2008

Annual Report
Center for Nanophysics and Advanced Materials
University of Maryland
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The Center for Nanophysics and Advanced Materials (CNAM) was established on July 1, 2007. It unifies the former Center for Superconductivity Research and Condensed Matter Physics groups into a single cohesive research entity covering all of condensed matter physics, nanoscience, and related technologies. CNAM brings essential resources to an important and vibrant field of physics research, and is a catalyst for enhancing the Physics department at the University of Maryland.

There is strong scientific output from CNAM in a number of important areas of cutting-edge research. For example, CNAM researchers are active in uncovering the unique electronic properties of graphene, which is a remarkable new material consisting of a single sheet of carbon atoms. This material shows many electrical properties dominated by the laws of quantum mechanics, even at room temperature. Our basic scientific research on this new material will lay the foundation for exciting new applications and technologies. CNAM is also active in developing new materials and concepts in the burgeoning area of quantum computing. Research is focused on superconducting quantum bits that show promise as a scalable technology for quantum-mechanics-based information processing. In addition, CNAM member Sankar Das Sarma has proposed a novel quantum computing scheme based on exotic states of two-dimensional electron gas materials. This proposal has garnered great attention in the popular press and has led to numerous experiments around the world searching for the states needed to achieve his proposed form of ‘topological quantum computing.’ Further scientific accomplishments enabled by Center funding are detailed in this report.

The goals for CNAM are 1) to create and maintain a strong and collaborative research effort in cutting-edge aspects of Condensed Matter Physics and Nanophysics at the University of Maryland, and 2) to enable the hiring of new outstanding faculty, in both theory and experiment, to further enhance the research productivity and visibility of the Center, and thus to strengthen the Maryland Physics department. Our research output speaks for itself in the pages of this report. We have hired two new faculty members in the past year, Johnpierre Paglione and Ian Appelbaum. These young researchers bring new expertise in correlated electron materials and electron-spin-based condensed matter physics to our Center. CNAM has also played an essential role in the establishment of the new Joint Quantum Institute (JQI) between Maryland and NIST. CNAM provides the main University monetary contribution to this important new research activity and has provided considerable administrative and technical assistance to JQI in its startup phase. CNAM and JQI have overlapping interests in condensed matter physics and quantum information science, and a number of faculty are members of both organizations.
Since it was established, the Center has supported research activities through a number of other efforts, including the CNAM Graduate Assistantship program, and the CNAM Post-Doctoral Fellowship program. These programs are designed to attract the top graduate and post-doctoral talent in the world, and bring them into the Center to carry out high quality collaborative research. CNAM also has a research seed-funding program that is designed to catalyze new research efforts that will lead to additional outside funding. CNAM also offers matching support for new proposals by its members to outside funding agencies to strengthen the proposal and enhance the likelihood of success. Further information about the Center can be found on our web site (http://cnam.umd.edu), including news, upcoming events, a list of CNAM-supported central research facilities, and summaries of our research.

The Center provides essential administrative support to its members. Unlike many other fields of physics, Condensed Matter Physics funding emanates from a diverse variety of federal and private sources. The administrative burden of applying for, and administering, these many grants is quite substantial. In addition because CNAM faculty members are so active in research and service there are many other administrative demands that must be addressed, such as organization of workshops and conferences on campus, travel to many conferences and universities to deliver invited talks, processing visas for new students and post-docs, etc. The CNAM staff acts tirelessly in support of our varied research efforts.

The first year of CNAM has been an exciting period of growth and adjustment for all of us. As you can see from this report we have had a productive year, with 51 invited talks, 78 publications, 13 Physics Ph.D. graduates, and over $2.6 million in external research support, all from a group of 17 faculty members. We are looking forward to completing the startup phase of CNAM soon and embarking on a future of even greater scientific accomplishment.

Steven M. Anlage
Interim Director
Invited Talks

Anderson, J. R.


Anlage, S. M


“Scanning Laser Microscopy of Superconducting Microwave Devices,” seminar at the Jefferson Laboratory Superconducting RF Institute, Newport News, VA, 11 July, 2007

DasSarma, S.

