Are Field X-ray Binaries Formed in Clusters?

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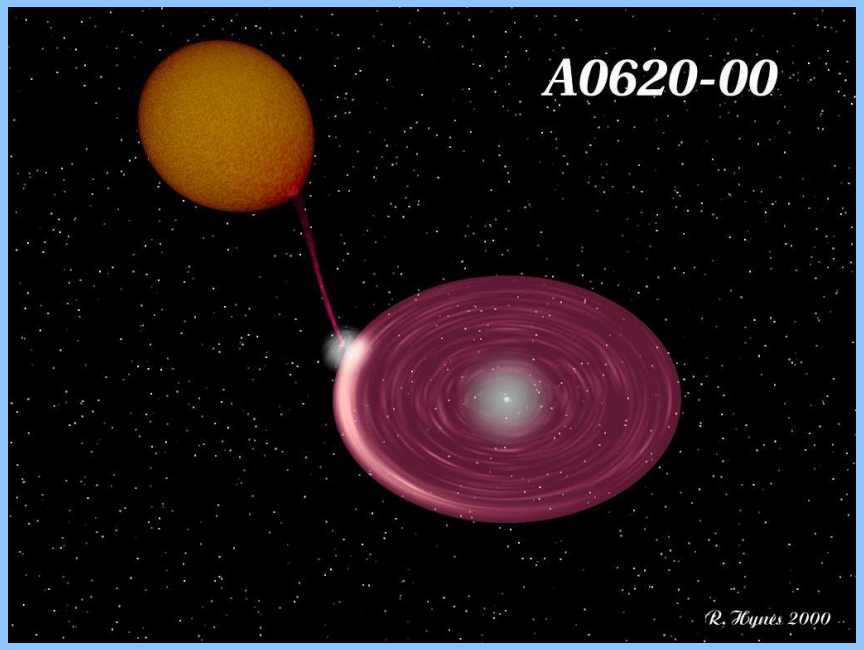
Low Mass X-ray Binaries

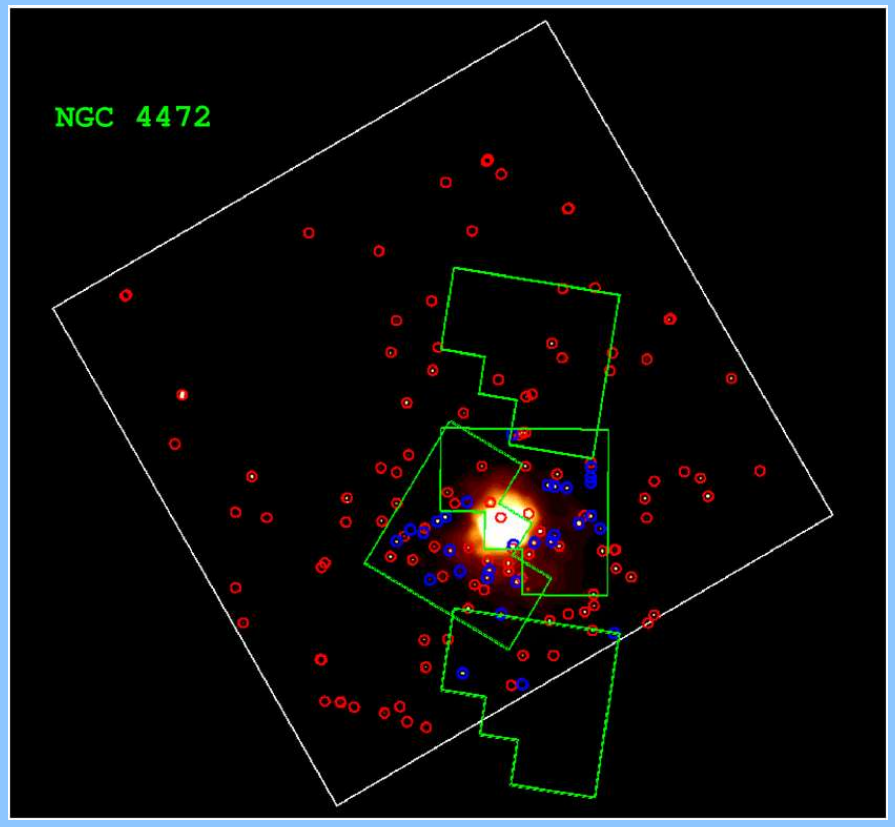


- Compact object (NS/BH) accreting mass from a low mass companion.
- Mass accretion by Roche Lobe overflow.
- $L_X \geq 10^{36}$ ergs/s (qLMXBs $L_X \geq 10^{34}$ ergs/s).
- Upper bound on lifetime of ~300 million years for $L_X \sim 10^{37}$ ergs/s.
- Found in both old and young stellar systems.
- Bright LMXBs are factors of a few hundred times more abundant in GCs as compared to the field.

