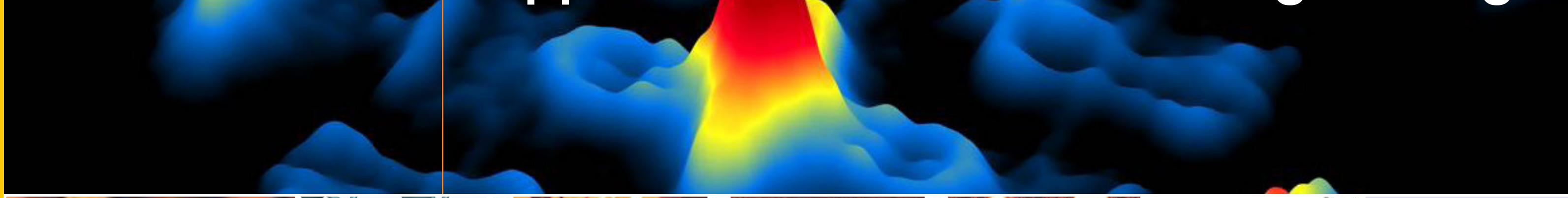
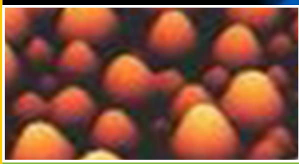
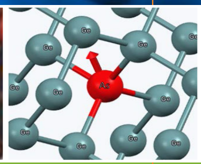
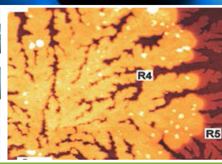
PCCM

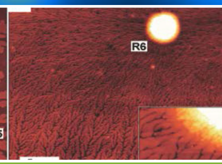
Tailoring the quantum and structural properties of complex materials for new applications in science and engineering

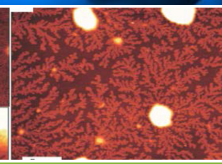


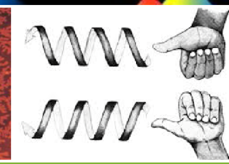


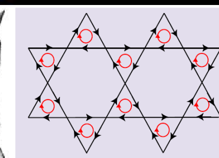












Princeton University

PCCM

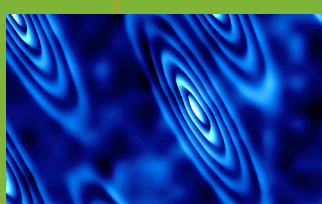
The three interdisciplinary research groups (IRGs) in the Princeton Center for Complex Materials (PCCM) investigate a diverse array of unconventional materials, ranging from topological semimetals and superconductors to block copolymers.

IRG-1 studies topological quantum states in novel insulators, semiconductors, metals, superconductors and magnetic materials. Researchers are studying topological phases in Bi-based semiconductors to further develop a new class of topological crystalline insulators and metals with strong spin-split electronic states to explore helical bulk electronic systems.

IRG-2 seeks to combine novel experiments with theory to understand the fundamental principles underlying the dramatic property deviations of amorphous polymers when confined to the nanoscale, and to uniquely exploit size and interfaces for advanced materials design. The interplay between novel processing methods and confining geometries as well as novel characterization tools combined with rigorous simulation and theory carried out in an integrated approach is the hallmark of IRG-2.

IRG-3 is focused on developing ultra-coherent quantum materials, in particular group IV materials such as Si, Ge, SiC, and diamond. Members of the team recently demonstrated that isotopically enriched silicon samples can support electron spin coherence times at least as long as 10 seconds, orders of magnitude longer than other solid state systems

HIGHLIGHTS . . .



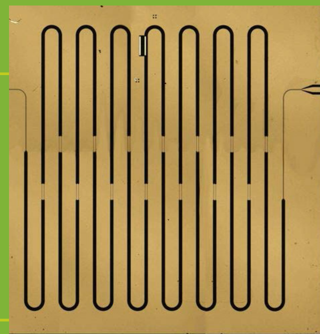
For the first time, an experiment has directly imaged electron orbits in a high-magnetic field, illuminating an unusual collective behavior in electrons and suggesting new ways of manipulating the charged particles.

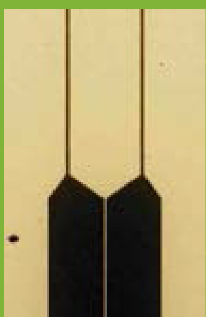
Electron spin coherence in germanium was measured for the first time. The new data show the spins can have coherence times of over 1 ms, and the evidence points to even longer coherence at lower temperatures. These results suggest that germanium is a good material for electron spin qubits.

DIRECTOR: Ali Yazdani
http://pccm.princeton.edu/

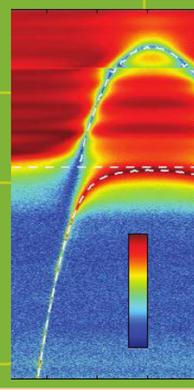
RESEARCH FUNDAMENTALS . . .

Photonic crystals provide for manipulation of optical dispersion and density of states. This unique control makes them a beautiful, if unexplored, playground for strong coupling quantum electrodynamics, where a single, highly nonlinear emitter hybridizes with the band structure of the crystal.





This work opens exciting prospects for engineering long-range spin models in the circuit QED architecture, as well as new opportunities for dissipative quantum state engineering.



This cavity structure is a promising platform for controlling and measuring high coherence quantum spin systems.

"Inspring the next generation of scientists and pushing the frontiers of materials science research is not only exciting - but essential to addressing the critical needs of society."

Ali Yazdani, PCCM Director
Class of 1909 Professor of Physics,
Princeton University

PCCM'S OUTREACH AND PARTNERSHIPS...

- **Princeton University Materials Academy PUMA:** Summer school for minority high- and middle-school students.
- **Stars of Materials Science and Holiday Lecture:** Science lectures for families by Princeton University professors.
- **Teachers as Scholars:** Interdisciplinary science professional development program for teachers (all grades).
- **REU** - Research Experience for Undergraduates: a 9-week summer program for undergraduates.
- **Condensed Matter Summer School:** Advanced topics curriculum for graduate students.
- **Partnership for Research and Education in Materials (PREM):** Partnership with California State University Northridge.
- **Materials Science Days:** hands-on workshops at the Princeton Public Library for children and families. Other outreach events include Community Day, Communiversity and Super Science Saturday.
- **Imaging and Analysis Center (IAC):** Advanced electron microscopes and analytical equipment are used regularly by local industries and universities.

For more information about workshops, internships, partnerships, and educational opportunities, visit:
http://pccm.princeton.edu/