Noisy nature of atoms

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University of California scientists working at Los Alamos National Laboratory have demonstrated a way to use the random fluctuations that exist naturally in all magnetic systems to perform magnetic resonance studies without disturbing the system's natural state. Conventional magnetic resonance techniques, such as those used in magnetic resonance imaging (MRI) machines, require the excitation and absorption of specific radio-frequency waves by atoms in a magnetic field. These absorption patterns can be used to reveal molecular and magnetic structure. The find could pave the way for perturbation-free magnetic resonance imaging techniques that are useful in fields like nanotechnology and quantum information science where systems containing only a few atoms are becoming commonplace and their associated magnetic fluctuations play an increasingly dominant role.

In research reported in today's issue of the scientific journal Nature , Los Alamos scientists Scott Crooker, Dwight Rickel, Alexander Balatsky and Darryl Smith explain how seemingly random fluctuations in an ensemble of magnetic spins -- called spin noise -- can actually be exploited to perform detailed magnetic resonance, without disturbing the spins from a state of thermal equilibrium. Using a laser technique known as Faraday rotation, the scientists measured the spectrum of spin noise in vapors of magnetic rubidium and potassium atoms. The noise spectrum alone revealed the complete magnetic structure of the atoms.

According to Greg Boebinger, director of the National High Magnetic Field Laboratory (NHMFL), "this work is especially important because a s devices shrink in size to the nanoscale regime, fewer atoms and spins dominate the device behavior and noise processes become more prominent. By drawing on the fluctuation-dissipation theorem, the work at Los Alamos firmly establishes the idea that one scienti st's noise is another scientist' s signal."

This work, performed at the National High Magnetic Field Laboratory facility at Los Alamos, provides a demonstration of the physical relationship known as the "fluctuation-dissipation theorem," which proposes that it is possible to "listen" very carefully to the tiny, intrinsic thermal or quantum-mechanical fluctuations of a physical system. Those fluctuations reveal a number of the properties of that system without having to disturb it from its natural resting state. Typically, in devices like MRI systems, an electromagnetic source must be used to "perturb" the spins of atoms so that they resonate in synchrony at radio frequencies, which are then recorded to create MRI scans.

Alex Lacerda, director of the NHMFL Pulsed Field Facility, said, "this work represents the vital importance of Los Alamos' scientific environment. The collaboration between the NHMFL and the Theoretical Division's Condensed Matter and Statistical Physics group takes full advantage of our scientific talents across the Laboratory."