Magnetism and Dynamics in Atomic Clusters

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When a magnetic particle is shrunk almost to the atomic scale, most of its atoms reside on its surface and it has only a hint of crystalline structure left. These changes, along with an elevated sensitivity to temperature and thermal influences, make atomic clusters a rich venue in which to examine the origins of magnetism in solids.

Systematic studies of particles ranging roughly from 2 to 1000 atoms explore the evolution of magnetic behaviors as particles gradually shift from surface-like to solid-like and develop crystalline structure, spatial order, and symmetry. In addition to being a sensitive test of theoretical predictions, this experimental work continues to uncover magnetism in unexpected places, most recently in clusters of pure chromium.

The polished iron pole faces of the magnet used to study magnetism in atomic clusters. A narrow beam of tiny magnetic particles enters the gap between the two carefully shaped pole faces and flies the length of the ¼-meter magnet. Magnetic forces bend the beam's path, affording a measurement of cluster magnetism.

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Education:
Four graduate students (Forrest Payne, Wei Jiang, Songbai Ye, and Jin Liu) are currently contributing to this work. In addition, one recent Ph.D. (Andy Dally) and two recent BAs (Catherine Pettit and Allison Laine) were awarded to students who were involved in this research. Payne, Jiang, Pettit, and Laine have been working on the magnetic studies, while Ye, Liu, and Dally have been examining the ultrafast dynamics of atomic clusters using picosecond laser systems.

Societal Impact:
Understanding the magnetism and dynamics of small particles is crucial to the future of magnetic recording and information processing. As they tend toward ever smaller devices, microelectronic and data storage technologies have begun to encounter the limits to scaling and are now struggling to advance further. Situated at the low end of the nanoscale arena, this cluster research offers insights that should help to guide future generations of storage and processing devices.