

University of Miami, Physics Department Colloquium

Date: Wednesday, Sep 10, 2025
Time: 4:00 pm – 5:00 pm
Location: Physics Library – Rm 335, Knight Physics Building

Magnetic J-oscillators: Audio-Band Molecular Masers

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Abstract

Maser phenomena are usually associated with microwave transitions and high-Q cavities. I will discuss a different regime: molecular masers that operate at audio-band frequencies and require no resonant cavity. The active medium is a liquid containing molecules whose nuclear spins are continuously hyperpolarized by parahydrogen. In the zero- to ultralow magnetic field regime, nuclear spin-spin (J-)couplings in hyperpolarized molecules under active digital feedback are driven into a limit cycle that produces narrow-line magnetic emission detected by optically pumped magnetometers. Recently, we demonstrated coherent oscillations from near-DC to the tens-of-hertz range, with frequencies tunable by chemical structure [1]. I will outline the minimal model for onset of oscillation, show how chemistry provides a toolbox for frequency control and magnetic gain, and discuss noise and stability of such oscillations. Beyond offering a new playground for non-equilibrium spin dynamics, J-oscillators suggest audio-band precision sensing, molecularly defined frequency clocks, and opportunities for zero-field NMR spectroscopy without the need for RF hardware.

1. Xu, Kircher, Tretiak, Budker, Barskiy. Quantum Magnetic J-Oscillators. 2025, <https://arxiv.org/abs/2504.06498>

Biography

Danila Barskiy joined the University of Miami in Fall 2025 as an Associate Professor in the Department of Chemistry and the Frost Institute for Chemistry and Molecular Science. His group works at the interface of spin physics, benchtop NMR, and zero- to ultralow-field NMR, with applications to quantum sensing and analytical chemistry. He received the 2025 Varian Young Investigator Award and previously led a research group at the Helmholtz Institute Mainz, Johannes Gutenberg University Mainz (Germany).