Study of the X-ray Source Population and the Dark Matter Halo in Dwarf Spheroidal Galaxies

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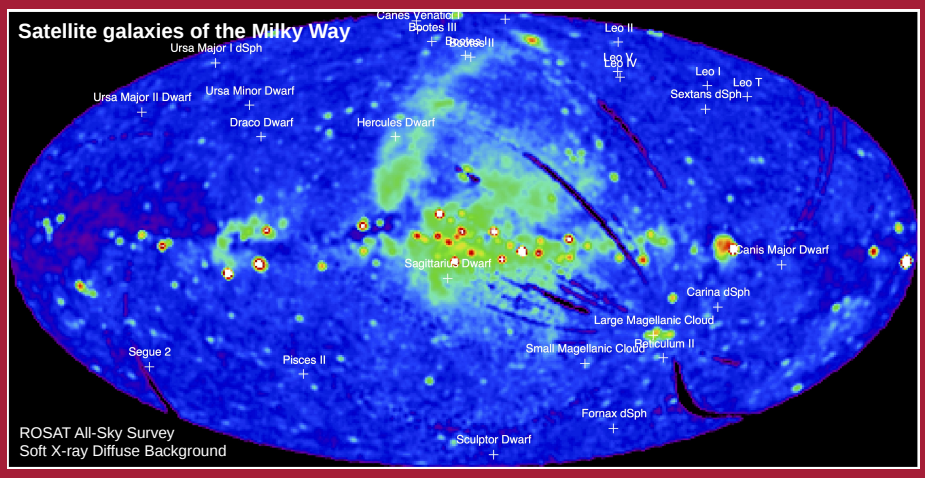
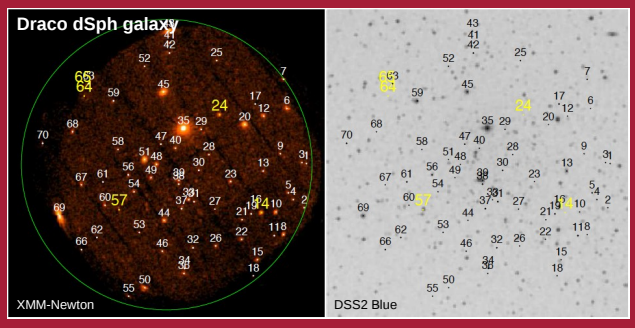


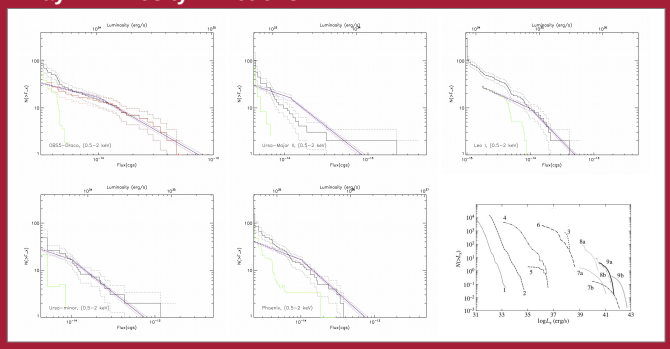
The **Local Group** of galaxies consists of the large spiral galaxies, Milky Way, M31, and M33, and a large number of dwarf galaxies. Most of the dwarf galaxies are dwarf spheroidal (dSph) galaxies, which are the least luminous galaxies with the largest mass-to-light ratios. In general, dSphs show no recent star formation, which means that they are ideal laboratories to study the old, pristine stellar populations formed in the earliest epochs of chemical enrichment of the Universe.

Observations with today's X-ray telescopes have revealed X-ray sources in the fields of the dSphs that are satellites of our Milky Way. The study of X-ray source population in these galaxies and their **X-ray luminosity function** will help us to trace back the sources that were formed ~1 - 10 Gyrs ago and thus understand the source population in galaxies at the early stages of galaxy evolution.



X-ray sources in Draco dSph detected with XMM-Newton (Saeedi et al., 2015, A&A, submitted) on broad band (0.3 – 12.0 keV) image (left) and Digitized Sky Survey 2 Blue image (right). X-ray binary candidates are marked in yellow.

X-ray Luminosity Functions



Cumulative X-ray luminosity functions (CXLFs) of Draco dSph, Ursa Major II dSph, Ursa Minor dSph, Leo I dSph, and Phoenix dwarf galaxy (based on XMM-Newton data). Black lines show the CXLFs without foreground stars. Red lines show the CXLFs of the identified AGNs, while the blue lines were calculated from the AGN CXLFs of Cappelluti et al. (2009, A&A, 497, 635). Green lines show the CXLFs of the dwarf galaxies after subtracting the contribution of the AGNs. The lower right diagram shows the XLFs of X-ray binaries calculated by Bogomazov & Lipunov (2008, Astronomy Reports, 52, 299). Models 1, 2, 3, 4, and 7 are binaries with accreting neutron stars. Models 5, 6, 8, and 9 are black hole binaries.

Dark Matter Halo Mass

The existence of X-ray binaries in these galaxies, if confirmed, would indicate that these galaxies are able to retain their compact objects, which are believed to obtain high kick velocities at their birth in asymmetric supernova explosions. Therefore, the search for and the study of X-ray sources in dSph galaxies in the Local Group will enable us to constrain the mass of dark matter in these galaxies and test different models of the formation and growth of galaxies out of primordial dark-matter halos.

The stellar mass of Draco dSph is 3 x 10^5 M_{Sun}. We have detected four X-ray binary candidates and 16 additional hard sources which are likely candidates. Compact objects usually obtain natal kick velocities higher than ~100 km/s. In order to keep the X-ray binaries in these low-stellar mass, faint dwarf galaxies, dark matter halo masses of the order of ~10^8 M_{Sun} are necessary, corresponding to a mass-to-light ratio of a few 100 $(M/L)_{Sun}$.

Observation of dwarf galaxies in the Local Group with Athena Wide-Field Imager

Owing to the large effective area, large field of view, and high spatial and time resolution, the Wide Field Imager of the Athena X-ray Observatory will make it possible to study X-ray sources down to very low flux limits. In Draco dSph, e.g., we will be able to observe X-ray sources with luminosities down to 10^{31} erg/s with 1000 to 2000 counts in 10 ksec, allowing not only a detection but also spectral analysis of each source. Objects emitting X-rays at these luminosities are X-ray binary systems with a neutron star and a main-sequence companion or binary systems with white dwarfs.

We will hence obtain unprecedented observational data of the stellar populations in primordial galaxies and dark-matter halo distribution in our Local Group through the study of high-energy sources.

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