How do LMXBs form?

- Evolution of isolated binary star systems with very favourable initial conditions.
- Tidal captures or N>2 body process in the dense environment of clusters (Clark 1975; Fabian et al. 1975; Hills 1976 etc.).
- Accretion may start immediately, or later when companion star evolves off the main sequence (Piro & Bildsten 2001).

LMXBs and GCs in NGC 4472



Kundu, Maccarone & Zepf (2002)

- 40% of LMXBs are in GCs.
- 4% of GCs host LMXBs
- r.m.s. of matches is better than 0.3 arcsecs.

Fractions of (bright) LMXBs in GCs

MW: ~5-10%

NGC 3115: ~25%

NGC 3379: ~25%

NGC 4594: ~30%

NGC 4365: ~35%

NGC 4472: ~40%

NGC 4649: ~50%

NGC 1399: 60%

- On face values the fraction of LMXBs in GCs appears to be roughly a function of Hubble type.

Fractions of GCs hosting LMXBs

MW: ~1-4%

NGC 3115: ~6%

NGC 3379: ~10%

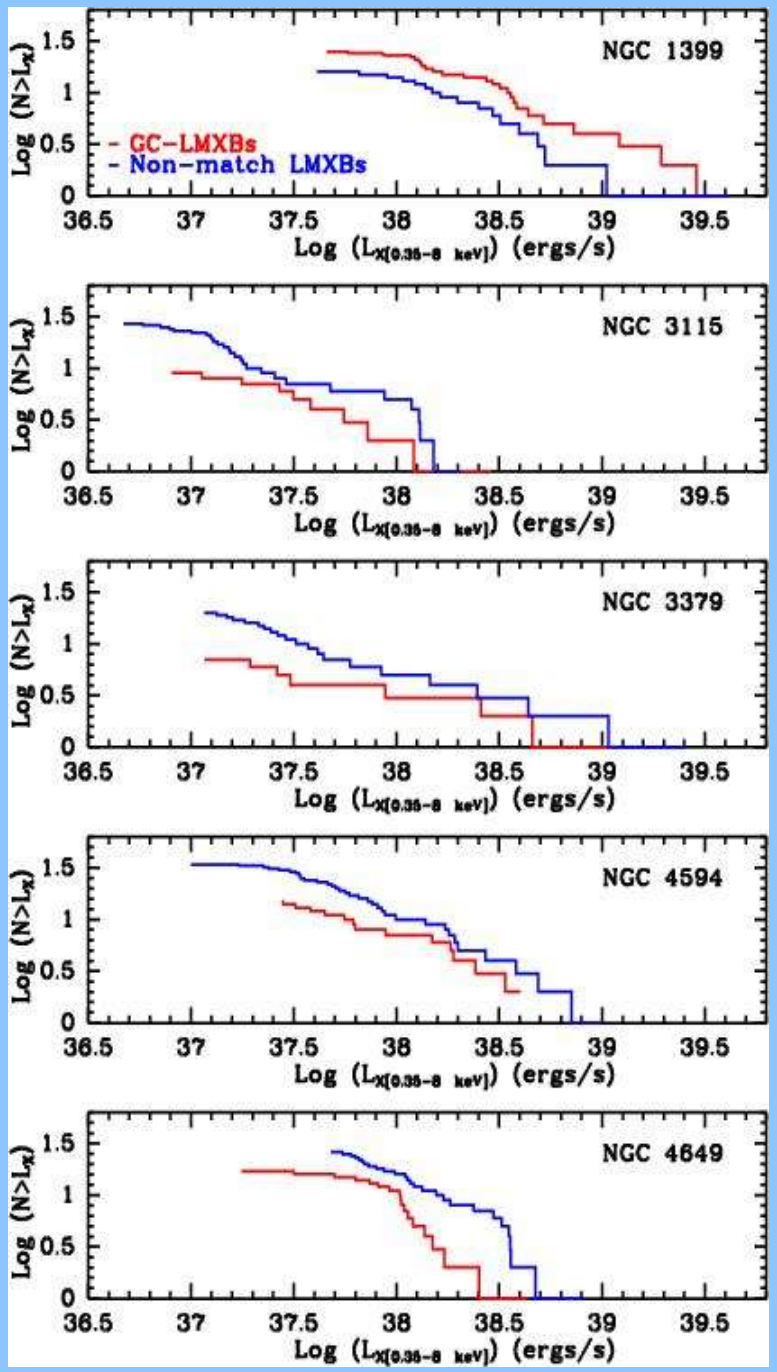
NGC 4594: ~7%

NGC 4365: ~5%

NGC 4472: ~4%

NGC 4649: ~4%

NGC 1399: ~4%

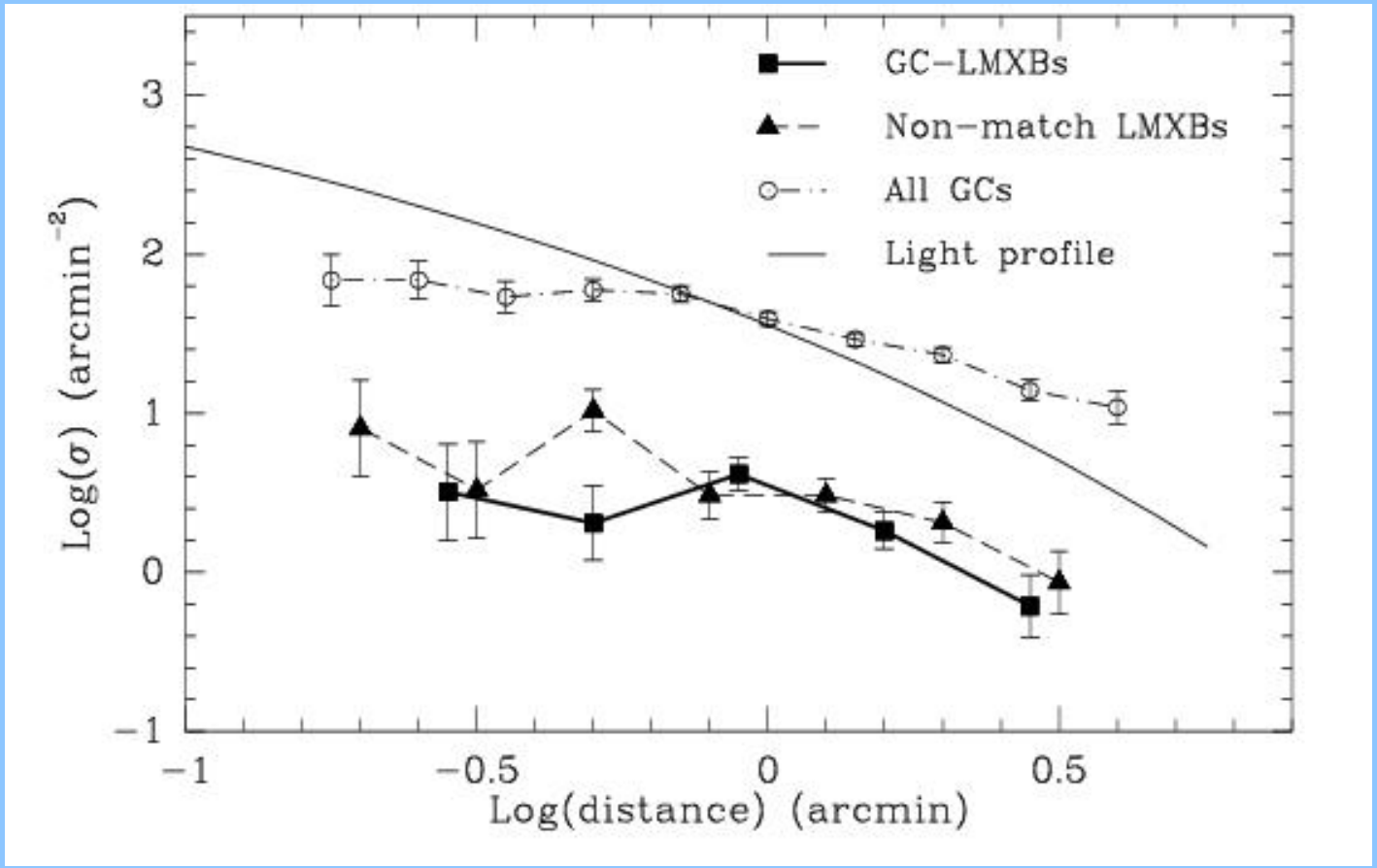


Log N – Log S curves

How are field LMXBs formed?

