**Research Interests of Dr. Kingshuk Majumdar**

My research interest is in theoretical condensed matter physics especially in the areas of magnetism and magnetic materials. The phenomenon of magnetism cannot be understood without quantum physics. Like mass and charge electrons have spin. For example in iron there are six localized electrons in the outer shell (*d* orbital) of each iron atom. Five of these electrons have spin up and one have spin down. This imbalance in spin-up and spin-down electrons results in a net magnetic moment of the atom. In magnetic materials spin-spin interactions between magnetic atoms are responsible for their magnetic properties. There are different types of magnetism such as diamagnetism, paramagnetism, ferromagnetism, and anti-feromagnetism. In ferromagnets such as iron the atoms align in one direction and magnetism is retained even at zero external magnetic field whereas in antiferromagnets like in MnO spins align in a parallel – antiparallel arrangement.

Frustrated magnetic systems are of great interest in present day condensed matter research due to their highly unusual physical properties. Frustration can arise either due to the underlying geometry or due to competing interactions. In other words, a magnetic spin system is frustrated when one cannot find a configuration of spins to fully satisfy the interaction (bond) between every pair of spins. In this case, the minimum of the total energy does not correspond to the minimum of each bond, which leads to highly [degenerate](http://en.wikipedia.org/wiki/Degenerate_energy_level) [ground states](http://en.wikipedia.org/wiki/Ground_state) with a nonzero [entropy](http://en.wikipedia.org/wiki/Entropy) at zero temperature. At zero temperatures it is possible to drive a magnetic material from an ordered phase to a disordered phase by changing some internal parameter(s) in the model for example by changing the coupling between two spins at different sites. My research focuses on such quantum phase transitions in frustrated magnetic materials. Any senior research project will include analytical and computational work on these magnetic spin systems. For the computational work students have to write codes in MATLAB or in C/C++ which may ultimately run in supercomputers. The work has the potential to get published in peer reviewed journals.

**Past Student Projects:**

1. Stephen Gardner, "***Non-linear spin wave analysis of quantum magnets* (2009).**
2. Nathan Lindy, "***Theoretical Study of electrical conductivity of thin films*** (**2008)**.