INORGANIC SEMINAR

Professor Ryan Hadt

Professor of Chemistry
Division of Chemistry and Chemical Engineering
California Institute of Technology

Quantum Coherence as a Chemical Observable

Ultrafast Molecular Spin Sensing from Catalysis to Biology

Quantum coherence—the ability for quantum states to exist in well-defined superpositions—lies at the heart of emerging quantum technologies. Direct experimental access to coherence in molecules, however, has traditionally relied on techniques poorly suited to the ambient and chemically complex environments in which molecular function occurs. This seminar will describe our development of time-resolved Faraday ellipticity (TRFE), an all-optical approach that uses femtosecond laser pulses to initialize and measure molecular electron spin coherence. TRFE enables direct observation of coherent spin dynamics on picosecond timescales in room-temperature solutions. I will discuss how molecular electronic structure can be designed to enable optical spin initialization and readout and how the resulting coherence reports on local chemical environments. Extension of this approach to reactive transition-metal intermediates reveals coherent electron–nuclear spin interactions and enables direct measurements in crude reaction mixtures. More recently, we have extended ultrafast spin coherence measurements to a native metalloprotein, expanding this emerging measurement regime from synthetic chemistry toward biology. More broadly, this work seeks to transform molecular quantum coherence from a spectroscopic observable into a source of chemically and spatially resolved contrast—analogous to how magnetic resonance imaging transformed nuclear spin relaxation into a powerful tool for imaging complex environments.

PURDUE UNIVERSITY | James Tarpo Jr. and Margaret Tarpo Department of Chemistry

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