Luminosity Function of X-ray Sources in Nearby Galaxies

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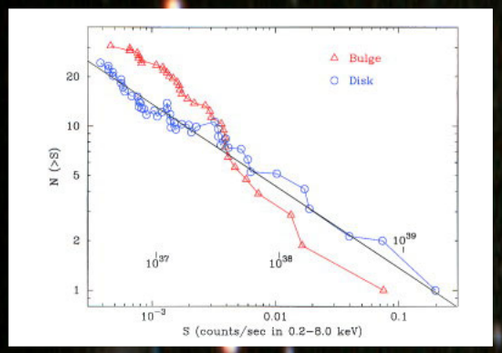

Figure 1.
log N(>S) – log S curves of the bulge and disk X-ray sources in M81 (Tennant et al. 2001)

Birth-death model for X-ray binary populations

Assumptions:

1. Formation of X-ray binary populations can be continuous (due to aging of the stellar populations or due to continuous star formation) or impulsive (due to a starburst)
2. more luminous X-ray binaries have shorter life spans

Results:

1. Luminosity break can be produced when an X-ray binary population ages; luminosity break can also be produced when a source population has a limiting luminosity, such as the Eddington luminosity of accreting neutron stars. Bulges of spiral galaxies and early-type galaxies are dominated by old LMXBs.
2. Power-law log N(>S) - log S curves of the disk sources in spiral galaxies and of sources in interacting/starburst galaxies are due to continuous star formation. X-ray source populations of these galaxies are dominated by young HMXBs.
3. There is a faint primordial X-ray binary population, which can be detected in galaxies with low star-formation activities throughout the Hubble time (e.g. dwarf spheroids).
4. Luminosity break can be used as an age indicator for disk spiral galaxies.

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Wu, 2001, Publ. Astron. Soc. Aus., 18, 443

log N(>S) - log S of nearby galaxies

Chandra observations show that nearby galaxies host hundreds of discrete X-ray sources (see Fabbiano 2003). Different morphologies are found in the log N(>S) – log S curves for early- and late-type galaxies and for different galactic components within spiral galaxies. Luminosity breaks are obvious in the log N(>S) – log S curves of the bulge sources of the spirals, e.g. M31 (Kong et al. 2002) and M81 (Tennant et al. 2001), but the log N(>S) – log S curve of sources in spiral disks and in interacting galaxies is a power law (Tennant et al. 2001, Grimm et al. 2002). This indicates different proportions of X-ray binaries (LMXBs vs HMXBs) and other X-ray sources among galaxies and among components within the galaxies.

Luminosity functions of model galaxies

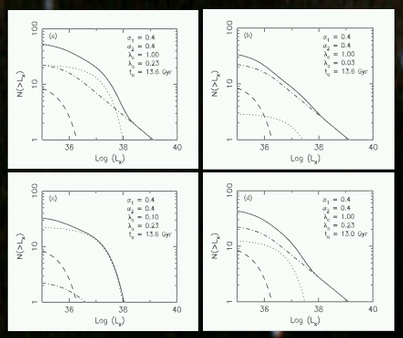

Figure 2.
Integral luminosity function N(>S) of X-ray binaries in a galaxy with an age of 15 Gyr. Populations of neutron-star and black-hole binaries are not considered separately. (a) The starburst episode occurred 0.4 Gyr ago. The strengths of the continuous- and impulsive-formation components are comparable. (b) Same as (a) except that the continuous-formation component dominates. (c) Same as (a) except that the impulsive-formation component dominates. (d) Same as (a) but the starburst episode occurred 1.0 Gyr ago.
solid line: total population
dotted line: impulsive formation component
dot-dashed line: continuous formation component
dashed line: primordial population

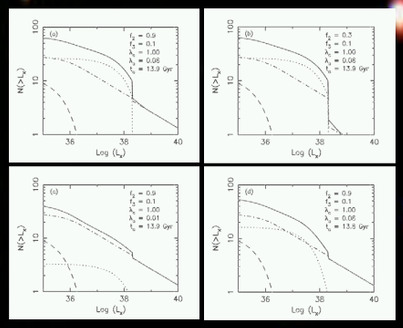

Figure 3.
Integral luminosity function N(>S) of X-ray binaries in a galaxy with an age of 15 Gyr. Populations of neutron-star and black-hole binaries are considered separately with the black-hole proportions in the continuous- and impulsive-formation components specified by f2 and f3 respectively. (a) Starburst occurred 0.1 Gyr ago; f2=0.9 and f3=0.1. (b) Same as (a) except f2=0.3 and f3=0.1. (c) Same as (a) except that the impulsive component is weak. (d) Same as (a) except that the starburst occurred 0.2 Gyr ago.

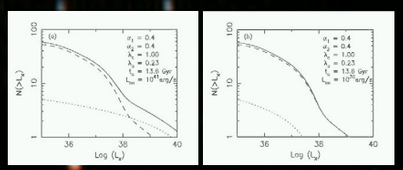

Figure 4.
Contamination of the luminosity function due to the presence of supernova remnants (represented by the dotted line). The intrinsic luminosity function (dashed line) is the same as in Figure 1a. (a) The initial brightness of supernova remnants is 10^{41}erg s^{-1}. (b) The initial brightness of supernova remnants is 10^{38}erg s^{-1}.