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Detecting keV-range super-light dark matter using graphene Josephson junction

Understanding the nature of dart matter has been a long-standing conundrum in particle physics. While most theoretical and experimental efforts in the search for dark matter have been focused on the weakly interacting massive particles, the fact that there have been no conclusive signal observations increasingly motivates searches for other dark-matter candidates. Of them, keV-scale super-light dark matter is receiving particular attention, as its existence is a crucial criterion to determine the "coldness" of dark matter in cosmological history. However, the direct probe of such super-light dark matter has been an experimentally challenging task primarily due to the difficulty in achieving an extremely small energy threshold ($E_{\rm th}$) as low as $\mathcal{O}$(meV). Very recently, a technological breakthrough for this experimental challenge has been reported in condensed matter physics, the graphene-based Josephson junction (GJJ) bolometer technology (arXiv:1909.05413, Nature accepted). The device using this "state-of-the-art" technology has shown the highest sensitivity to $E_{\rm th} \sim 0.1$ meV. We demonstrate that the adoption of this GJJ-based bolometer can lead to an immediate and unprecedented sensitivity in exploring keV-range super-light dark matter, improving the minimum detectable mass by more than three orders of magnitude over the ongoing experiments (arXiv:2002.07821). We then report the current status of doing the first experiment with existing devices fabricated for the study in arXiv:1909.05413, and briefly mention other high energy physics applications, e.g., detection of cosmic neutrino background and search for other well-motivated super-light particles such as axion, sterile neutrino, and dark photon.

Primary frontier topic

Cosmic Frontier

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