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Revealing Dark Matter under the Lens

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Unveiling the true nature of Dark Matter (DM), which manifests itself only through gravity, is one of the principal quests in physics. Leading candidates for DM are weakly interacting massive particles (WIMPs) or ultralight bosons (axions), at opposite extremes in mass scales, that have been postulated by competing theories to solve deficiencies in the Standard Model of particle physics. Whereas DM WIMPs behave like discrete particles (ρ DM), quantum interference between DM axions is manifested as waves (ψ DM). Here, we show (Amruth et al. Nature Astronomy, 2023) that gravitational lensing leaves signatures in multiply-lensed images of background galaxies that reveal whether the foreground lensing galaxy inhabits a ρ DM or ψ DM halo. Whereas ρ DM lens models leave well documented anomalies between the predicted and observed brightnesses and positions of multiply-lensed images, we show for the first time that ψ DM lens models are remarkably able to correctly predict the level of observed anomalies. More challengingly, when subjected to a battery of tests for reproducing very high angular resolution observations of quadruply-lensed triplet images in the system HS 0810+2554, ψ DM is able to reproduce all aspects of this system whereas ρ DM often fails. The ability of ψ DM to resolve lensing anomalies even in demanding cases like HS 0810+2554, together with its success in reproducing other astrophysical observations, tilts the balance towards new physics invoking axions.

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