Contributed Talk

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Title: The imitation game: Proca stars that can mimic the Schwarzschild shadow

Abstract: Can a \textit{dynamically robust} bosonic star (BS) produce an (effective) shadow that mimics that of a black hole (BH)? We focus on models of spherical BSs with free scalar or vector fields, as well as with polynomial or axionic self-interacting fields. The BH shadow is linked to the existence of light rings (LRs). For free bosonic fields, yielding \textit{mini}-BSs, it is known that these stars can become ultra-compact - $i.e.$, possess LRs - but only for perturbatively unstable solutions. We show this remains the case even when different self-interactions are considered. However, an effective shadow can arise in a different way: if BSs reproduce the existence of an innermost stable circular orbit (ISCO) for timelike geodesics (located at $r_{\rm ISCO}=6M$ for a Schwarzschild BH of mass M), the accretion flow morphology around BHs is mimicked and an effective shadow arises in an astrophysical environment. Even though spherical BSs may accommodate stable timelike circular orbits all the way down to their centre, we show the angular velocity Ω along such orbits may have a maximum away from the origin, at R_{Ω}; this scale was recently observed to mimic the BH's ISCO in some scenarios of accretion flow. Then: (i) for free scalar fields or with quartic self-interactions, $R_{\Omega}\neq 0$ only for perturbatively unstable BSs; (ii) for higher scalar self-interactions, $e.g.$ axionic, $R_{\Omega}\neq 0$ is possible for perturbatively stable BSs, but no solution with $R_{\Omega}=6M$ was found in the parameter space explored; (iii) but for free vector fields, yielding Proca stars, perturbatively stable solutions with $R_{\Omega}\neq 0$ exist, and indeed $R_{\Omega}=6M$ for a particular solution. {Thus, dynamically robust spherical Proca stars succeed in the imitation game: they can mimic the shadow of a (near-)equilibrium Schwarzschild BH with the same M, in an astrophysical environment, despite the absence of a LR, at least under some observation conditions, as we confirm by explicitly comparing the lensing of such Proca stars and Schwarzschild BHs.