CMQT
CENTER FOR MOLECULAR
QUANTUM TRANSDUCTION

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Ryan G. Hadt received his B.S. and M.S. degrees in chemistry at the University of Minnesota Duluth (with V. N. Nemykin) and his Ph.D. at Stanford University (with E. I. Solomon). He was a visiting postdoctoral fellow at Harvard University (with D. G. Nocera) before continuing research at Argonne National Laboratory as a postdoctoral appointee (with L. X. Chen) and later as an Enrico Fermi Fellow. He is currently a Professor of Chemistry in the Division of Chemistry and Chemical Engineering at the California Institute of Technology. Professor Hadt's research interests are broadly based in the fundamental understanding of transition metal electronic structure, with applications in catalysis, photophysics, and quantum information science.

Ultrafast Molecular Spin Coherence for Quantum Transduction in Complex Environments

Coherent molecular electron spins provide a chemically tunable platform for quantum information, capable of interacting with photons, phonons, and the local chemical environment. This seminar will focus on how ultrafast, all-optical spin coherence measurements in transition-metal complexes realize molecular quantum transduction in solution, using light to both write and read quantum information stored in spins.

Time-resolved Faraday ellipticity/rotation (TRFE/R) in octahedral Ir(IV) hexahalometallates enables room-temperature, all-optical detection of picosecond ground-state free-induction decays, revealing strong sensitivity to rotational degrees of freedom. In electrolyte solutions, decoherence quantitatively encodes ion-pairing–mediated molecular dynamics and the thermodynamics of ion-pair equilibria; the neurotransmitter acetylcholine produces distinct, concentration-dependent changes in coherence, demonstrating label-free detection. Immobilization of $[IrBr_6]^{2-}$ in polymer films yields an order-of-magnitude increase in all-optical T_2^* and amplifies magnetic-field sensitivity, while ligand-to-metal charge-transfer tuning allows access to the biological tissue transparency window. Extending TRFE/R to lower-symmetry, functionalizable complexes with spin coherence times exceeding a nanosecond in room-temperature solution further broadens the molecular design space.

Together, these advances establish ultrafast, all-optical spin coherence as a powerful molecular quantum transduction platform—coherently linking spins, photons, and the chemical environment—and lay the groundwork for bottom-up designed spin–photon interfaces, paving the way toward a new molecular spin-coherence imaging modality.