The LMXB population of local early-type galaxies: implications for the IMF

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We present the LMXB population of eight local early-type galaxies and their globular clusters. We use these data to test for previously proposed systematic variations in the IMF of a galaxy, as a function of its mass. The number of LMXBs in these galaxies is found to scale with stellar light and we derive a formation efficiency of \(\sim 1\) LMXB (with \(L_{\text{X}} > 2 \times 10^{37} \text{erg/s}\)) per \(10^9 \text{M}_\odot\). These galaxies are consistent with an invariant IMF for stellar masses greater than \(\sim\)solar.

### Background: a variable IMF?

The stellar IMF is fundamental to many branches of astrophysics. Recent studies have reignited the debate over the IMF by suggesting that, for early-type galaxies, it varies systematically with galaxy mass. Evidence includes:
- stellar absorption lines (e.g. van Dokkum & Conroy 2010, 2011, Conroy & van Dokkum 2012, La Barbera et al. 2013, Macci\text{"o}ri et al. 2014)
- dynamical studies (e.g. Cappellari et al. 2012)

LMXBs can probe the IMF!

The number of LMXBs formed, per stellar light, provides a unique probe of the more massive end of the IMF specifically we measure the ratio of massive stars formed with \(M \geq 8 \text{M}_\odot\) (now evolved in to neutron stars or black holes) to stars now dominating the stellar light (those with slightly sub solar masses).

### The LMXB populations

A clean sample of field LMXBs was produced by identifying the optical counterparts to AGN and globular cluster LMXBs. For each galaxy, we scale the number of LMXBs by the K-band stellar light covered.

Figure 1 shows that the scaled XLF for each galaxy is generally similar. Figure 2 shows the scaled number of field LMXBs in each galaxy vs. the galaxy mass. The galaxies have a similar average formation efficiency of \(\sim 1\) LMXB (with \(L_{\text{X}} > 2 \times 10^{37} \text{erg/s}\)) per \(10^9 \text{M}_\odot\).

### Effect of IMF variations on LMXBs

We consider how the number of LMXBs produced varies under three proposed IMF models, where the IMF is:
- Kroupa like at low mass, but becomes increasingly top heavy reaching an \(x=-2.8\) at high mass (blue line)
- Kroupa like at low mass, but becomes increasingly bottom heavy reaching an \(x=-1.5\) at high mass (red line)
- invariant: here the number of LMXBs simply scales with the number of stars (and hence with \(L_{\text{X}}\))

An invariant IMF favored ...

Inconsistent IMF begins to appear at high masses (the fit is worse, discrepant at 2.1 \(\sigma\) above background AGN). For all galaxies the X-ray sources (red points) are taken from published catalogs: Pasinetti ca. (2011), Treu ca. (2008, 2009), Joseph (2013), Li ea. (2010), Lio ea. (2013), Sivakoff ca. (2008), Gultekin ca. (2012) and see also Maraston et al. (2010). Constraints on IMF: The LMXB populations of these galaxies favor an invariant IMF, but are also consistent with a top heavy IMF. Bottom heavy IMFs with single steep power laws are rejected (breaks in the IMF could produce the observed invariant IMF at higher masses and keep proposed variability for only very low mass stars).

Future: New, deep, Chandra observations (particularly of lower mass galaxies) will enable sharper tests in the future. Such observations are being taken in cycles 15 (PI Lehmer) and 16 (PI Peacock).

### Conclusions

See Peacock et al. (2014) for more details.