College of Natural Sciences & Mathematics
UNIVERSITY OF DENVER

Physics & Astronomy Colloquium

April 23, 4:00pm, Olin 105

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Seeing More With MRI: Materials Physics for Contrast, Sensing, and Metrology

Magnetic resonance imaging (MRI) is a non-invasive technique that produces three-dimensional (3D) visualizations of soft tissue and human anatomy. The signal in MRI comes from ^{1}H proton spins (found abundantly in water molecules and tissue throughout the body). During an imaging sequence, proton spins are manipulated with large static magnetic fields, magnetic field gradients, and time-varying magnetic fields, to produce images.

MRI signal is sensitive to small-scale magnetic fields. We can use this fact to engineer interactions between ^{1}H protons and magnetic materials for applications in sensing and metrology. I will describe three examples from recent research projects: magnetic nanoparticles for low-field MRI contrast, multispectral MRI sensors, and MRI-readable radiation dosimetry.

First, I will describe possibilities for using magnetic nanoparticles (MNPs) as positive contrast agents with low field MRI (LF-MRI). LF-MRI scanners require less infrastructure than clinical MRI scanners and can be wheeled next to a patient's bedside, creating revolutionary possibilities for point-of-care diagnostics. Our recent work showed that iron oxide-based MNPs have desirable properties for positive T1 contrast at emerging field strengths used for LF-MRI [1]. I will discuss how LF-MRI contrast is related to the magnetic and structural properties of MNPs, and comment on future opportunities for research.

Secondly, I will describe how hollow cylinder shaped MNP-polymer microparticles can be used as radio frequency (RF) multispectral MRI contrast agents [2]. Multispectral, or "color" contrast is a unique form of contrast that uses three-dimensional magnetic microstructures to produce a distinct frequency readout [3]. Using special polymer materials, these contrast agents can be transformed into sensors. I will show proof-of-principle experiments using reconfigurable "smart" hydrogels to create MRI-addressable environmental microsensors.

Finally, I will describe recent work on MRI-readable radiation dosimeters. Together with researchers at NIST and CU Anschutz, we have been developing anthropomorphic dosimeters for visualizing therapeutic radiation doses in 3D. I will describe ongoing work and describe plans for future NIST-traceable measurements.

1. Oberdick, S. D. et al., Sci. Rep., Vol. 13, p. 11520 (2023)
2. Oberdick, S. D. et al., ACS Sens., Vol. 9, p. 42–51 (2024)
3. Zabow, G. et al., Nature, Vol. 453, p. 1058–1063 (2008)