Physicists Discover Potential Way to Store Memory in Ferroelectric Nanodisks and Nanorods

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University of Arkansas physicists have discovered **a new phase in tiny nanodisks and nanorods that potentially may enable researchers to increase memory storage by more than one thousand fold**. This finding also opens a new area in physics to fundamental investigation.

Ivan Naumov, Laurent Bellaiche and Huaxiang Fu report their findings in the Dec. 9 issue of the journal Nature.

"This ordered phase with technological relevance is previously unknown," said Naumov, a research scientist who works with Fu. "The new phase is possible because the nano-size of the disks wouldn't allow disorder due to properties no one has characterized before."

"It's a new phenomenon. You can think of using it to make new, hugely increased memories" for storing information, Bellaiche said.

The researchers studied ferroelectric materials at the nanometer scale. Ferroelectric materials possess spontaneous dipoles, or charge separations, that allow them to create the images seen in medical ultrasound and naval sonar, and also are used to convert signals to sound in cell phones and other audio devices. How these dipoles behave when the material is on the nanoscale is not well known.

"Our goal is to explore the possibility of using a single nanoparticle to store one data bit," Naumov said. However, the net polarization -- which is spontaneously formed in bulk materials and is so far the key to storing information -- does not normally exist in nanoparticles. Naumov, Bellaiche, and Fu decided to search instead for a new phase in the world of nano-ferroelectrics.

They found to their surprise that the dipoles in nanomaterials form a new state when the temperature is lowered. The researchers used computer simulations to determine what happens to the nanorods and nanodiscs when they reach this state.

They found that instead of polarization, the new phase creates what the researchers call a toroid moment, which rotates in a circular fashion like a vortex or a tornado. These moments can rotate in one direction or another, forming a bi-stable state that is capable of storing information, like polarization.

However, the toroid moment provides a different kind of order. Unlike polarization, the toroid moment can exist in tiny nanoparticles, which thus allows storage of one bit of information in a single particle, which has the advantage of increasing memory density. Also, unlike the polarization state, in which particles influence one another if moved in close proximity, the vortices created by this new phase do not interact strongly with one another. This means they can be packed together in a small space.

"This eliminates the 'cross-talk' problem. You can compact the materials very densely," Naumov said.

"We know that in principle this new finding can increase the memory capacity using nanoparticles, we don't yet know how long it will take to make a technology reality," Fu said. "But it's a new direction in which to point people."

Source: University of Arkansas