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Vector Wave Dark Matter and Terrestrial Quantum Sensors

Ultralight spin-1 particles can constitute all of dark matter and leave their signature as a coherent, oscillatory signal in terrestrial quantum detectors. Leveraging advancements in quantum metrology, these sensors are well-poised to measure these signals due to their incredible sensitivity to tiny forces and displacements. However, a statistical frequency-space analysis of this signal accounting for the inherent stochasticity of the vector field and the rotation of the Earth is missing; this is important to construct representative exclusion limits and discovery regions. In this talk, I will account for these effects and build a generalised statistical framework to infer ultralight dark matter properties, such as its mass and coupling strength. I will begin by showing that the vector field leads to a characteristic three-peak signal in Fourier space. I will then develop the statistics underpinning our framework, accounting for the intrinsic stochasticity of the field. Using this framework, I will derive an exclusion limit on a generalised parameter that can be recast onto concrete choices of the dark matter model and sensor. Finally, I will apply our results to specific choices: $B - L$ dark matter and the canonical optomechanical cavity. Our results provide a generalised framework that can be used by similar detector technologies to perform inferences on ultralight vector dark matter.

Mini Symposia (Invited Talks Only)

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