. He has applied SQUIDs to a variety of topics, including superconductivity, geophysics, immunoassay, nuclear magnetic resonance, magnetic resonance imaging, astrophysics, and superconducting qubits. He is a Fellow of the Royal Society.

2:55–3:25 PM

BREAK

BECKMAN, ROOM 1005

3:25–4:00 PM

TWO-DIMENSIONAL SUPERCONDUCTIVITY*

BECKMAN AUDITORIUM

Superconductivity in two dimensions is special because the transition into the superconducting state is a topological phase transition, with the ordered (superconducting) phase exhibiting quasi-long range, rather than long-range, order. Disordered two-dimensional systems are of particular interest in that, with increasing disorder, the electrons become localized, the transition temperature is driven downward, leading to a regime in which quantum fluctuations are important. The new physics that emerges is the possibility of superconductor-insulator transitions, which are quantum phase transitions, tunable by adjusting parameters of the system, such as magnetic field, disorder, or carrier concentration. This talk will review the evidence for Kosterlitz-Thouless-Berezinskii or topological phase transitions in superconducting films and related structures, and will discuss the experimental situation and open issues related to insulator-superconductor transitions tuned by magnetic fields, disorder, and charge carrier density.

** Supported in part by the National Science Foundation under Grant NSF/DMR-0455121*

Presenter: A. M. Goldman, University of Minnesota

Professor Allen Goldman grew up in New York City, where he attended the Bronx High School of Science (1954). He was an undergraduate at Harvard (1958) and received a PhD in Physics (1965) under the direction of the late William Fairbank. After a brief time as a postdoctoral researcher at Stanford, he joined the faculty of the University of Minnesota in 1965 as an Assistant Professor. He was promoted to Associate Professor in 1968 and Professor in 1975. He became Institute of Technology Distinguished Professor in 1992 and Head of the School of Physics and Astronomy in 1996, positions that he currently holds.

Professor Goldman is an experimental condensed matter physicist, whose research has been on the properties of superconductors and related materials, mostly in the configuration of thin films, with emphasis on the effects of disorder and dimensional constraints. The work has included studies higher order Josephson effects, which resulted in the discovery of order parameter collective modes, as well as investigations of quantum size effects, electronic localization, topological phase transitions, and superconductor-insulator transitions. Other interests include the study of magnetic superconductors and heavy fermions, and the investigation of the properties of high-Tc superconductors and magnetic oxide materials. He was one of the pioneers in the growth of complex oxides using molecular beam epitaxy techniques.

Goldman was an Alfred P. Sloan Research Fellow (1966), and was elected to Fellowship in the American Association for the Advancement of Science (1982) and the American Physical Society (1984). He shared the Fritz London Memorial Prize (2002) with Russell Donnelly and Walter Hardy, and was elected to the National Academy of Sciences in 2007. Goldman is currently chair-elect of the Division of Condensed Matter Physics of the American Physical Society.

4:00–4:35 PM

FROM BCS THROUGH HTS TO RTS

BECKMAN AUDITORIUM

On this auspicious occasion of celebrating the 50th anniversary of the BCS theory, it appears to be most fitting for some of us to contemplate the possibility of room temperature superconductivity (RTS). Room temperature superconductivity, if achieved, can change the world both scientifically and technologically. Unfortunately, it has long been considered by some to belong to the domain of science fiction and to occur only “at an astronomical distance and under an astronomical pressure.” With the advent of liquid nitrogen superconductivity in 1987, its outlook has turned much brighter. Currently, there appears to be no reason, either theoretical or experimental, why room temperature superconductivity is impossible. The optimism is reflected in part in the 2006 Department of Energy report, Basic Research Needs for Superconductivity, which has chosen the search for RTS as one grand challenge and in the joint enthusiasm expressed by participants in the RTS Workshop held recently in Norway. The BCS theory has provided the basic framework for the occurrence and understanding of superconductivity since its inception, but it has failed to show where and how to find superconductivity at a higher temperature. To date, the enlightened empirical approach remains the most effective way to discover superconductors with high transition temperatures. In this talk, I shall present several possible approaches toward room temperature superconductivity that we are currently pursuing, after briefly summarizing what has happened in the long search.

