Dwarf spheroidal galaxies in X-rays

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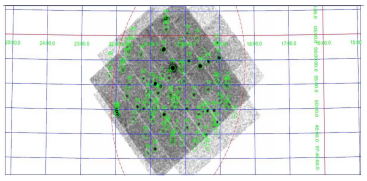
We report the results of archive XMM-Newton and Chandra observations of some dwarf spheroidal galaxies (Draco, Fornax, Leo I, Leo T, Ursa Major II and Ursa Minor) that stand in Milky Way neighbourhood. Their X-ray source population is fully characterized and cross-correlated with the available databases and colour-colour diagrams are used. Data analysis of the deep X-ray observations allows us to infer the possible nature for the sources. We also search for the intermediate-mass black holes (IMBHs) expected to be hosted in the centre of this kind of galaxies. At least in one case (Ursa Minor), we identify an X-ray object at the galaxy centre and classify it as an IMBH since it also correlates with a radio source.

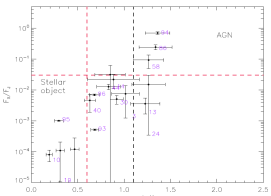
Draco dSph

[Distance~76 kpc $T_{exposure}$**~90 ks]**



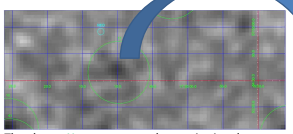
0.3 – 10 keV XMM-Newton Image

96 sources
5 possible local objects after
cross-correlation with others catalogues



For the entire catalogue of sources, see Manni et al. (2014).

IMBH ?



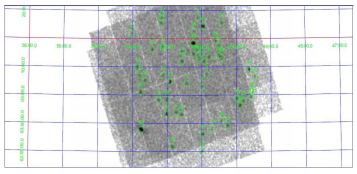
The closest X-ray source to the gravitational centre.

$$L^{Unabs}_{0.2-12keV} \simeq 4.98 \times 10^{33}\ erg\ s^{-1}$$

$$M_{BH} \simeq \frac{2.4}{\sqrt{\epsilon\eta}} \times (10^1 - 10^2)\, M_\odot$$

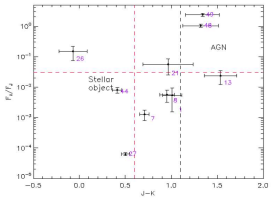
Ursa Major II dSph

[Distance~34 kpc $T_{exposure}$**~34ks]**



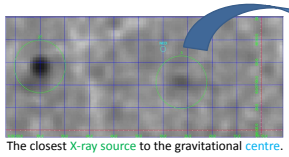
0.3 – 10 keV XMM-Newton Image

49 sources
4 possible local objects after
cross-correlation with others catalogues



For the entire catalogue of sources, see Manni et al. (2014).

IMBH ?



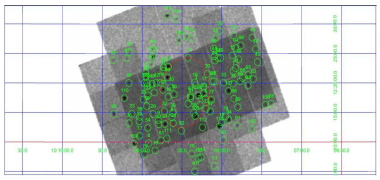
The closest X-ray source to the gravitational centre.

$$L^{Unabs}_{0.2-12keV} \simeq 1.05 \times 10^{33}\ erg\ s^{-1}$$

$$M_{BH} \simeq \frac{1.1}{\sqrt{\epsilon\eta}} \times (10^1 - 10^2)\, M_\odot$$

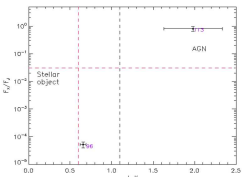
Leo I dSph

[Distance~242 kpc $T_{exposure}$**~90 ks]**



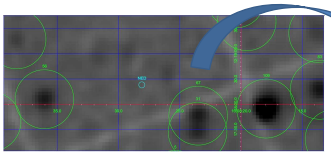
0.3 – 10 keV XMM-Newton Image

116 sources
16 possible local objects after
cross-correlation with others catalogues



For the entire catalogue of sources, see Manni et al. (2014).

IMBH ?



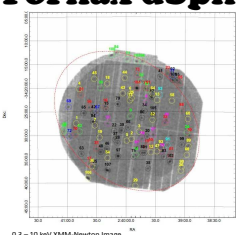
The closest X-ray source to the gravitational centre.

$$L^{Unabs}_{0.2-12keV} \simeq 2.45 \times 10^{34}\ erg\ s^{-1}$$

$$M_{BH} \simeq \frac{5.2}{\sqrt{\epsilon\eta}} \times (10^1 - 10^2)\, M_\odot$$

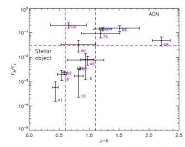
Fornax dSph

[Distance~138 kpc $T_{exposure}$**~100ks]**



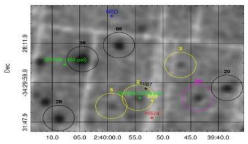
0.3 – 10 keV XMM-Newton Image

107 sources (1 variable star)



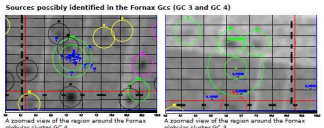
Color-color diagram for the X-ray sources of our sample with a counterpart in the 2MASS catalog (see text for details).

