Axion phenomenology in magnetized neutron stars

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Axions are pseudo-Goldstone bosons that provide a solution to the strong CP problem [1], and are prominent candidates for dark matter. In neutron stars, it has been shown recently [2] that the potential of the QCD axion acquires finite density corrections that shift the axion field expectation value, which can be large compared to the vanishing expectation value in vacuo. Such a shift leaves an imprint on typical neutron star observables such as the redshifted thermal luminosity, which can be used to constrain the axion parameter space.

In this talk we focus on the coupling of axions with photons, which modifies Maxwell's equations and alters the neutron star magnetic field. By performing state-of-the-art magneto-thermal simulations, we calculate the axion-induced perturbations to the neutron star' magnetic field, and show that they grow on relatively short time-scales. At the same time, intense electric currents form, leading to enhanced ohmic dissipation, which increases the stars' observable thermal luminosity. The activation of such mechanisms depends on the axion decay constant and the axion mass, two long-sought parameters at the center of several experimental and theoretical investigations. Both parameters can be constrained by comparing our simulations to observations of thermally-emitting neutron stars. The latter do not exhibit uncontrolled growth of the magnetic field that causes enhanced ohmic dissipation, allowing us to place bounds on axion parameters.

Our results open a new astrophysical avenue to constrain axions, extending significantly the parameter range that can be probed with direct axion searches.

[1] R. D. Peccei and H. R. Quinn, CP conservation in the presence of pseudoparticles, *Phys. Rev. Lett.* 38, 1440 (1977).

[2] Anson Hook and Junwu Huang, *Journal of High Energy Physics*, 2018(6):36, June 2018.