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Classical and quantum and probes of axionlike particles

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Axionlike particles (ALPs) are among the most well-motivated extensions of the Standard Model of particle physics, and are increasingly popular dark matter candidates. Extreme astrophysical environments, such as dense and hot supernovae, or vast and magnetised galaxy clusters, provide unique opportunities to test the theory. In this talk, I will discuss recent progress in searching for ALPs using classical and quantum phenomena.

First, classical ALP-photon mixing underlies the most powerful probes of light ALPs, but often hinges on astrophysical magnetic fields that are poorly known. In this talk, I will combine theoretical arguments about the structure of ALP-photon conversion with state-of-the-art magnetic field models, including those from new magnetohydrodynamic (MHD) simulations, to test the robustness of the ALP predictions. Magnetic non-Gaussianity of MHD models leads to novel "fat tails"in the distribution of conversion probabilities, but simpler models often generate conservative predictions.

Second, quantum ALP-photon mixing can be of critical importance even for ALPs that only couple to electrons at tree-level. I will show that properly accounting for the quantum effective couplings has drastic implications for ALP dark matter searches by direct detection experiments, and leads to new, subtle predictions for ALP production in supernovae.

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