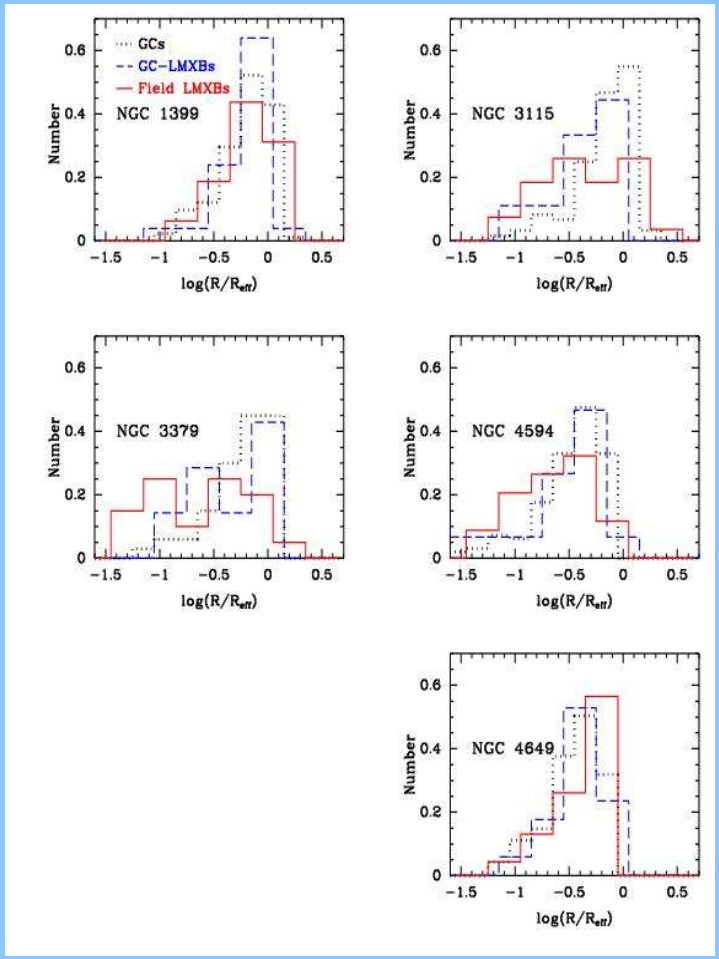
- In situ formation is problematic because SN explosion can ionize the binary
  - Common envelope evolution which ejects much of the mass of the progenitor before SN explosion
  - Finely tuned asymmetric velocity kicks.
  - Ultracompact X-ray binaries (NS/BH accreting from WD) (Bildsetn & Deloye 2004)
  - Low duty cycle transients (Piro & Bildsten 2002)
- Binaries ejected from globular clusters due to interactions.
- Remnants of globular cluster destruction processes.

Distinguish between scenarios by using spatial distribution of LMXBs, GCs and Galaxy light.