Presenter: Paul C. W. Chu, University of Houston and The Hong Kong University of Science and Technology

Professor Paul C. W. Chu is the President of The Hong Kong University of Science and Technology (HKUST). He is also the executive director of the Texas Center for Superconductivity and the T. L. L. Temple Chair of Science at the University of Houston.

After assuming the presidency of HKUST in 2001, Professor Chu has set out to further raise the profile of the University internationally. In June 2005, Prof. Chu launched the HKUST Strategic Plan 2005–2020, which envisions the development of HKUST into one of the world’s academic leaders in five academic fields, namely nanoscience and nanotechnology; biological sciences and biotechnology; electronics, wireless, and information technology; sustainable development and energy, as well as management education and research. He has also initiated the establishment of an Institute for Advanced Study at HKUST, which is dedicated to the advancement of *knowledge to meet the great challenges of the 21st century.*

In January 1987, he and his colleagues achieved stable superconductivity at 93 K (-180°C) above the critical temperature of liquid nitrogen (-196°C), a major advancement in modern science. Later, they again obtained stable superconductivity at a new record high temperature of 164 K (-109°C) in another compound when it was compressed. Professor Chu remains actively engaged in the basic and applied research of high temperature superconductivity.

He is a member of the U.S. National Academy of Sciences, the American Academy of Arts and Sciences, the Chinese Academy of Sciences (Beijing), the Academia Sinica (Taipei), the Academy of Sciences for the Developing World, and a foreign member of the Russian Academy of Engineering. He was awarded honorary degrees from several universities worldwide. In 2007, he was appointed as a member of the U.S. President's Committee on the National Medal of Science, responsible for the selection of recipients for this top scientific honor in the United States.

Professor Chu has received numerous awards, including the National Medal of Science, the International Prize for New Materials, the Comstock Award, the Texas Instruments Founders' Prize, the John Fritz Medal, and the Freedoms Foundation National Award. He also serves on the editorial boards of various professional journals. He is a member of the board of directors of the Council on Superconductivity for American Competitiveness and a member of the Steering Committee on Innovation and Technology of Hong Kong.

6:00 – 10:00 PM

BANQUET

CHAMPAIGN COUNTRY CLUB

Host: Iesanmi Adesida, Dean, College of Engineering, University of Illinois at Urbana-Champaign

Transportation to the Champaign Country Club will be provided from the Illini Union, Hampton Inn, Hawthorn Suites, and Historic Lincoln Hotel. See shuttle bus schedule on Page 3 for times.

****This event is complimentary for those who have paid the conference registration fee or ordered tickets in advance. A limited number of additional tickets for guests, graduate students, and UIUC personnel will be available for purchase at the conference registration desk on Wednesday, October 10, only.**

Day 4: Areas Impacted by BCS

Chair: C. Pethick
Nordita

8:00 AM–4:00 PM

REGISTRATION/HELP DESK
BECKMAN AUDITORIUM FOYER

9:00–9:35 AM

NEUTRON STARS
BECKMAN AUDITORIUM

Presenter: Gordon Baym, University of Illinois at Urbana-Champaign

9:35–10:10 AM

NUCLEAR SUPERFLUIDS
BECKMAN AUDITORIUM

Presenter: Ben Mottelson

10:10–10:40 AM

BREAK
BECKMAN, ROOM 1005

10:40–11:15 AM

COLOR SUPERCONDUCTIVITY IN QUARK MATTER
BECKMAN AUDITORIUM

Matter at high density and low temperature is expected to be a color superconductor, which is a degenerate Fermi gas of quarks with a condensate of Cooper pairs near the Fermi surface. At the highest densities, where the QCD coupling is weak, rigorous calculations are possible, and the ground state is a particularly symmetric state, the color-flavor locked (CFL) phase. At lower densities the CFL phase suffers from stresses that seek to separate the Fermi surfaces of the different flavors, and alternative phases, some of which break translation and/or rotation invariance, may be favored. I will review the state of our understanding of these phenomena, and discuss the effort to develop signatures of the presence of color superconducting quark matter in neutron stars.

