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XSINGS: probing X-ray binaries in galaxies

Chandra observations and supercomputer simulations

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Abstract. We present the largest population synthesis study of X-ray binaries (XRBs) in nearby galaxies to date. We consider an extensive set of physically motivated models for formation and evolution of binaries with the population synthesis code `StarTrack`. We convolve them with star formation histories obtained with SED modelling (Noll et al. 2009) and construct theoretical X-ray binary luminosity functions (XLFs) for a subset of nearby galaxies in the Spitzer Infrared Nearby Galaxy Sample (SINGS). We also construct observational XRB-XLFs for these galaxies from XSINGS, the extension of SINGS in the X-rays with *Chandra*. Using a likelihood approach, we identify models that produce XLFs consistent with the observations, providing constraints for XRB formation and evolution.

Key words. binaries: close galaxies: spiral stars: evolution X-rays: binaries

1. Introduction

Population synthesis (PS) models of XRBs can be convolved with star formation histo-

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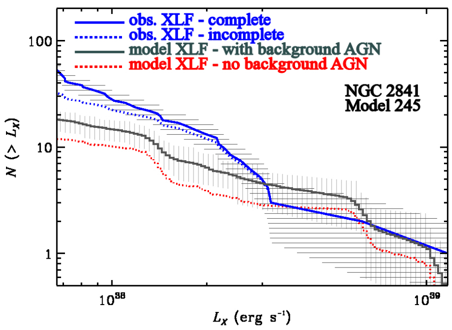

Fig. 1. mXLF and oXLF for galaxy NGC 2841. The best model is shown by the grey line.

ries (SFHs) for specific galaxies to construct model luminosity functions of XRBs in galaxies (mXLFs). When these are compared with observationally obtained XLFs (oXLFs) one can constrain the physical parameters that are input to the PS models. Thus effectively our understanding at the *stellar scale* is improved via information obtained at the *galactic* and *extragalactic* scale.

2. Observations and simulations

We used 12 galaxies from the diverse sample of the Spitzer Infrared Nearby Galaxy Survey (SINGS, Kennicutt et al. 2003) observed in the X-rays as part of the large *Chandra* program XSINGS. After standard data reduction, we produced lists of X-ray point sources using CIAO WAVDETECT and ACIS EXTRACT (AE, Broos et al. 2010). Completeness corrections were computed using the method of Zezas et al. (2007). We thus obtained oXLFs for all galaxies, shown as light gray curves in Fig. 1. We used `StarTrack` (Belczynski et al. 2008) to carry out high-performance computing simulations and construct a grid of 288 PS models and 9 metallicities to follow the evolution of 5.12×10^6 stars over 14 Gyr per model. Varied physical XRB parameters include, among others, $\lambda\alpha_{\rm CE}$, the product of common envelope ejection efficiency and central donor concentration, $\eta_{\rm wind}$, the stellar wind strength, the IMF slope, as well as the distribution of binary initial mass ratios, q. We scale XRB numbers in each look-back time window by convolving models with SFHs from Noll et al. (2009), thus producing mXLFs, shown as dark gray curves in Fig. 1. We also corrected these for the expected AGN background contribution (Kim et al. 2007).

3. Results

We compare each oXLF with all mXLFs by calculating a 'pair likelihood' for each galaxy-model pair. For ~half of the galaxies, we match oXLFs with a best mXLF. For each `StarTrack` model, we also calculate a 'global likelihood' over all galaxies, effectively smoothing out uncertainties introduced by individual galaxy SFHs. All best models, both for pairs and globally, strongly support $\lambda\alpha_{\rm CE}$ values of $\simeq$ 0.1 and mixed q distributions (half flat, half 'twins'). IMFs have high-end slopes of -2.35 or -2.7. The $\eta_{\rm wind}$ range is $\simeq 1.0-2.0$. beginfigure[] Remarkably, our best *global* model 245 is the same as in independent work that applies the same models to the high-redshift Universe (Fragos et al. 2013; Tremmel et al. 2013), suggesting that we our starting to constrain the physics of XRB populations over all cosmic time.

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