Newly identified 'universal' property of metamagnets may lead to everyday uses

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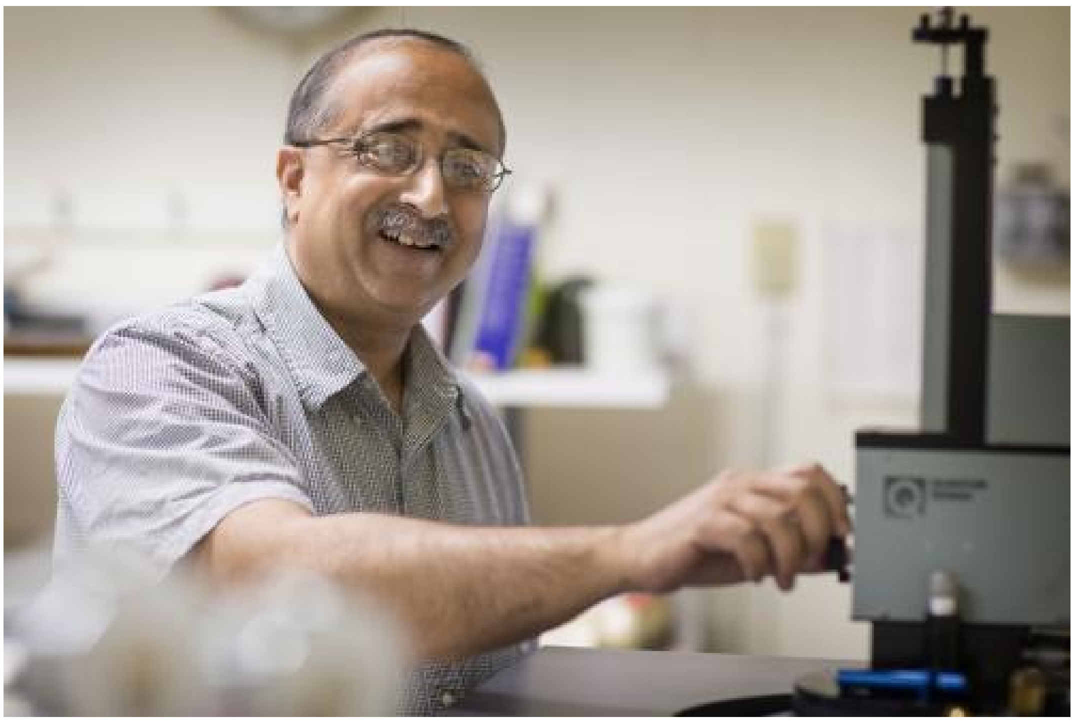

Physics professor Bellave Shivaram has discovered a universal law governing the properties of metamagnets. Credit: Dan Addison

(Phys.org) —A new physics discovery made by a University of Virginia-led team may lead to more efficient refrigerators, heat pumps and airport scanners, among many possible uses –perhaps within a decade.

The team of physicists and materials scientists have discovered a universal law governing the magnetic properties of metamagnets – metal alloys that can undergo dramatic increases in magnetization when a small external magnetic field is applied, such as from a permanent magnet or an electromagnet.

The scientists have discovered that the magnetic effect of apparently all metamagnets is that it is non-linear. When these metamagnets are placed in an initial magnetic field and the field is doubled, they more than double in magnetic strength. This is significant because eventually scientists and engineers likely will harness this unique property for a variety of applications, including refrigeration.

"We found that this nonlinear property has the same quantitative behavior in all different types of metamagnets, which is the universal law," said Bellave Shivaram, a University of Virginia professor of physics who led the studies, which were conducted in his lab and using materials synthesized at Argonne National Laboratory in Illinois.

The findings are published in separate papers currently online in the journals *Physical Review B: Rapid Communications*, and *Review of Scientific Instruments*.

According to Shivaram, the newly unveiled non-linear property can be exploited in many ways.

"A very useful property of this type of magnetism is in magnetic refrigeration," he said. "Magnetic refrigerators are not commonplace; they still are in the experimental stage. But they could eventually become part of everyday home appliances, from heat pumps to the refrigerators we store food in."

Currently, metamagnets produce efficient cooling only at very low temperatures, using superconducting magnets, making them impractical for general refrigeration.

"With the new discoveries of the properties of metamagnets, they could become part of everyday home appliances within a decade or so," Shivaram said.

Current refrigerators are among the biggest consumers of energy in the home. They include several moving parts, which make them costly to repair, and they can leak fluorocarbons into the atmosphere, which can deplete ozone. Refrigerators of the future, using metamagnets, would have fewer moving parts, would not require refrigerants, and, likely would use less electricity, Shivaram said.

"In these new materials, the magnetism can be cycled on and off, enabling heat to be pumped away in a manner similar to what happens in a heat pump today," Shivaram said. "In today's heat pump, we use pressure to cycle the cooling medium from liquid to vapor phase. In the new magnetic refrigerators we will use a magnetic material and cycle the magnetic field instead."

Another possible application for metamagnets would be, as an example, more effective airport screening devices. Such screeners use harmless terahertz waves to scan through materials. A screener using metamagnets would generate more efficient generation of terahertz waves, Shivaram said, by converting high-powered, low-frequency radio waves into terahertz waves by using the non-linear properties of metamagnets.

"By discovering the properties of these materials we've shown their promise," Shivaram said. "We will figure out future directions and what new materials we should go after for possible uses."

His co-authors on the Physical Review B paper are former U.Va. graduate student Brian Dorsey, materials scientist David Hinks of

Argonne National Laboratory and physicist Pradeep Kumar of the University of Florida. This collaborative work is continuing and recently has been augmented with the participation of Vittorio Celli, U.Va. professor emeritus of physics.

Provided by University of Virginia

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