Presenter: Mark Alford, Washington University

11:15–11:50 AM

OBSERVING COSMIC SUPERFLUIDITY IN GLITCHES OF THE PULSARS
BECKMAN AUDITORIUM

The superfluid nature of neutron star matter determines the rotational dynamics and magnetic properties of neutron stars. In the neutron star crust, where the neutron superfluid coexists with a crystal lattice, pinning and creep of vortex lines determines the dynamics of the neutron star, manifesting the effects of superfluidity through glitches and post-glitch relaxation. Models based on vortex pinning and creep explain the detailed glitch and post-glitch observations, with some predictive power, as well as identifying a universal pattern of pulsar dynamical behavior. In the neutron star core, the presence of entrained neutron and proton superfluids and the resulting spontaneous magnetization of neutron vortices, as well as the interaction of proton flux lines with neutron vortex lines result in very short coupling times, as observed.

Presenter: Ali Alpar, Sabancı Üniversitesi, Orhanlı- Tuzla

Ali Alpar received his BS in Physics from Middle East Technical University, Ankara, in 1972 and his PhD from the University of Cambridge in 1977. Since his PhD thesis with Phil Anderson, he has worked on neutron star superfluid dynamics. For the neutron star crust, where a neutron superfluid coexists with an exotic crystal lattice, this work invokes vortex pinning and creep to explain pulsar glitches and post-glitch relaxation, dissipation, nonlinearity, precession, and universal glitch behavior. For the dynamics of the neutron star core superfluids, entrainment of proton and neutron superfluid currents plays a central role, leading to magnetization of neutron vortex lines and, thereby, to strong dynamical coupling of the superfluid core to electrons and normal matter.

Other endeavors in astrophysics include work on the fastest rotators; the millisecond pulsars, explained and confirmed as evolutionary products of spinup in low mass X-ray binaries, which contain 108- to 109-year-old neutron stars, and, more recently, the possibility that fallback disks left over from supernovae acting as gyrostats provide the key to different pathways of young neutron stars.

11:50 AM–1:10 PM

LUNCH AT BECKMAN
BECKMAN CENTER/EAST ATRIUM

(Additional seating available in Rooms 1005 and 1237.)

Chair: N. David Mermin, Cornell University

1:10–1:45 PM

SUPERFLUID 3HE: THE FIRST UNCONVENTIONAL BCS STATES

BECKMAN AUDITORIUM

The ordered phases of liquid 3He represent the first known unconventional BCS states, in which the Cooper pairs contain internal structure, most notably intrinsic spin and orbital angular momentum.

They are also the only observable BCS states in which the fermions order in the absence of an underlying lattice structure, although it is believed that similar order also occurs in neutron stars. Because of this, the 3He superfluids are free to exhibit the symmetry that truly minimizes their free energy, resulting in liquid crystal-like textures over macroscopic distances. The "spontaneously broken spin-orbit symmetry" of the Cooper pairs leads to a remarkably complex set of spin dynamical properties, which Leggett so quickly explained, and which allow one to probe the nature of these condensates with remarkable ease. The speaker will describe these ordered states and some of his favorite superfluid 3He behavior.

Presenter: Doug Osheroff, Stanford University

Douglas D. Osheroff was born and raised in Aberdeen, Washington, a logging town in the Pacific Northwest. He attended Caltech and graduated with a BS in Physics in 1967 and then attended Cornell University, graduating with a PhD in Physics in 1973. During his graduate work, Osheroff participated in the discovery of superfluidity in liquid 3He, for which he and his thesis advisors, David M. Lee and Robert C. Richardson, shared the 1996 Nobel Prize for Physics.

Osheroff left Cornell for AT&T Bell Laboratories, where he spent the next 15 years as a member of their technical staff and the last 6 as head of the Solid State and Low Temperature Research Department. In 1987, Osheroff joined the Physics Faculty at Stanford University, where he is now the J. G. Jackson and C. J. Wood Professor of Physics and the Gerhard Casper University Fellow for Undergraduate Education. Osheroff's main research interests are the study of matter near absolute zero, including the five ordered phases of 3He, and the behavior of glassy materials.

1:45–2:20 PM

APPLICATION OF BCS—LIKE IDEAS TO SUPERFLUID HELIUM -3

BECKMAN AUDITORIUM

The light isotope of helium (3-He) remains liquid at pressures from less than about 34 atm down to the lowest temperatures. In the temperature range between about 100 mK and 3 mK, the liquid is excellently described by Landau's theory of a Fermi liquid. However, below 3 mK it is found to display not one, but three, new phases (conventionally called A, B, and A_1), all of which are found to exhibit the phenomenon of superfluidity; thus, these new phases are collectively labeled "superfluid 3-He." The theory of these phases, while firmly based on the same fundamental idea of Cooper pairing, which is central to the BCS theory of superconductivity, needs to take into account several features which are absent in the latter: the elementary excitations in the normal phase are quasiparticles, rather than real particles; the pairing interaction may be itself modified by the process of pair formation; and most importantly, the internal state of the pairs is anisotropic, so that the rotational symmetry of the Hamiltonian is broken in both spin and orbital space and effects that are small or negligible in the normal phase may play a dominant role. I will present a review of the theory that emphasizes these features, as well as the fundamental connection to the work of BCS.