Invited Talk, Graphene Workshop, KITP, UCSB (Winter 2007)

Invited Talk, Strongly Correlated AMO Workshop, KITP, UCSB (Spring 2007)

Plenary Lecture, Inaugural Symposium for JQI, Maryland (Spring 2007)

Invited Talk, Brazilian Workshop on Semiconductor Physics, Sao Paulo, Brazil (Spring 2007)

Invited Talk, Silicon Nanoelectronics Workshop, Lorenz Institute, Leiden, Ireland (Spring 2007)

Invited Lecture Series, KITPC, Conference and Workshop on Quantum Phases of Matter, Beijing, China (Summer 2007)

Invited Talk, EPQHS Conference, State College, PA (Summer 2007)

Invited Plenary Talk, 17th International EP2DS Conference, Genoa, Italy (Summer 2007)
Invited Talk, International Conference on Topological Matter, Perugia, Italy (Summer 2007)

Invited Talk, Quantum Computation Review, Minneapolis, MN (Summer 2007)

Invited Talks (two), Nordita Workshop on Quantum Phases, Stockholm, Sweden (Summer 2007)

Invited Talk, International Conference on Topological Quantum Computation, Dublin, Ireland (Fall 2007)

Invited Talk, NRI Annual Review, Santa Clara, CA (Fall 2007)

Invited Talk, Chiral Superconductor Program, KITP, UCSB (Fall 2007)

Drew, H. D.

“Electromagnons in multiferroics,” seminar at Physics Department, Johns Hopkins University, April, 2007.

“IR Hall Effect in cuprates,” invited talk given at the A.I. Larkin Memorial Conference, Landau Institute for Theoretical Physics, Chernogolovka, Russia, June, 2007.

Einstein, T.


“Impurity Decoration for Crystal Shape Control: C60 on Ag(111),” CMSN Workshop, Iowa State U, Ames, IA, Oct. 2007.
Fuhrer, M.


Galitski, V.

“Non-equilibrium dynamics of a mesoscopic atomic system,” NIST, Gaithersburg, MD February, 2007.


“Superconducting fluctuations near a quantum critical point,” Landau Institute for theoretical physics, Chernogolovka, Russia, June, 2007.


Greene, R.


Ouyang, M.

Institute of Chemistry, Chinese Academy of Science, July

Wellstood, F.


Williams, E.


“Flexible Electronics, NanoCenter Industrial Workshop (Samsung),” August, 2007.

“Graphene is all surface (why it’s good to be clean),” CMSN Workshop, Ames Laboratory, Iowa State University, September, 2007.


**Yakovenko, Y.**


“Time-reversal-symmetry breaking and the Kerr effect in Sr$_2$RuO$_4$,” Miniprogram on Sr$_2$RuO$_4$ and Chiral p-wave Superconductivity, Kavli Institute for Theoretical Physics, University of California at Santa Barbara, December, 2007.

“Evidence for the horizontal lines of nodes from the tunneling spectrum of Sr$_2$RuO$_4$,” Miniprogram Sr$_2$RuO$_4$ and Chiral p-wave Superconductivity, Kavli Institute for Theoretical Physics, University of California at Santa Barbara, December, 2007.
Publications

Acta Physica Polonica A


Advanced Materials


Annals of Physics


Applied Physics Letters


IEEE Transactions on Applied Superconductivity


Journal of Applied Physics


Journal of Materials Research

Journal of Statistical Mechanics


Nano Letters


Nature Materials


New Journal of Physics


Physica C


Physical Review A


Physical Review B


Physical Review E


Physical Review Letters

Electromagnons in Multiferroic $\text{YMn}_2\text{O}_5$ and $\text{TbMn}_2\text{O}$, A. B. Sushkov, R. Valdes Aguilar, S. Park, S-W. Cheong, and H. D. Drew, Phys. Rev. Lett. 98, 027202 (2007).


