

March 15, 2010 - Seeking Dark Matter on a Desktop

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Contact:

- Melinda Lee, SLAC Media Manager: 1 (650) 926-8547, melinda.lee@slac.stanford.edu
- Robert Brown, SLAC Director of Communications: 1 (650) 926-8707, robbrown@slac.stanford.edu

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- [Dynamical Axion Field in Topological Magnetic Insulators, *Nature Physics*, March 7, 2010](#)

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Menlo Park, Calif.—Desktop experiments could point the way to dark matter discovery, complementing grand astronomical searches and deep underground observations. According to recent theoretical results, small blocks of matter on a tabletop could reveal elusive properties of the as-yet-unidentified dark matter particles that make up a quarter of the universe, potentially making future large-scale searches easier. This finding was announced today by theorists from the Stanford Institute for Materials and Energy Science (SIMES), a joint institute of the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, at the American Physical Society meeting in Portland, Oregon.

"Tabletop experiments can be extremely illuminating," said condensed matter theorist Shoucheng Zhang, who published the results with SIMES colleagues Rundong Li, Jing Wang and Xiao-Liang Qi. "We can make observations in tabletop experiments that help us figure the deeper mysteries of the universe."

In a paper published in the March 7 online edition of *Nature Physics*, Zhang and his colleagues describe an experimental set-up that could detect for the first time the axion, a theoretical tiny, lightweight particle conjectured to permeate the universe. With its very small mass and lack of electric charge, the axion is a candidate for the mysterious dark matter particle. Yet, despite much effort, the axion has never been observed experimentally.

That may change thanks to the SIMES theorists' forefront research into topological insulators. In this small, newly discovered subset of materials, electrons travel with great difficulty through the interior but flow with much less resistance on the surface, much as they can in superconductive materials. Even better, they do this at room temperature. This leads to unusual properties that may be important for applications such as spintronics, an emerging technology that could allow for a new class of low-power, high-density, superior-performance electronic devices.

In their research into other applications for topological insulators, Zhang and his colleagues discovered that the electromagnetic behavior of topological insulators is described by the very same mathematical equations that describe the behavior of axions; wondrously, the laws of the universe related to axions are mirrored in this new class of materials. As a result of this mathematical parallel, the theorists posit that experiments on topological insulators can reveal much about the axions that are predicted to pervade the universe.

"That both are described by the same mathematical equation is the beauty of physics," said Zhang. "Mathematics is so powerful—it means we can study these things in topological insulators as if they were a baby universe."

In their paper, Zhang and his colleagues describe one particular class of topological insulator in which the parallel mathematics related to axions is most apparent, and suggest several experiments that could be performed to "see" axions in the electromagnetic behavior of topological insulators. These experiments could offer additional insight into the physical characteristics of the axion, insight that would simplify the astronomical search by giving observers a better idea of where to look for evidence of the axion hidden behind the overall roar of the universe.

"If we 'see' an axion in a tabletop experiment, it will be extremely illuminating," Zhang said. "It will help shed light on the dark matter mystery."

The Stanford Institute for Materials and Energy Science, SIMES, is a joint institute of SLAC National Accelerator Laboratory and Stanford University. Research at SIMES is supported in part by the U.S. Department of Energy's Office of Science.



Shoucheng Zhang of the Stanford Institute for Materials and Energy Science.

(Photo courtesy Brad Plummer; click on image for larger version.)

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by Kelen Tuttle

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