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The high energy search for IMBHs in close dSph Milky Way satellites

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Abstract. We analyse archival XMM-Newton and Chandra observations of some dwarf MW satellites (Leo T, Fornax, and Ursa Minor) with the aim to fully characterize the X-ray source population (in most of the cases background AGNs) detected towards the targets. We also searched for intermediate mass black holes expected to be hosted in the center of the galaxies. While for Leo T the quality of the data did not allow any useful analysis, we have hints of the existence of IMBHs in Fornax and Ursa Minor.

Key words. Galaxy: globular clusters: individual: Leo T, Fornax, Ursa Minor – X-rays: general

1. Introduction

By extrapolating the M_{BH}-$M_{\rm Bulge}$ relation (Magorrian et al. 1998) found for super massive black holes in galactic nuclei, it is expected that intermediate mass black holes (IMBHs, in the mass range $10^2 - 10^5$ $M_\odot$) exist in globular clusters and dwarf galaxies (see e.g. Maccarone et al. 2005). Following this idea, we analysed archival XMM-Newton and Chandra observations of the dwarf Milky Way satellites Leo T, Fornax, and Ursa Minor to search for high energy signatures of an accreting IMBH expected to be located in the center of the respective hosting galaxy (see Nucita et al. 2012 a,b). A preliminar analysis on Chandra data (Observation ID: 12753) from the Leo T dSph showed no clear detection at the position where the IMBH is expected to be: we can estimate only the 68% upper limit to the (unresolved) source unabsorbed 0.2-7 kev band flux to be $< 5.9 \times 10^{-16} erg s^{-1} cm^{-2}$. This flux corresponds to a luminosity limit of $L_X \simeq 1.2 \times 10^{34} erg s^{-1}$ for a distance to the galaxy of $\simeq$ 420 pc. Using the fundamental plane of black hole accretion (Merloni et al. 2003) and the observed X-ray luminosity, it would be possible to get an estimate of the IMBH mass (if any) if a moderately deep radio observation will be performed. In the case of the Fornax dSph, Jardel & Gebhardt (2012) recently constructed axisymmetric Schwarzschild models in order to estimate the mass profile of the dwarf galaxy and, once these models were tested versus the available kinematic data, it has been possible to put a 1-σ upper limit of $M_{BH} = 3.2 \times 10^4$ $M_\odot$ **on** the IMBH mass.

By using a rather restrictive analysis, we detected 107 X-ray sources (most of them be-

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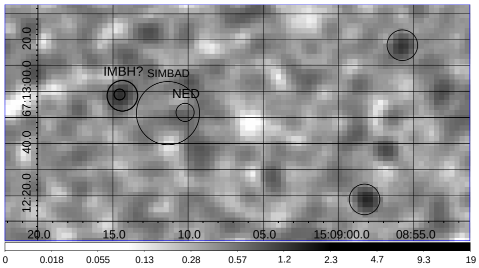

Fig. 1. The circle labeled as SIMBAD is located at the galaxy center and has a radius of $\simeq$ 12.2″ - for comparison, we also show the galaxy center (with a positional error of $\simeq$ 3.5″) as reported by NED. The circle labeled as IMBH (having radius of 5″ and position error of $\simeq$ 0.52″) is located on the X-ray source detected in our analysis while the smaller circle represents the position of the radio source 150914+671258 found in the NVSS catalogue.

ing background objects). However, we can not exclude that a few of the detected objects belong to the Fornax dSph, as also clear when comparing the $0.2-2.4$ keV and the NIR (J band) fluxes with the J-K colour for the X-ray sources with a counterpart in the 2MASS catalogue. We also confirm the analysis of Orio et al. 2010 who claimed that a few sources are associated with the GC 3 and GC 4 globular clusters in Fornax. Finally, we searched for the Fornax IMBH and found that one of the X-ray sources might be associated with one of the possible galaxy centroids identified by Stetson et al. (1998). In this framework, we estimated the IMBH accretion parameter (assuming a spherical accretion scenario) to be $\epsilon\eta \simeq 10^{-5}$. As far as Ursa Minor is concerned, the target is one of the nearest (its distance is 73 ± 11 kpc, as reported by NED), most diffuse and massive ($M \simeq 2.3 \times 10^7$ M$_\odot$) among the Milky Way dwarf satellites. As shown by N-body numerical simulations (Lora et al. 2009), it may host a central IMBH with upper limit of $(2-3)\times10^4$ M$_\odot$ which is consistent with the estimate obtained by extrapolating the $M_{BH}-\sigma$ relation. We searched for signatures from the IMBH possibly hosted in its center identifying an X-ray source (with estimated unabsorbed flux in the 0.5-7 keV band of $\simeq 5.0 \times 10^{-15}$ erg s^{-1} cm^{-2}). Altough the confidence of the X-ray detection is as low a 2.5σ, the source is spatially coincident (see Figure 1) with a radio source (having flux density of $\simeq$ 7.1 mJy at 1.4 GHz) already observed in the NRAO VLA Sky Survey (see Maccarone et al. 2005). In the black hole scenario, the fundamental plane relation involving the black hole mass, the X-ray and the radio luminosities allows us to estimate a mass of the putative compact object to be $(2.9^{+33.6}_{-2.7}) \times 10^6$ M$_\odot$ (being still compatible -altough at its lower bound- with the IMBH scenario), which seems to radiate at a very tiny fraction of the associated Eddington luminosity. By using webPIMMs and assuming a power law model with spectral index $\Gamma = 1.7$ and absorption column density $N_H = 2.2\times 10^{20}$ cm^{-2}, we evaluated the minimum detectable unabsorbed flux (at a level of 1σ) to be $F^{Una}_{0.5-7\ \rm keV} \simeq 1.5\times10^{-15}$ erg s^{-1} cm^{-2} which corresponds to a flux of $F^{Una}_{0.5-2\ \rm keV} \simeq 6.6 \times 10^{-16}$ erg s^{-1} cm^{-2} in the 0.5-2 keV band. Thus the log N - log S diagram (Hasinger et al. 2005) allowed us to evaluate the expected number of background AGNs whithin $\simeq$ 25″ from the UMi dSph center which turns out to be $\simeq$ 0.15. Hence, the background AGN scenario cannot be completely excluded.

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