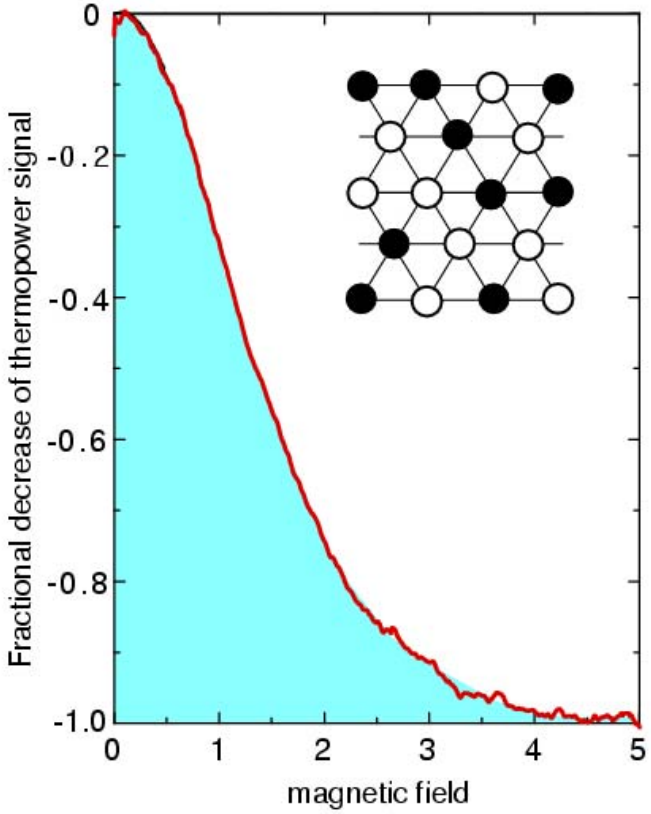
Strongly interacting electrons in Na_xCoO_2
- a quantum game of *Go* on a triangular lattice

N. P. Ong and R. J. Cava, Princeton University, DMR-0213706

Oxide materials exhibit many useful properties for potential applications. The cobalt oxide Na_xCoO_2 exhibits a large thermoelectric effect. It may find future applications in thermoelectric coolers, which are compact and vibration-free. The origin of its large thermopower has been traced to electron spins which carry a large fraction of the heat in an applied current. Surprisingly, a magnetic field can suppress this spin-heat current by 100 percent (figure). In addition, Na_xCoO_2 superconducts when water is added. These exotic behaviors reflect the quantum rules of how electrons hop in the material's triangular lattice, much like marbles in the popular board game *Go*.

Wang et al. Nature **423**, 425 (2003).



A magnetic field kills the heat-carrying capability of the electron spins as shown by the red curve. Inset depicts the *Go*-like hops of electrons moving in the Na_xCoO_2 crystal lattice.

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Education:

Ben Essenburg and Jonathan Levine (undergraduates), Yayu Wang, Nyrissa Rogaldo, Maw Lin Foo and Virginia Miller (graduate students) contributed to this work.

Outreach:

Above: Prof. N.P. Ong works with middle school teachers to develop education products to be placed on the web site of the Princeton Center for Complex Materials (PCCM). Many teacher training sessions have been developed directly as result of the Science Curriculum Support Program (SCSP).
Left:PCCM director Ravindra Bhatt works with N.P. Ong and teachers on SCSP curriculum. These STC middle school kits are adopted in thousands of districts across the US.

For latest news on PCCM outreach including this event go to URL:
http://www.princeton.edu/~pccm/outreach/outreach-news.htm

Princeton Center for Complex Materials (PCCM)
International Outreach

International Collaborations
- Oxford
- Cambridge
- Max Planck Institute,Stuttgart
- Karlsruhe-Nanotech Center
- Toronto
- Alberta
- Bangalore
- Louvain
- Erlangen
- Africa
- and many others!

Supported by Director for Research Initiatives; University cost-share helps with travel, workshops and seed funding for new research projects.

PCCM links with NSF-funded African Research Initiative, hosting 16 Materials Researchers from Africa for extended visits to Princeton.

PCCM helped spearhead a university-wide Partnership between Oxford & Princeton Universities

OX-PU Partnership promotes fully integrative exchange for students in the sciences & engineering; provides seed money for joint research projects.

OX-PU Highlight: Oxford student Judith Waller, working with *Guided Self-Assembly* IRG.

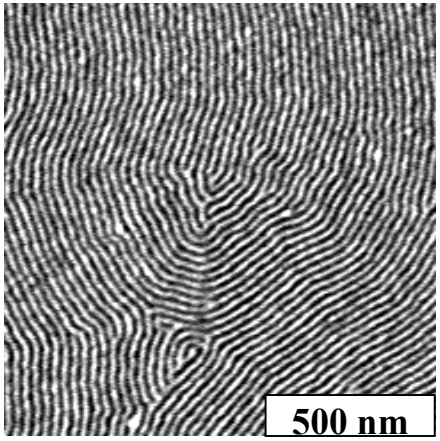
PCCM

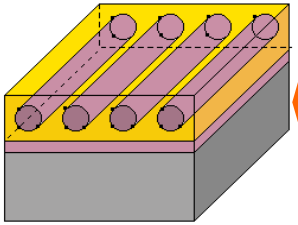
Oxford-Princeton Partnership in Materials Science

Judith Waller spent AY '02-'03 at Princeton conducting the research for her "Part II" thesis (Oxford Materials M.Eng.) working with Dan Angelescu (Princeton Physics Ph.D.). Advisors: Profs. Rick Register and Paul Chaikin

Goal: Develop means for aligning block copolymer microdomains in thin films over large areas
- aligned films can serve as templates (masks) for the fabrication of ordered nanostructure arrays

Problem: Disclination defects, shown in AFM image of a 50-nm thick film of a PS-PEP diblock copolymer, must be eliminated to achieve long-range orientational order





Schematic of cylinder-forming block copolymer films, supported on Si wafer substrate

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