Proceedings of the National Academy of Sciences


Review of Scientific Instruments


Surface Science


<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Institution</th>
<th>Topic</th>
</tr>
</thead>
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<tr>
<td>January 22, 2007</td>
<td>Dr. Johnpierre Paglione – University of California, San Diego</td>
<td>CeCoIn₅: a “quasi-breakdown” of the Quasi-particle Paradigm at a Quantum Critical Point</td>
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<tr>
<td>January 25, 2007</td>
<td>Dr. Xuan Gao – Harvard University</td>
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<td>The Sensitivity Limits of Nanowire Bio-Sensors</td>
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<tr>
<td>January 29, 2007</td>
<td>Dr. Huiqiu Yuan – University of Illinois, Urbana-Champaign</td>
<td>Novel Superconducting Pairing States in Heavy Fermion Systems and Non-centrosymmetric Materials</td>
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<tr>
<td>February 1, 2007</td>
<td>Dr. Feng Wang – University of California at Berkeley</td>
<td>Optical Spectroscopy of Semiconducting and Metallic Nanostructures</td>
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<tr>
<td>February 5, 2007</td>
<td>Dr. Seongshik Oh – NIST Boulder</td>
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<td>Precision Material Engineering at Nanoscale: Elimination of Decoherence Sources in Superconducting Quantum Bits</td>
</tr>
<tr>
<td>February 8, 2007</td>
<td>Dr. Emil Yuzbashyan – Rutgers University</td>
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<td>Dynamical Vanishing and Persistent Oscillations of the Order Parameter in Fermionic Condensates</td>
</tr>
<tr>
<td>February 12, 2007</td>
<td>Dr. Nuh Gedik – California Institute of Technology</td>
<td>Ultra Structural Dynamics Observed with Atomic Scale Resolution</td>
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<tr>
<td>February 22, 2007</td>
<td>Dr. Cyrus Hirjibehedin – IBM Almaden Research Center</td>
<td>Magnetic Nanostructures Probed on the Atomic Scale</td>
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<tr>
<td>February 26, 2007</td>
<td>Dr. Robert Kaindl – UC Berkeley &amp; Lawrence Berkeley National Laboratory</td>
<td>Ultrafast THz Spectroscopy: From Excitons to Cooper Pairs</td>
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<tr>
<td>March 1, 2007</td>
<td>Dr. Etienne De Poortere – Columbia University</td>
<td>Novel Nanofabrication Techniques for Molecular Electronics</td>
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<tr>
<td>Date</td>
<td>Speaker</td>
<td>Institution</td>
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<tr>
<td>March 15, 2007</td>
<td>Dr. Barbaros Ozyilmaz</td>
<td>Columbia University</td>
<td>Coherent Charge and Spin Transport Phenomena in Graphene</td>
</tr>
<tr>
<td>April 12, 2007</td>
<td>Dr. Andrei Sushkov</td>
<td>University of Maryland</td>
<td>Electromagnons in Multiferroics</td>
</tr>
<tr>
<td>April 19, 2007</td>
<td>Dr. Jeff Lynn</td>
<td>NIST Center for Neutron Research</td>
<td>Magnetic Order and Spin Fluctuations in the Cuprate Superconductors</td>
</tr>
<tr>
<td>April 26, 2007</td>
<td>Dr. Tudor Stanescu</td>
<td>University of Maryland</td>
<td>Pseudogaps and Fermi arcs: A cluster Dynamical Mean Field Theory Description of Mottness</td>
</tr>
<tr>
<td>May 3, 2007</td>
<td>Dr. Kevin Osborn</td>
<td>Laboratory for Physical Sciences</td>
<td>Two-Level Systems in Superconducting Circuit Resonators</td>
</tr>
<tr>
<td>May 10, 2007</td>
<td>Dr. Eva Andrei</td>
<td>Rutgers University</td>
<td>Graphite, Graphene and Relativistic Electrons</td>
</tr>
<tr>
<td>September 13, 2007</td>
<td>Dr. David Reilly</td>
<td>Harvard University</td>
<td>The Nuclear Environment of a GaAs Spin Qubit</td>
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<tr>
<td>October 25, 2007</td>
<td>Professor Oskar Vafek</td>
<td>National High Magnetic Lab &amp; FSU</td>
<td>Two Dimensional Massless Dirac Fermions in Condensed Matter</td>
</tr>
<tr>
<td>November 1, 2007</td>
<td>Dr. Ross McDonald</td>
<td>LANL, Pulsed Field Facility</td>
<td>Towards and Understanding of the Cuprates – Some Recent Quantum Oscillation Experiments at the National Magnetic Field Laboratory</td>
</tr>
<tr>
<td>November 8, 2007</td>
<td>Dr. Masa Ishigami</td>
<td>University of Maryland</td>
<td>Understanding Nanoscale Physics from Atomic-Scale</td>
</tr>
<tr>
<td>November 15, 2007</td>
<td>Dr. Joseph A. Stroscio</td>
<td>NIST</td>
<td>Speed Bumps in Graphene</td>
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<tr>
<td>November 29, 2007</td>
<td>Dr. Caroline Kilbourne</td>
<td>NASA</td>
<td>Cold Probes of the Hot Universe</td>
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CNAM Budget for FY08