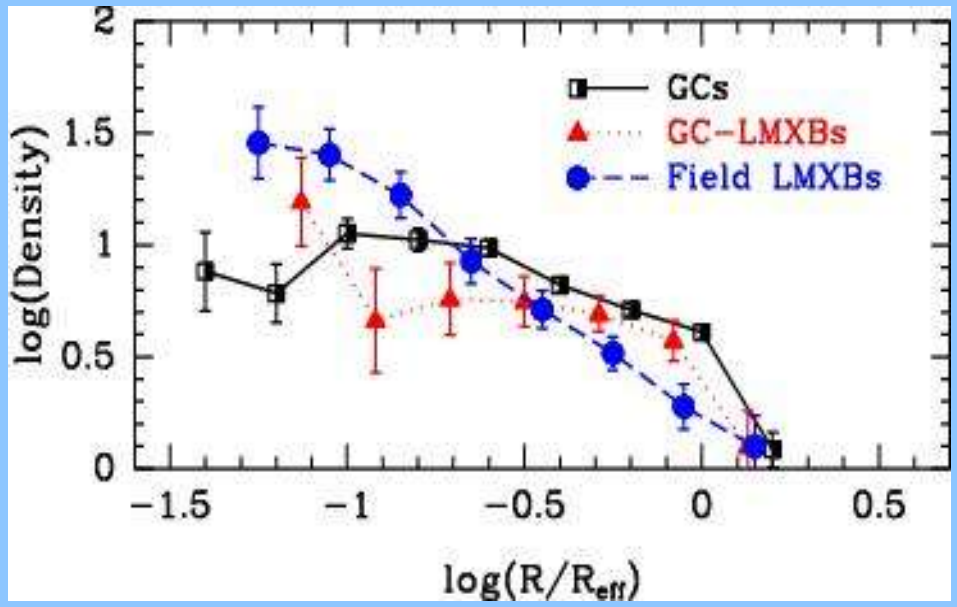


X ray properties of field and GC LMXBs appear to be similar

Spatial distribution of LMXBs



NGC 1399 + NGC 3115 + NGC 3379 + NGC 4594 + NGC 4649



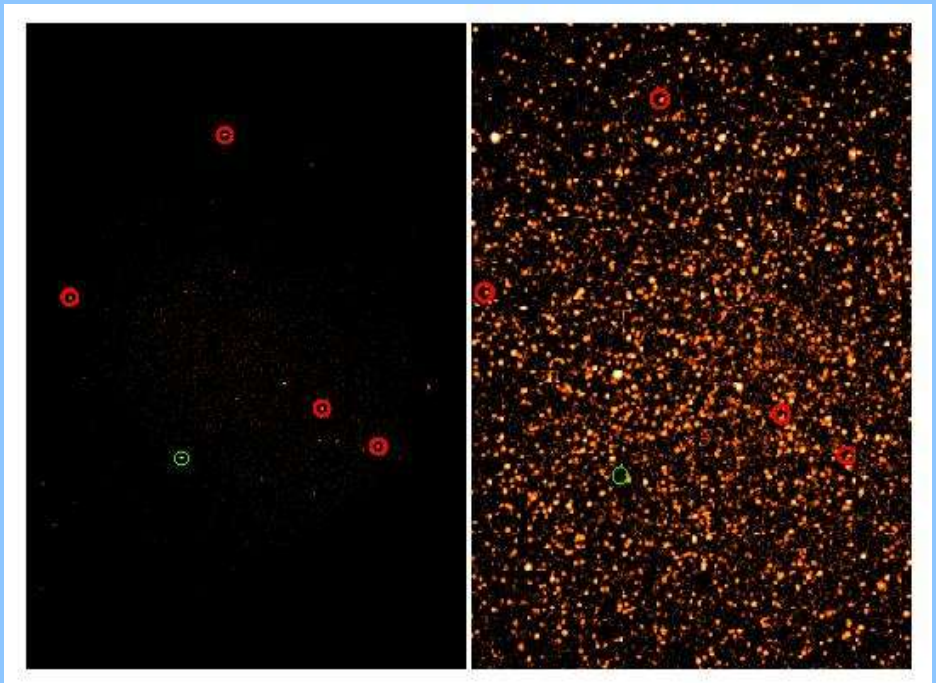
Field LMXBs are more centrally concentrated than globular cluster LMXBs and globular clusters.

Ejection from GCs cannot explain the field population.

Can we Find a Field Population in an Old Stellar System with no Globular Clusters

- Sculptor dwarf spheroidal is:
  - Nearby (79+/-4 kpc)
  - Has an old stellar population (Mateo et al. 1998)
  - Has no globular clusters
- 21 observations of 6 kilosecs each with Chandra-ACS

- 74 sources in the 0.5-8 keV band
- Of the 9 brightest sources 4 correspond to red giant/HB stars in Sculptor (Schweitzer et al. 1995, Westfall et al. 2005).
- Brightest source corresponds to main sequence companion.
- All 5 confirmed Sculptor sources have 0.5-8 keV luminosities greater than $L_x > 6 \times 10^{33}$ ergs/s.
- Likely XRBs. Too bright and have too hard a spectrum to be explained by CVs, symbiotic stars etc.



Maccarone et al. 2005

Implications of Sculptor observations

- If they are transients (Piro & Bildsten 2002) scaling the field population of NGC 4472 and assuming a duty cycle of 1/200 predicts ~20 such sources.
- Scaling up the qLMXBs observed in NGC 6440 a globular cluster with high stellar collision rates gives at most an order of magnitude enhancement of qLMXBs in GCs. The effects of interactions in GCs are less significant than suggested by studies of bright LMXBs.
- Scaling up the XRBs to the mass of the MW gives ~25000 XRBs. More, ~100000, if there is a metallicity effect.
- About ~20% of the background emission from X-ray faint elliptical galaxies may come from XRBs.

Conclusions

- Comparison with GCs show that bright ≥ 10^{36} erg/s field LMXBs are not a dynamically ejected globular cluster population.
- We have discovered 5 XRBs in the old field stellar population of the Sculptor dwarf spheroidal.
- Must be formed in situ since Sculptor does not have any globular clusters.
- Overabundance due to dynamical effects for fainter XRBs (≥ 5x10 ^{33} ergs/s) is an order of magnitude less important than brighter LMXBs.
- There may be up to ~100000 XRBs in the MW field.
- ~20% of the emission from X-ray faint early type galaxies may be from such unresolved sources.