The Birthplace of LMXBs: Field vs. Globular Cluster Populations in Early-type Galaxies

Jimmy A. Irwin
University of Michigan

Where are Low-Mass X-ray Binaries Formed?

Field LMXBs formed in globular clusters

- explains the similarities in XLFs, spectral properties, or $<L_X>$ of GC and non-GC LMXBs

OR

LMXBs presently in the field formed in the field

- explains why percentage of LMXBs in GCs varies from galaxy to galaxy with Hubble type or number of GCs

OR

Combination of both effects?

Fraction of LMXBs in Globular Clusters

Galaxy	% in GCs	Reference
NGC1553	18^{+9}_{-12}%	**Blanton et al. 2001**
NGC3115	25^{+9}_{-8}%	**Kundu et al. 2003**
NGC1332	30^{+11}_{-9}%	**Humphrey & Buote 2004**
NGC4552	40^{+12}_{-11}%	**Xu et al. 2005**
NGC4472	42^{-7}_{+6}%	**Kundu et al. 2002**
NGC4649	47^{+6}_{-9}%	**Randall et al. 2004**
NGC4365	49^{+6}_{-10}%	**Sivakoff et al. 2003**
NGC4261	49^{+8}_{-8}%	**Giordano et al. 2005**
M87	62^{+5}_{-6}%	**Jordán et al. 2004**
NGC1399	68^{+8}_{-9}%	**Angelini et al. 2001**

Where are Low-Mass X-ray Binaries Formed?

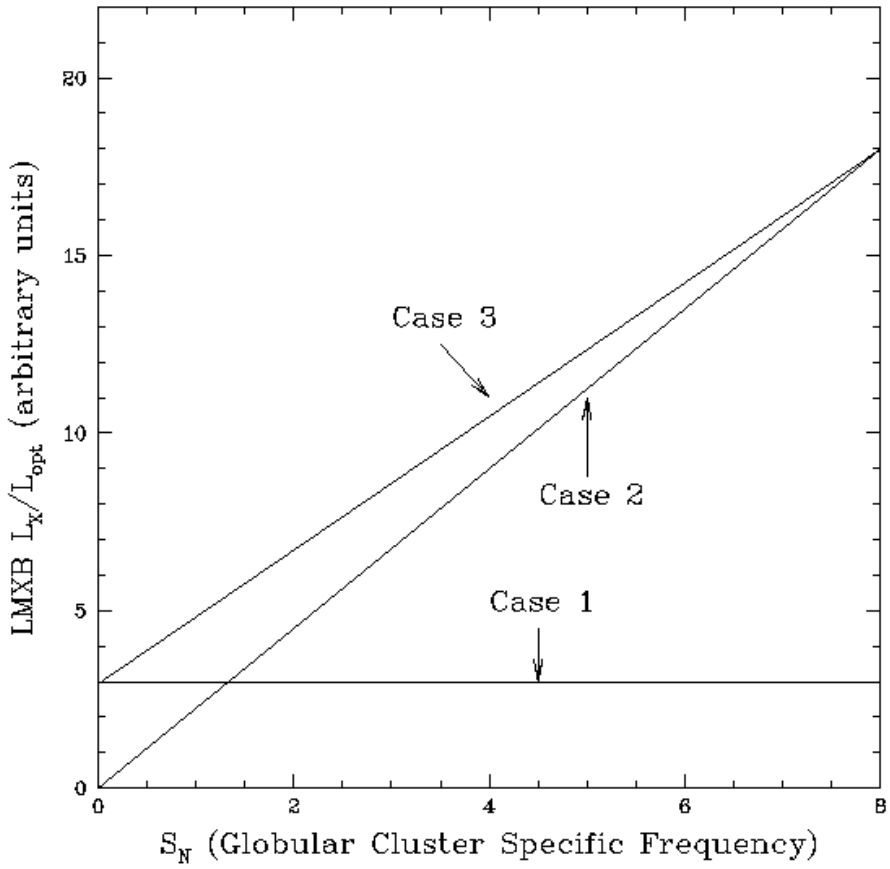
If all LMXBs formed within globular clusters, there should be a linear relation between the number of LMXBs per unit optical light and the number of globular clusters per unit optical light.

Two observables: L_X/L_{opt} of the sum of LMXBs

S_N

where $S_N = N_{globular} * 10^{0.4(Mv+15)}$ is called the **globular cluster specific frequency**.

Compare L_X/L_{opt} to S_N



Case 1: All LMXBs formed in the field (no dependence on S_N).