Presenter: Anthony Leggett, University of Illinois at Urbana-Champaign

Anthony J. Leggett was born in London, England, in March 1938. He attended Balliol College, Oxford, where he majored in Literae Humaniores (classical languages and literature, philosophy, and Greco-Roman history); and, thereafter, Merton College, Oxford, where he took a second undergraduate degree in Physics. He completed a D.Phil. (PhD) degree in theoretical physics under the supervision of D. ter Haar. After postdoctoral research in Urbana, Kyoto and elsewhere, he joined the faculty of the University of Sussex (UK) in 1967, being promoted to Reader in 1971, and to Professor in 1978. In 1983, he became John D. and Catherine T. Macarthur Professor at the University of Illinois at Urbana-Champaign, a position he currently holds. In 2006, he was also appointed to the Mike and Ophelia Lazaridis Distinguished Research Chair at the University of Waterloo. His main research interests lie in condensed matter physics, particularly high-temperature superconductivity, glasses, and ultracold atomic gases, and the foundations of quantum mechanics.

2:20–2:50 PM

BREAK

BECKMAN, ROOM 1005

Chair: T. Greytak, MIT

2:50–3:25 PM

BCS-BEC CROSSOVER IN COLD ATOMS

BECKMAN AUDITORIUM

Presenter: Deborah Jin, University of Colorado

Deborah Jin graduated from Princeton University in 1990. In 1995, she received a PhD from the University of Chicago, where she worked on experimental studies of exotic low temperature superconductors. From 1995 to 1997, she was a National

Research Council research associate with NIST, working at JILA in Boulder, Colorado. At JILA, Jin worked with Dr. Eric Cornell and Prof. Carl Wieman on some of the first studies of dilute gas Bose-Einstein condensates. In 1997, she accepted a permanent position with NIST and began work on creating and exploring a dilute Fermi gas of atoms. Her group at NIST created the first quantum degenerate Fermi gas in 1999 and reported the first observation of fermionic condensate in 2004.

Jin is also currently a NIST Fellow, a JILA Fellow, and a Professor Adjoint at the University of Colorado. She is a Fellow of the American Physical Society and the American Academy of Arts and Sciences, and a member of the National Academy of Sciences. Her awards include a Presidential Early Career Award for Scientists and Engineers in 2000, NIST's Samuel W. Stratton Award in 2001, the Maria-Goeppert Mayer Award and the National Academy of Sciences Award for Initiatives in Research, both in 2002, a MacArthur fellowship and the Arthur S. Flemming Award (Scientific Category), both in 2003, the Service to America Medal: Science and Environment in 2004, the I.I. Rabi Prize in 2005, and the Bonfils-Stanton Foundation Award in Science and Medicine in 2006.

3:25–4:00 PM

BCS QUANTUM HALL STATES

BECKMAN AUDITORIUM

When two 2D electron gas layers are brought sufficiently close together, and an appropriate magnetic field is applied, an exotic new state of matter appears. A subtle combination of intra- and inter-layer correlations characterizes this collective phase. These correlations may be described in several equivalent languages, but perhaps the most evocative is the language of BCS. Here the Cooper pairs are not pairs of electrons, but instead are excitons. These excitons are somewhat unusual, consisting of electrons in one layer bound to conduction band holes in the other.

In this talk, Dr. Eisenstein will describe a subset of the rich variety of physical phenomena exhibited by this peculiar quantum liquid, stressing the similarities to, and differences from, conventional BCS superconductors.

Presenter: James Eisenstein, California Polytechnic Institute

Jim Eisenstein received his AB degree from Oberlin College in 1974 and his PhD in physics from UC Berkeley in 1980, where he did experiments on superfluid 3-He. After a brief stint as an assistant professor of physics at Williams College, he moved to Bell Laboratories in 1983, becoming a Distinguished Member of Technical Staff in 1993. In 1996, Eisenstein moved to Caltech where he is now the Frank J. Roshek Professor of Physics and Applied Physics.