The pie chart below shows the relative scale of expenditures made by CNAM in FY08. The single greatest expense is salary costs for 6 CNAM faculty members. Substantial resources are currently devoted to startup of new faculty members in CNAM, both in terms of direct support and facilities improvements related to their laboratories and office space. Resources are also devoted to supporting graduate students and post-doctoral researchers as part of matching agreements, bridge-funding, and legacy commitments from the former CSR. Explicit matching and seed support for CNAM members is also a major component of our annual expenditures.

The staff and operations expenditures are complicated by our agreement to support the newly-established Joint Quantum Institute (JQI). CNAM and JQI utilize a shared administrative and technical staff, share their administrative operations expenses, and split the research operations costs for liquid Helium. This is accomplished through a direct transfer of funds to JQI, followed by partial support for the above-mentioned activities (denoted with a “*” in the pie chart).
Personnel

FACULTY

James R. Anderson
Steven Anlage
Satindar Bhagat
Andrey Chubukov
Sankar DasSarma
H. Dennis Drew
Theodore Einstein
Michael Fuhrer
Richard Greene
Theodore Kirkpatrick
Christopher Lobb
Min Ouyang
Johnpierre Paglione
Fred Wellstood
Ellen Williams
Victor Yakovenko

RESEARCH SCIENTISTS

William Cullen
Dan Hines
R. D. Vispute

VISTORS

Paola Barbara
Malgorzata Gorska
Anna Herr
William Johnson
Andrew Millis

RESEARCH ASSOCIATES

Laura Adams
Benedetta Camarota
Mariona Colbau
Sankar Dhar
Sudeep Dutta
Elba Gomar-Nadal
Masahiro Ishigami
Daisuke Kan
Rupert Lewis
John Matthews
Makoto Murakami
Elba Gomar-Nadal
Dmitri Petrovykh
Costel Rotundu
Don Schmadel
Andrei Sushkov
Weiqiang Yu
Antonio Zambano
Peng Zhao

FACULTY AFFILIATES

John Cumings
Michael Fisher
John Fourkas
Christopher Jarzynski
Bruce Kane
Dan Lathrop
San Bok Lee
Gottlieb Oehrlein
Kevin Osborn
Raymond Phaneuf
Lourdes Salamanca Riba
Lawrence Sita
Ichiro Takeuchi
Edo Waks
John D. Weeks
GRADUATE STUDENTS

Rolando Aguilar
Paul Bach
Anand Banerjee
Jianhao Chen
Sung Jae Cho
Enrique Cobas
Brad Conrad
Benjamin Cooper
Gokhan Esen
Shigehiro Fujino
Tarek Ghanem
Jason Hattrick-Simpe
Emmanuel Hourdakis*
Joshua Higgins
Dwight Hunter
Patrick Hughes*
Chaun Jang
Hyeokshin Kwon
Jonghee Lee*
Kwan Lee
Dan Lenski
Pengcheng Li*
Su Li*
Sung Hwan Lim
Christian Long
Meem Mahmud
William McConville
Dragos Mircea*
Kaushik Mitra
Tracy Moore
Hiroyuki Oguchi
Hanhee Paik*
Tauno Palomaki
Anthony Przybysz
Shenqiang Ren
Michael Ricci*
Vinod Sangwan
Adrian Southard
Yun Tang
Chenggang Tao*
David Tobias*
Patrick Truiitt*

*Graduated with a Ph.D. in 2007
UNDERGRADUATE STUDENTS

Mohamed Abutaleb
Lawrence Bazille
Elliott Bradshaw
Kristen Burson
Alexandra Curtin
Massimiliano Ferrucci
Joseph Fox-Rabinovitz
Samit Gupta
Charles Hawkins
Walter Hutchinson
Neetal Jagadeesh
Kyu Jang
Samitha Kulathunga
Paul Lambert
Geun Lee
Andrew Marsh
David McGrady
Brian Tran
Bjorn Van Bael

STAFF

Brian Barnaby
Doug Bensen
Denise Fagins
Margaret Lukomska
Musharraf Nazir
Belta Pollard
Grace Sewlall
Brian Straughn
Cleopatra White