

# Snowmass2021 - Letter of Interest

## *Novel Astrophysical Probes of Bosonic Dark Matter*

### **Thematic Areas:**

- (CF1) Dark Matter: Particle Like
- (CF2) Dark Matter: Wavelike
- (CF3) Dark Matter: Cosmic Probes
- (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
- (CF5) Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before
- (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
- (CF7) Cosmic Probes of Fundamental Physics
- (TF02) Effective field theory techniques
- (TF09) Astro-particle physics and cosmology

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**Abstract:** Dark matter congregates around compact objects with significant gravitational fields such as black holes and compact stars. A variety of dark matter theories have bosonic dark matter candidates<sup>1-15</sup>. Current multi-messenger probes of compact objects provide insight into the nature of bosonic dark matter<sup>16-26</sup>. This white paper will highlight how effective field theory techniques can be used to understand the evolution of bosonic (axion) dark matter as it oscillates around black holes and compact stars. The white paper considers (1) superradiantly and non-superradiantly enhanced processes, (2) the polarization of the outgoing photons and (3) the evolution of axion clouds on inspiralling massive black hole (and compact star) binaries. This results new, unique signatures that, when merged with well vetted astrophysical backgrounds, may produce statistically significant probes of bosonic dark matter.

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