Eisenstein's research is now focused on the collective behavior of two-dimensional electron systems in semiconductor heterostructures at low temperatures and high magnetic fields. He is especially interested in double layer 2D systems since they exhibit a variety of unusual condensed phases, which are not found in ordinary single layer systems. In addition, his group is studying the various liquid crystalline phases of 2D electrons and the so-called "5/2" fractional quantum Hall state. The latter is rumored to have implications for quantum information science.

Eisenstein is a member and Fellow of the APS and was elected to the National Academy of Sciences in 2005. He received the APS Oliver E. Buckley Condensed Matter Physics Prize in 2007.

3:55–4:00 PM

CONFERENCE SUMMARY AND LOOKING AHEAD

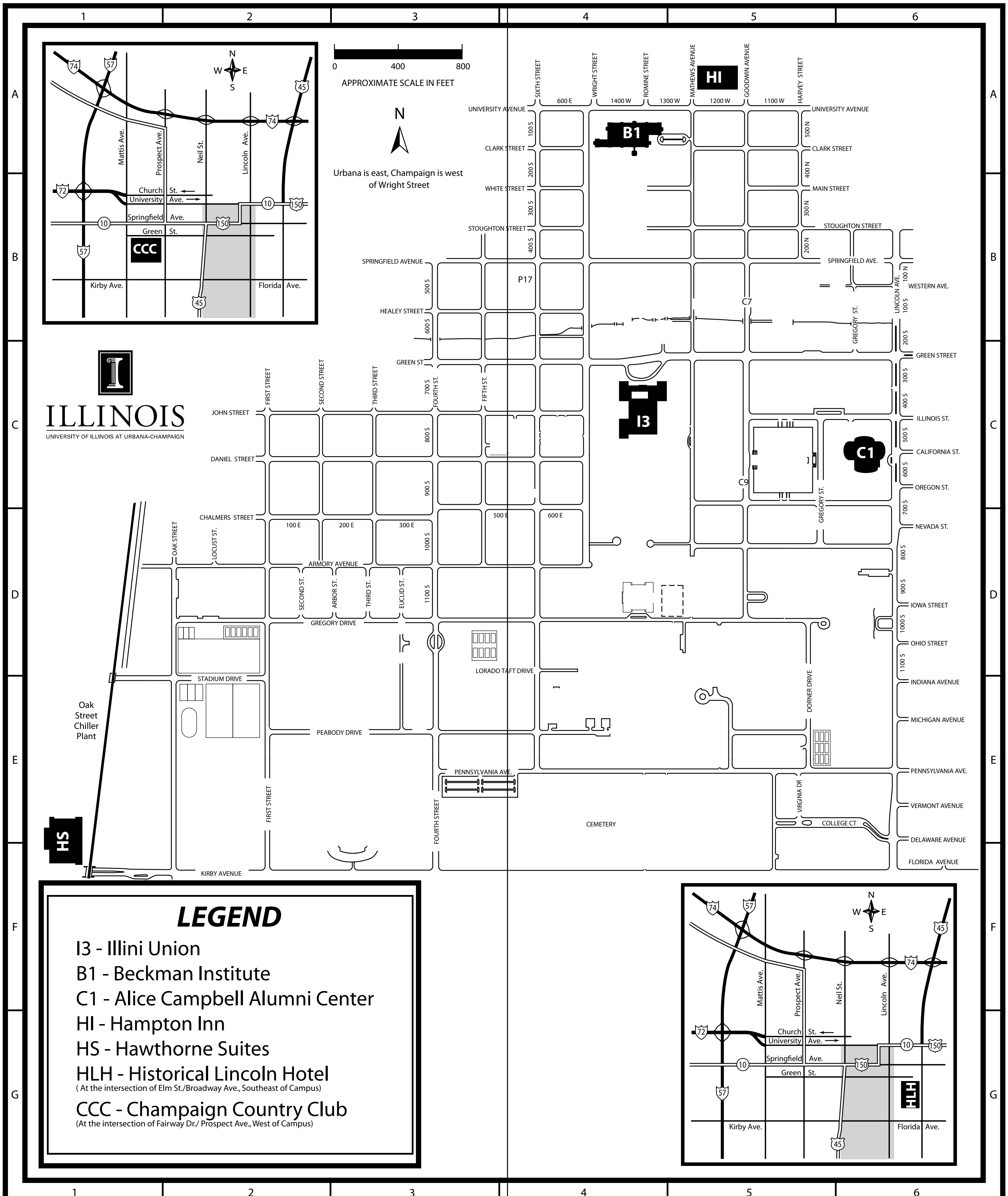
BECKMAN AUDITORIUM

Based on the various talks at the conference, an attempt will be made to put the past, present, and future of the BCS theory of superconductivity and all that surrounds it into a coherent whole.

Presenter: Malcolm Beasley, Stanford University

M. R. Beasley is the Theodore and Sydney Rosenberg Professor of Applied Physics at Stanford University. He received his BS Degree in Engineering Physics and his PhD in Physics at Cornell University. He then went to Harvard University where he served on the faculty of the Division of Engineering and Applied Physics. Following this, he came to Stanford University. At Stanford, he has served as the Chair of the Applied Physics Department, Director of the Center for Materials Research, Founding Director of the Geballe Laboratory for Advanced Materials, and Dean of the School of Humanities and Sciences.

Professor Beasley's research interests are in materials physics, with an emphasis on superconductivity. He also has worked in nonlinear dynamical systems. He has been elected a member of Tau Beta Pi, Fellow of the American Physical Society, Fellow of the American Academy of Arts and Sciences, and is a member of the National Academy of Sciences.


