Strong quantum confinement in semiconductors compresses the wavefunctions of band carriers to nanometer-scale volumes, significantly enhancing their interactions with dopants. In magnetically doped semiconductors, where paramagnetic dopants couple to band carriers via strong \( sp-d \) spin exchange, giant magneto-optical effects can be realized using few, or even single, impurity spins. Importantly, however, thermodynamic spin fluctuations become increasingly relevant in this few-spin limit: the statistical \( N^{1/2} \) fluctuations of \( N \) spins are expected to generate giant effective magnetic fields \( B_{\text{eff}} \), which dramatically impacts carrier spin dynamics, even in the absence of an applied field.

Here, I present measurements of both the initial and final stages of exciton magnetic polarons (EMPs) in lightly doped \( \text{Cd}_{1-x}\text{Mn}_x\text{Se} \) colloidal nanocrystals. In the first section, I show our ultrafast spectroscopic investigations of the large \( B_{\text{eff}} \) in this system. At \( B_{\text{applied}} = 0 \text{T} \), extremely rapid (300–600 GHz) electron spin precession is observed, indicating \( B_{\text{eff}} \approx 15–30 \text{T} \) [1]. In the second part of the talk, I show our work on fully-formed EMPs. Using the highly sensitive technique of resonant photoluminescence, we directly measure the EMP binding energy to be tens of meV. Temperature- and field-dependent studies reveal that the exchange field is approximately 10 T, which agrees with theoretical estimates [2]. Taken together, the measurements of initial, ultrafast coherent dynamics and final, static formation states, give us a comprehensive picture of EMPs in doped nanocrystals.