# PHYSICS COLLOQUIUM

**Wednesday, October 12 | 3:15-4:15 p.m. | RNS 210**

ST · OLAF COLLEGE

# Causing a Big Racket with Tiny Magnets: Emergent 1/f noise in collections of oscillating nanomagnetic dots

On the tiniest scales, everything wiggles—this is one of the primary ideas to come from thermodynamics. Be it the jiggling of atoms in a lattice, the erratic movement of electrons in a resistor, or the slow diffusion of particles through a liquid, these random thermal processes help define how matter functions on the smallest scales. Random processes don't just exist on the nanoscale though; any sufficiently complicated system can exhibit effectively random behavior, from river flood levels, to the ebb and flow of the stock market, to traffic patterns. Interestingly, a statistical analysis among all these disparate systems shows each displays the same character of fluctuations, called 1/f noise for its frequency dependence on power spectral density. Some in-roads have been made theorizing what types of underlying mechanisms could explain 1/f noise in these systems, but experimental verification has proven difficult in any kind of top-down approach.

My research instead has focused on a bottom-up building of 1/f noise from well-characterized Random Telegraph Noise (RTN) in magnetic nanodots. Usually a permanent magnet's magnetization direction is fixed in place, but for small enough magnets, pinning energies can be overcome by thermal fluctuations, causing the north pole of the magnet to jump back and forth between two states. Using this two-state switching as a building block, collections of these tiny magnets combine to show a 1/f noise signal, and both the number of RTN signals required to achieve 1/f and the size of the fluctuations of individual RTN signals can give insight into 1/f noise observed in both other magnetic systems, and in noisy systems in general.

**Barry Costanzi '09, PhD**

**Barry N Costanzi** received his B.A. in Physics and Mathematics from St. Olaf College in 2009. While at St. Olaf, he worked with Jason Engbrecht on constructing a "cold" pulsed positronium beam (aka "Mr. Beam") by exploiting thermalization effects of positronium interacting with polymer nanotubes. After graduating, Barry joined Dan Dahlberg's Condensed Matter lab at the University of Minnesota as a graduate student. While there, he worked with collaborators from the KTH Institute in Stockholm, Sweden on refining electron-beam induced deposition (EBID) processes in order to fabricate and measure novel geometries in magnetic tunnel junctions (MTJs), before beginning his thesis work on magnetic noise in nanoscale magnets. In August 2016 Barry defended his thesis, titled "Emergent 1/f noise in system of oscillating nanomagnetic dots", which explores magnetic noise phenomena in both individual nanomagnets undergoing thermal fluctuations, and in collections of such nanomagnets. Upon graduation, Barry began work as Visiting Assistant Professor of Physics at St. Olaf College in September of 2016.