On the motion of stars driven by scalar fields

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ABSTRACT

Ultra light scalar fields have been predicted in a variety of scenarios and advocated as a possible component of dark matter [1]. Its phenomenology includes the formation of compact regular structures - boson stars [2] - and, in the presence of a black hole, of scalar hair [3, 4]. In the latter case, the scalar field modifies the geometry of the spacetime surrounding the black hole, which gives rise to non-trivial effects on the motion of bodies orbiting it. We address this question by analysing an Extreme Mass Ratio Inspiral composed of a super massive black hole supporting an ultra light scalar field, which is orbited by a compact object (a stellar mass black hole, a neutron star or a white dwarf). Given the fact that the mass of the scalar field is very small, we use a perturbative approach to investigate its contribution to the motion of the compact object. We find that the presence of the scalar field leaves imprints on the orbital motion of the compact object, particularly it is responsible for the appearance of resonant orbits whose location depend on its mass. The existence of these resonances may enable angular momentum exchange between the scalar field and the orbiting object, giving rise to mechanisms similar to planet migration in proto-planetary discs. These effects have a direct consequence on the orbital evolution of binary systems and may be used as probes for the existence of scalar fields.

References

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