Explorations and Applications of Spin Coherence at Room Temperature

Until recently, most research into harnessing the spin degree of freedom (“spintronics”) has focused on either metals or semiconductors while highly disordered materials have remained relatively untouched. Disordered media exhibit drastically different charge transport properties (i.e. through localized states) from crystalline materials such that only rudimentary elements of spin dynamics theory developed in crystalline materials are applicable in the highly disordered regime. New classes of localized spin physics, contingent on spin coherence and spin correlations through large Coulomb/exchange interactions, have been discovered recently in an array of disordered materials with large magneto-responses at room temperature. Instead of being a niche effect, the physics is predicted in a diverse array of systems such as biological compasses, tumor growth, and charge transport through magnetic heterostructures.

I will introduce the field of spintronics broadly and then focus attention on the emerging field of quantum spintronics which examines room temperature phenomena that rely on spin coherence and correlations. The main part of my talk will be about my contributions to this exciting field in two areas that appear to be very dissimilar but actually have a lot in common: light emission in organic light emitting diodes (OLEDs) and the dynamics of spin at the boundary of a normal metal and a ferromagnet. In certain OLEDs that are designed to maximize efficiency, the optical output of the device can change by over 4000% at room temperature! I will explain how such large responses require both disorder and spin coherence of the recombining constituents. I will then demonstrate how the same theoretical framework clarifies a contentious debate regarding spin injection into metals and semiconductors.