For the entire catalogue of sources, see Nucita et al. (2013).



Zoomed view around the Fornax dSph center. The diamonds indicate the global centroids of the galaxy obtained by several authors. In particular, the green diamonds (with labels *SHS98 500 pxl* and *SHS98 2000 pxl*) correspond to the galaxy centers obtained by Stetson et al. (1998), the red and black diamonds indicate the centroids as derived by Hodge & Smith (1974) and Demers & Irwin (1987), respectively (see text for details).

Sources possibly identified in the Fornax Gcs (GC 3 and GC 4)



A zoomed view of the region around the Fornax globular cluster GC 4.

A zoomed view of the region around the Fornax globular cluster GC 3.

We found few X-ray sources, located within the tidal radii of these two GCs, possibly associated to them as already noted by Orio et al., 2010. In the case of GC3, source 96 is unlikely to be associated.

Furthermore, we detected a source possibly associated, within 2", to one (J023941.4-343340) belonging to a catalog of variable stars (Bersier & Wood, 2002)

IMBH !?

For a Bondi accretion, i. e.

$$L_X \simeq \epsilon\eta 8\times10^{38}\left(\frac{M_{BH}}{10^3\,M_\odot}\right)^2\left(\frac{V}{15\ km\ s^{-1}}\right)^{-3}\left(\frac{n}{0.1\ cm^{-3}}\right)\ erg\ s^{-1}\ cm^{-2}$$

assuming an IMBH upper limit of $M_{BH} = 3.2\times10^4\ M_\odot$

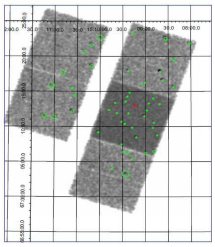
and using the observed luminosity $L_X \simeq 1.4\times10^{34}\ erg\ s^{-1}$

we obtained $L_X/L_{Edd} \simeq 3\times10^{-9}$

It implies that the putative IMBH must be extremely radiatively inefficient.

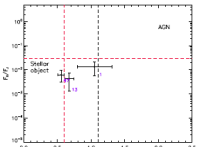
Ursa Minor dSph

[Distance~72 kpc $T_{exposure}$**~27 ks]**

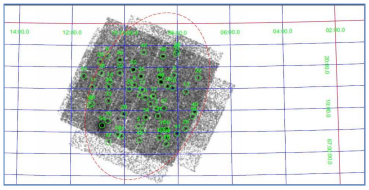


0.5 – 7.0 keV Chandra Image

For the entire catalogue of sources, see Manni et al. (2014).

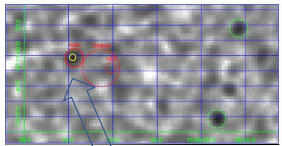


54 sources
2 possible local objects after
cross-correlation with others catalogues

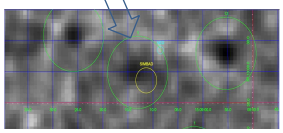


0.3 – 10 keV XMM-Newton Image

The closest X-ray source to the gravitational centre.



Chandra detection on a radio (5 GHz) source.



XMM-Newton confirms Chandra detection.

IMBH !

$$L^{Un\ Chandra}_{2-10keV} \simeq 2.4\times10^{33}\ erg\ s^{-1}$$

$$M^{Chandra}_{BH} = (2.9^{+3.6}_{-2.7})\times10^6\ M_\odot$$

$$L^{Un\ XMM-Newon}_{2-10keV} \simeq 2.5\times10^{33}\ erg\ s^{-1}$$

$$M^{XMM-Newon}_{BH} = (2.76^{+32.00}_{-2.54})\times10^6\ M_\odot$$

Leo T

[Distance~411 kpc]

A preliminar Chandra data analysis from this far dSph (distance > 400 kpc) showed no clear detection of an high-energy source at the galaxy centre, where an IMBH is expected to be.

We can only estimate a 1σ (68%) upper limit to the source, although unresolved, unabsorbed 0.2-7.0 keV flux to be 5.9 x 10 -16 erg s^{-1} cm^{-2}.

References:

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