The Discovery of Quasisoft and Supersoft Sources in External Galaxies

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abstract

We apply a uniform procedure to select very soft sources from point sources observed by Chandra in 4 galaxies. This sample includes one elliptical galaxy (NGC 4967), 2 face-on spirals (M101 and M83), and an interacting galaxy (M51). We report on some intriguing results, including the following.

(1) We have found very soft X-ray sources (VSSs) in every galaxy. Some of these fit the criteria for canonical supersoft sources (SSSs), while others are somewhat harder. These latter have characteristic values of $kT \lesssim 300$ eV; we refer to them as quasisoft sources (QSSs). We found a combined total of 149 VSSs in the 4 galaxies we considered; 77 were SSSs and 72 were QSSs.

(2) The data are consistent with the existence of a large VSS population, most of whose members we cannot observe due to the effects of distance and obscuration. The total VSS population of sources with $L > 10^{37}$ erg s\textsuperscript{-1} in each galaxy could be on the order of 1000.

(3) Whereas in M31 only $\sim 5 - 10\%$ of all X-ray sources detected by Chandra are VSSs, more than 35\% of all detectable X-ray sources in the face-on galaxy M101 fit the phenomenological definition of VSSs. This difference may be due to differences in $N_H$ between typical lines of sight to sources in each galaxy.

(4) SSSs can be super-Eddington.

(5) We find evidence for SSSs and QSSs with luminosities $10^{36}$ erg s\textsuperscript{-1} $< L < 10^{37}$ erg s\textsuperscript{-1}. These sources have luminosities lower than those of the $\sim 30$ soft sources used to establish the class of SSSs.

(6) In the spiral galaxies M101, M83 and M51, a large fraction of the SSSs and QSSs appear to be associated with the spiral arms. This may indicate that some SSSs are young systems, possibly younger than $10^8$ years.

(7) In addition to finding hot white dwarfs and soft X-ray binaries, our method should also be efficient at selecting supernova remnants (SNRs). A small fraction of the VSSs in the spiral arms of M101 appear to be associated with SNRs.