Physical Chemistry Seminar

Leah Dodson

Assistant Professor | Department of Chemistry and Biochemistry |
University of Maryland at College Park

When Reactions Slow Down: Mechanic Insight from Controlled and Confined Chemistry

Many chemical reactions of fundamental interest proceed through pathways that are difficult to observe directly because they are either transient, weakly bound, or intrinsically slow. In such cases, kinetics themselves can serve as a powerful probe of mechanism—provided the reaction environment can be sufficiently controlled. In this talk, I will describe two complementary research efforts from our group that leverage confinement, reduced collision rates, and high-resolution spectroscopy to uncover mechanistic detail in slow chemical processes.

First, I will discuss our work on ion–molecule reactions that proceed through long-lived collision complexes, focusing on the challenge of distinguishing radiative association from three-body stabilization. Using our new glow-discharge ion trap instrument, we measure pressure-dependent reaction kinetics that allow us to decouple these competing pathways and extract mechanistic insight into ion–neutral association reactions under low-collision conditions.[1]

In the second part of the talk, I will describe recent results on nuclear-spin isomer conversion in molecular hydrogen confined within cryogenic crystalline hosts. by embedding H2 in ordered solids and probing it with infrared spectroscopy, we exploit lattice-induced perturbations to render H2 infrared-active and resolve ortho–para populations spectroscopically. Our measurements reveal that the symmetry of the host crystal field imposes selection rules on nuclear-spin conversion, leading to distinct, symmetry-controlled kinetic pathways.[2]

Together, these projects illustrate how slowing chemistry down—whether by reducing collision frequency or by confining molecules in structured environments—can expose mechanistic information that is otherwise hidden. More broadly, they demonstrate how modern spectroscopic tools enable quantitative insight into reaction dynamics at the edge of detectability.

1. arXiv:2601.09862

2. arXiv:2510.16155