Magnetic Control

Windl group determines heat can be regulated by magnetic fields

Phonons — the elemental particles that transmit both heat and sound — have magnetic properties, according to a landmark study conducted by a research group from The Ohio State University and supported by the Ohio Supercomputer Center.

In the journal *Nature Materials,* the researchers describe how they employed a magnetic field to reduce the amount of heat flowing through a semiconductor by 12 percent. Simulations performed later at OSC identified the reason—a magnetic field induces a diamagnetic response in vibrating atoms known as phonons, which changes how they transport heat.

Heat and sound are both expressions of the same form of energy, quantum mechanically speaking. So any force that controls one should control the other.

"This adds a new dimension to our understanding of acoustic waves," said Joseph Heremans, Ph.D., Ohio Eminent Scholar in nanotechnology and a professor of mechanical engineering at Ohio State. "We've shown that we can steer heat magnetically. With a strong enough magnetic field, we should be able to steer sound waves, too."

The nature of the effect of the magnetic field initially was not understood and subsequently was investigated through computer simulations performed on OSC's Oakley Cluster by Oscar Restrepo, Ph.D., a research associate, Nikolas Antolin, a doctoral student and Wolfgang Windl, Ph.D., a professor, all of Ohio State's Department of Materials Science and Engineering. After painstakingly examining all possible magnetic responses that a non-magnetic material can have to an external field, they found the effect is due to a diamagnetic response, which exists in all materials.

The implication: In materials such as glass, stone, plastic—materials which are not conventionally magnetic—heat can be controlled magnetically if you have a powerful enough magnet. This development may have future impacts on new energy production processes.

"OSC offered us phenomenal support; they supported our compilation and parallel threading issues, helped us troubleshoot hardware issues when they arose due to code demands, and moved us to the Lustre high-performance file system," said Antolin, the expert for high-demand computations in Windl's group. Next, the group plans to test whether they can deflect sound waves sideways with magnetic fields.

Coauthors on the study included graduate student Hyungyu Jin and postdoctoral researcher Stephen Boona from mechanical and aerospace engineering; and Roberto Myers, Ph.D., an associate professor of materials science and engineering, physics and mechanical and aerospace engineering. •

An artist's rendering of a phonon heating solid material demonstrates research findings proving that acoustic phonons—the elemental particles that transmit both heat and sound—have magnetic properties.

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