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Probing New Frontiers of Astroparticle and Astrophysics with Cryogenic Quantum Sensor

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The Universe, born from the Big Bang, which is revealed by cosmic microwave background (CMB) photons that escaped during the epoch of recombination, evolved through the "dark ages"until gravity drove the collapse of primordial gas into the first stars and galaxies. These early structures reionized the intergalactic medium and seeded the large-scale cosmic web observed today. Interactions among baryons, dark matter, and dark energy shaped the spatial fluctuations of CMB photons and the large-scale distribution of galaxies, forming the basis of the standard cosmological model derived from observations of both the early and late Universe.

However, disturbing discrepancies remain across multimessenger observations, including the Hubble and S_8 tensions, the local missing baryon problem, and the unexpectedly rapid formation of massive black holes revealed by JWST. The unresolved origin of the cosmic infrared background and its possible correlation with the cosmic X-ray background may hint at a hidden population of primordial black holes, known as one kind of dark matter candidates.

To uncover such hidden information and resolve the missing pieces of cosmic evolution, extremely sensitive detectors are required. Cryogenic quantum sensors represent a promising approach for future astrophysical missions. I will introduce the principles and applications of cryogenic quantum sensors in probing new frontiers of astrophysics and astroparticle, including investigations of potential particle candidates for dark matter such as sterile neutrinos and axion-like particles.

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