Dealing with Frustrated Materials

Haidong Zhou wins a third NSF CAREER grant in three years for UT Physics

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Haidong Zhou is not a scientist who is easily daunted by frustration. In fact, his latest research deals with materials that have frustration built right in. The project, titled "Emergent Quantum Spin-Liquid in Yb-Pyrochlores and Yb-Spinels," begins August 1 of this year and lasts for five years. The work is funded by the physics department's third National Science Foundation CAREER grant in three years.

The research falls in line with Zhou's interest in new materials with novel properties. Quantum spin liquids, or QSLs, are an interesting state of matter because of their magnetic "frustration." Magnetically-frustrated materials have a crystal lattice structure where there are strong spin correlations (spin is an intrinsic property, like charge or mass) but no static magnetic order, as the electrons' magnetic orientations are constantly changing. To understand QSLs, Zhou will be working with the rare element ytterbium in some interesting arrangements.

As he explained, "(the) arrangement of the magnetic spin is kind of strange. Three magnetic spins arrange themselves as a triangular lattice: kind of a very unique structure."

The lattice is two-dimensional and frustrated, whereas "for pyrochlores and spinels, you have a three-dimensional frustrated lattice, like a pyramid. Instead of three corners, I now have four. It is still a frustrated lattice, just from 2-D to 3-D," he said. "In the quantum spin liquid, the idea is that my spin can select several directions . . . (yet), it cannot select which one to settle on," he explained. "One second it's like that and one second it's like that,' he said, pointing his fingers in opposite directions to emphasize the point. "The time scale is (actually) much, much smaller than a second; they jump very quickly."

Frustrated materials give scientists like Zhou an opportunity to investigate novel properties related to spin and magnetism. He will also study how the sample's structure—the arrangement of atoms—might affect its magnetic properties. Given the importance of magnetism in everyday applications (computer hard drives or magnetic resonance imaging, just to name two), getting a clearer picture of how this phenomenon is influenced is fundamental to capitalizing on its potential.

There are some parameters Zhou will have to account for to see what QSLs are all about. For one, they only show their more exotic properties at extremely low temperatures, so he will be working with temperatures down to 20 milli-Kelvin, as well as studying how the materials respond to any perturbations. A second challenge is that there aren't that many samples available for study. Fortunately, Zhou is a crystal grower and will grow single-crystal samples in his lab. The CAREER grant supports two graduate students who will benefit from learning that process: Zhiling Dun and Ryan Sinclair. Zhou will also make materials samples and student training available to colleagues interested in the same kind of research.

Zhou earned the Ph.D. in physics at the University of Texas at Austin in 2005. He worked as a postdoc and then assistant scholar/scientist at Florida State University's National High Magnetic Field Laboratory before joining the UT physics faculty in August 2012. The NSF CAREER grant is a prestigious

award for junior faculty like Zhou who are dedicated to integrating outstanding research and education. The honor is the third for UT Physics in three consecutive years: Dr. Jaan Mannik was a CAREER awardee in 2013 and Dr. Norman Mannella won the honor in 2012.

More information

- **Condensed Matter Physics at UT (http://www.phys.utk.edu/research/cmp/index.html)**
- **Dr. Zhou's NSF Award (http://www.nsf.gov/awardsearch/showAward?AWD_ID=1350002)**
- **NSF CAREER Program (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503214)**