



Colloquium

Harnessing Metastable States for Next-Generation Quantum Sensors and Clocks

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Abstract:

Metastable states in alkaline-earth-like atoms provide a powerful and largely untapped resource for advancing quantum sensing and optical clock technologies. In particular, long-lived metastable manifolds enable novel cooling, trapping, and state-control techniques, forming a rich toolbox for the development of continuous-operation quantum devices. In this talk, I will present two distinct Sisyphus cooling schemes that exploit narrow-line transitions involving metastable states to achieve efficient cooling and enhanced atomic clock performance, leveraging state-dependent optical potentials and engineered dissipation pathways beyond conventional limits.

I will also report on the latest progress in our ytterbium neutral atom lab at the Institute of Atomic and Molecular Sciences, including recent spectroscopy of previously unexplored transitions, the development of optical system design tools tailored for modular architectures, and numerical simulations that guide the implementation of novel cooling strategies in realistic experimental geometries.

Together, these developments outline a pathway toward continuous ultracold atomic sources and next-generation optical clocks, where metastable-state engineering plays a central role in overcoming current limitations imposed by dead time and laser-induced decoherence.