SCIENCE HALL SEMINARS

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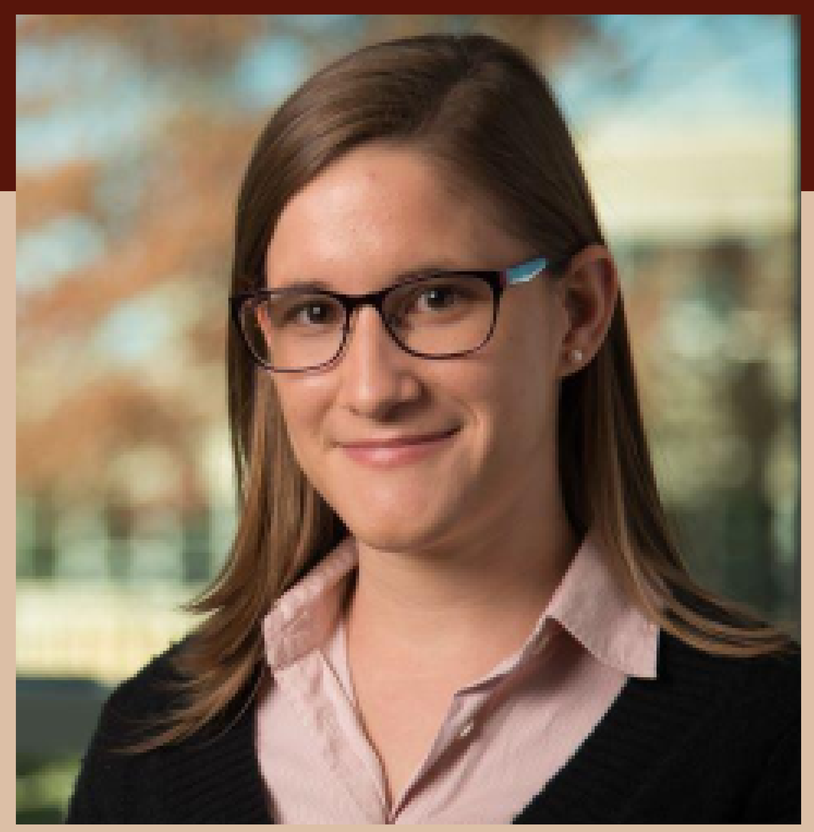
The Quantum Identity Crisis of Molecular Hydrogen:

Cryogenic Spectroscopy in Confinement



Leah G. Dodson, Ph.D.

University of Maryland

Assistant Professor, Department of Chemistry and Biochemistry

Abstract: Molecular hydrogen (H_2) is the simplest molecule in the universe—but also one that can still be confounding. In its ground vibrational state, H_2 exists in two distinct nuclear-spin isomeric forms: ortho-H_2, with parallel nuclear spins, and para-H_2, with antiparallel spins. Although chemically identical, these species differ in symmetry, energy, and reactivity, forming the basis of a long-standing quantum identity crisis.

In this talk, I will present our group's recent work to detect and study ortho- and para-hydrogen in solid cryogenic environments using quantum-state-resolved infrared spectroscopy. By embedding H_2 in inert matrices and porous materials cooled below 20 K, we overcome the limitations imposed by its lack of a permanent dipole and exploit subtle perturbations induced by the surroundings to reveal nuclear-spin-specific signatures.

The core of this work is a new laboratory instrument developed in our group that couples a closed-cycle helium cryostat with a commercial FTIR spectrometer, enabling direct infrared measurements of optically thin solids and porous materials (such as COFs, MOFs, and zeolites) at cryogenic temperatures. These experiments lay the groundwork for using surface interactions and paramagnetic dopants to catalyze ortho-para conversion—an avenue with implications for quantum control, energy storage, and the modeling of interstellar chemistry.

In addition to sharing scientific results, I will also discuss how this research connects fundamental quantum mechanics with experimental design, and highlight ways students can get involved in small-molecule spectroscopy, instrumentation, and low-temperature physical chemistry.

Wednesday, September 17th | 2:00pm-3:15pm | Science Hall 126 & Zoom

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