APPROXIMATE SCALE IN FEET
0
400
800
N
Urbana is east, Champaign is west of Wright Street
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
UNIVERSITY AVENUE
CLARK STREET
WHITE STREET
STOUGHTON STREET
SPRINGFIELD AVENUE
HEALEY STREET
GREEN ST
JOHN STREET
DANIEL STREET
CHALMERS STREET
ARMORY AVENUE
GREGORY DRIVE
STADIUM DRIVE
PEABODY DRIVE
LORADO TAFT DRIVE
PENNSYLVANIA AVE.
KIRBY AVENUE
CEMETERY
SIXTH STREET
WRIGHT STREET
ROMINE STREET
MATHEWS AVENUE
GOODWIN AVENUE
HARVEY STREET
FIRST STREET
SECOND STREET
THIRD STREET
FOURTH ST.
FIFTH ST.
OAK STREET
LOCUST ST.
SECOND ST.
ARBOR ST.
THIRD ST.
EUCLID ST.
FOURTH STREET
DORNER DRIVE
VIRGINIA DR
COLLEGE CT
GREGORY ST.
LINCOLN AVE.
MAIN STREET
SPRINGFIELD AVE.
WESTERN AVE.
GREEN STREET
ILLINOIS ST.
CALIFORNIA ST.
OREGON ST.
NEVADA ST.
IOWA STREET
OHIO STREET
INDIANA AVENUE
MICHIGAN AVENUE
PENNSYLVANIA AVE.
VERMONT AVENUE
DELAWARE AVENUE
FLORIDA AVENUE
Oak Street Chiller Plant
B1
HI
I3
C1
HS
P17
C7
C9
Mattis Ave.
Prospect Ave.
Neil St.
Lincoln Ave.
Church St.
University Ave.
Springfield Ave.
Green St.
Kirby Ave.
Florida Ave.
CCC
HLH
LEGEND
I3 - Illini Union
B1 - Beckman Institute
C1 - Alice Campbell Alumni Center
HI - Hampton Inn
HS - Hawthorne Suites
HLH - Historical Lincoln Hotel
(At the intersection of Elm St./Broadway Ave., Southeast of Campus)
CCC - Champaign Country Club
(At the intersection of Fairway Dr./ Prospect Ave., West of Campus)

WE ACKNOWLEDGE THE GENEROUS FINANCIAL CONTRIBUTIONS IN SUPPORT OF BCS@50

from the University of Illinois at Urbana-Champaign:

Department of Physics

College of Engineering

The Office of the Provost

The Office of the Chancellor

and from our Corporate Sponsors:

Lake Shore Cryotronics, Inc.

Oxford Instruments

Quantum Design

50th ANNIVERSARY BCS@50

The Bardeen-Cooper-Schrieffer Theory Of Superconductivity