Contribution ID: **11** Type: **not specified**

Quantum Enhanced Sensing of Ultra-Light Dark Matter

Wednesday, 21 January 2026 12:00 (30 minutes)

The nature of dark matter (DM) remains one of the most pressing open questions in fundamental physics. Among the viable candidates, ultra-light bosonic dark matter such as axions and dark photons can manifest as coherent, wave-like fields that naturally couple to photons. In this talk, I present quantum-enhanced approaches to detect such signals by exploiting tools from quantum information science. We show how single-photon counters and non-classical states, such as Schrödinger cat states, can surpass the standard quantum limit and significantly improve scan rates. Furthermore, by harnessing quantum coherence across entangled sensor networks, incoherent backgrounds can be eliminated, leading to a quadratic signal enhancement scaling as N^2. Finally, I discuss a quantum metrological framework in which Dicke states saturate the Heisenberg limit for dark matter sensing. These developments highlight the synergy between quantum technologies and fundamental physics, and point toward new opportunities for probing the quantum nature of dark matter.

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Session Classification: Wed Morning II