Accretion of Self-interacting Scalar Field Dark Matter Onto a Reissner Nordström Black Hole

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Abstract

Self-interacting scalar field dark matter [1] is a suitable extension of the free case known as Fuzzy dark matter [2]. The interactive case can reproduce the goodness of the free case at both astrophysical and cosmological scales and, more importantly, can avoid the stringent constraint from Lyman-alpha forest data [3]. On the other hand, the distribution of dark matter around the central part of galaxies has been the subject of intense debate in the last decade because of its possible imprint on gravitational wave signals of extreme mass ratio inspirals [4,5]. Most efforts, however, have been focused on the (colissionless) cold dark matter model, leaving thus open the possibility of tackling other well-motivated alternatives such as spin-0 bosons that give rise to Bose–Einstein condensates, or simply self-interacting scalar fields. Recently, some numerical approaches [6] and analytical treatments [7] have both investigated the accretion of free scalar dark matter onto Schwarzschild black holes.

We extend previous studies of accretion of self-interacting scalar field dark matter [8] to the Reissner Nordström black hole case under the assumption of spherically symmetric flows. Extensive numerical examples of how the black hole charge affects the accretion process are amply discussed. In particular, we demand regularity and causality in the infall radial velocity to guarantee the transonic flow of dark matter particles as in the case of standard Bondi accretion of polytropic fluids. As a main result, we find that the black hole charge reduces the energy flux up to percent level and the critical radius is, accordingly, shifted towards smaller values in comparison to the uncharged case, as can be evidenced in Figure 1. These results constitute a first attempt to describe the distribution of self-interacting scalar field dark matter in a more general class of black holes, which are of primary importance in observational perspectives of gravitational wave probes of dark matter.

Acknowledgements: L. G. G. acknowledges financial support from Agencia Nacional de Investigación y Desarrollo ANID through the FONDECYT postdoctoral Grant No. 3210417. Y. R. is supported by the following grants: Beca Interna USACH, Convenio Marco and Beca Doctorado Nacional año 2021 Folio No. 21211644. N. C. acknowledges Universidad de Santiago de Chile for financial support through the Proyecto POSTDOCDICYT, Código 043131 CM-POSTDOC.

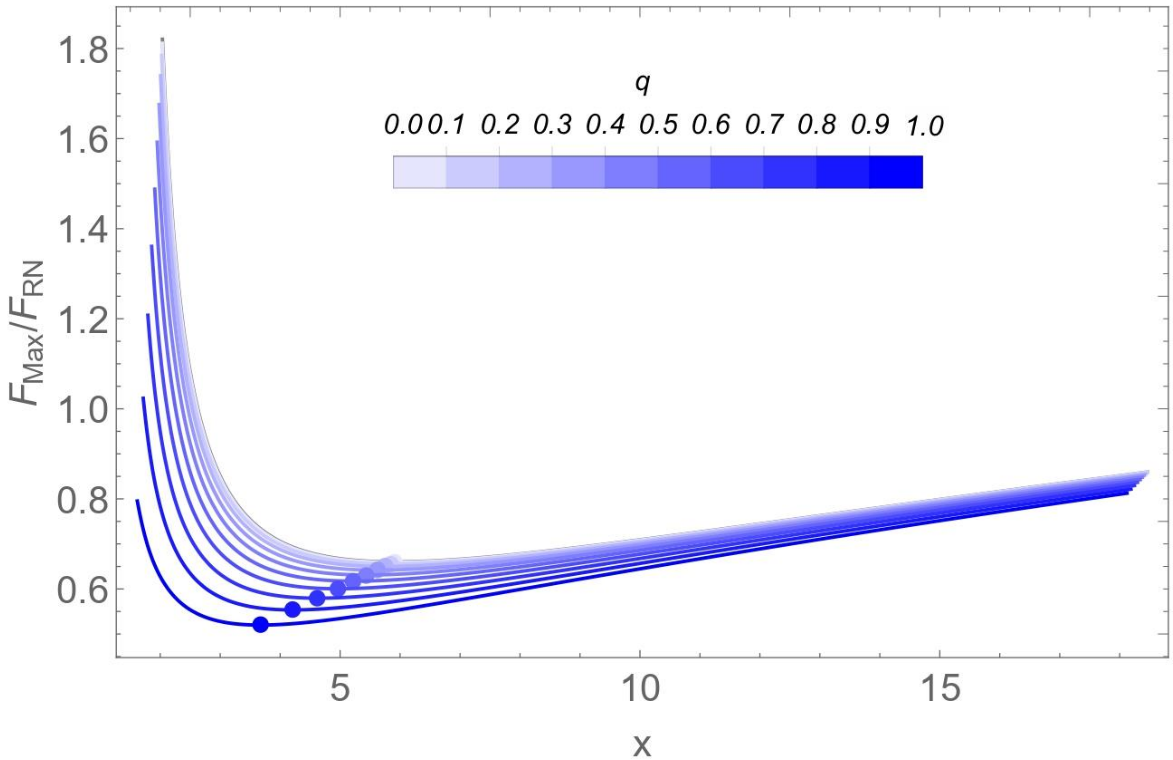

Figure 1: Normalized maximum energy flux as a function of the radial position for different charge values.

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