Magnetic nanoparticles have many diagnostic and therapeutic applications. We have developed methods of interrogating the microscopic environment surrounding magnetic nanoparticles that can be used *in vivo*. This set of methods is termed magnetic spectroscopy of nanoparticle Brownian motion (MSB) and is capable of evaluating any physical effect that affects the Brownian motion of the nanoparticles; e.g., temperature, viscosity, and chemical binding. MSB is capable of human use throughout the body. Two applications where these methods show significant promise are in planning nanoparticle cancer therapy and ovarian cancer screening.

Cancer therapy using magnetic nanoparticles activated with an alternating magnetic field preferentially kills cancer cells both *in vitro* and *in vivo*. *In vitro* experiments have shown that the microscopic proximity of the nanoparticle to the targeted cells is of central importance when activating the nanoparticles, that is, nanoparticles that are in vesicles are more cytotoxic than those in the media surrounding the cells. Therefore, it is important to understand where the nanoparticles are before magnetic field activation. We have applied MSB to directly measure the nanoparticle microscopic state. Specifically, the progression of nanoparticle endocytosis can be monitored rapidly and non-invasively. Once the nanoparticles are in intracellular vesicles, they are more effective cytotoxic agents when activated with an external magnetic field.

Ovarian cancer screening is another application of magnetic nanoparticles that shows significant promise. Ovarian cancer has a high cure rate if found early but a very poor survival rate if found at an advanced state. Unfortunately ovarian cancer is rarely found early so an effective early detection method would save many lives. Dendrites or phagocytes quickly phagocytose magnetic nanoparticles injected into the peritoneal cavity. Cytokine signaling draws phagocytes to malignancies and they bring the endocytosed magnetic nanoparticles with them. MSB methods have been used to detect the resulting collection of magnetic nanoparticles. The result is immunologic nanoparticle targeting. Magnetic detection of the nanoparticles in a unique genetic mouse model for ovarian cancer has shown the method can identify microscopic ovarian malignancies.