Dark matter searches with matter wave interferometry

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I will discuss the use of atom interferometry as a tool to search for dark matter composed of virialized ultralight fields. Previous work on dark matter detection using accelerometers has considered the possibility of equivalence-principle-violating effects whereby gradients in the dark matter field can directly produce relative accelerations between media of differing composition. In atom interferometers, we find that time-varying phase signals induced by coherent oscillations of dark matter fields can also arise due to changes in the atom rest mass that can occur between light pulses throughout the interferometer sequence as well as changes in Earth's gravitational field. We estimate that several orders of magnitude of unexplored phase space for dark matter couplings can be probed due to these new effects.

I will also introduce a novel, exotic physics channel, in multi-messenger astronomy. I will discuss detection of exotic light fields emitted during LIGO detected mergers with networks of quantum sensors. If successful, such detection can provide the first experimental signature of quantum gravity.

References:

[1] A. A. Geraci and A. Derevianko, *Sensitivity of Atom Interferometry to Ultralight Scalar Field Dark Matter*, Phys. Rev. Lett. **117**, 261301 (2016).

[2] C. Dailey, C. Bradley, D. F. Jackson Kimball, I. A. Sulai, S. Pustelny, A. Wickenbrock, and A. Derevianko, *Quantum Sensor Networks as Exotic Field Telescopes for Multi-Messenger Astronomy*, Nature Astronomy **5**, 150 (2021).