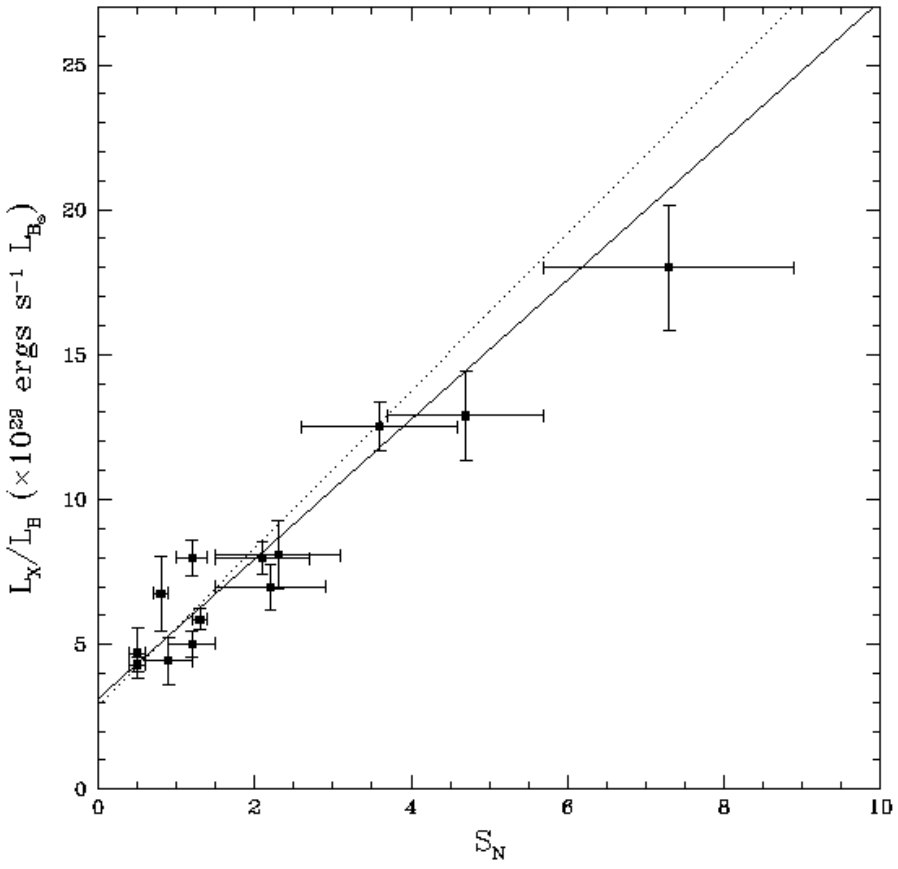
Case 2: All LMXBs formed in globular clusters.

Case 3: LMXBs formed in both the field and in globular clusters.

$$(L_X/L_{opt})_{total} = (L_X/L_{opt})_{globular} + (L_X/L_{opt})_{field}$$

$$= A * S_N + B$$

Compare L_X/L_B to S_N



A=2.41 +/- 0.33, B=3.12 +/- 0.39

There is indeed a strong relation between L_X/L_B and S_N, but the *y*-intercept of the best-fit linear relation between L_X/L_B and S_N is different from zero at the 8σ level.

➔ some LMXBs are formed in the field (Case 3).

For low S_N galaxies field LMXBs dominate, while for high S_N galaxies globular cluster LMXBs dominate.

Fraction of LMXBs in Globular Clusters

Galaxy	S_N	Predicted %	Measured %	Galaxy Type
NGC1553	0.5 +/- 0.1	28%		
NGC4472	1.1 +/- 0.1	46%		
NGC4552	1.2 +/- 0.2	48%		
NGC3115	1.3 +/- 0.1	50%		
NGC4649	1.4 +/- 0.2	52%		
NGC4365	2.1 +/- 0.6	62%		
NGC1332	2.2 +/- 0.7	63%		
NGC1399	4.7 +/- 1.0	78%		

$$\text{Predicted \%} = \frac{(L_X/L_B)_{\text{globular}}}{(L_X/L_B)_{\text{total}}} = \frac{A * S_N}{A * S_N + B}$$

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NGC4472	1.1 +/- 0.1	46%	42^{+7}_{-6}%	E
NGC4552	1.2 +/- 0.2	48%	40^{+12}_{-11}%	E
NGC3115	1.3 +/- 0.1	50%	25^{+9}_{-8}%	S0
NGC4649	1.4 +/- 0.2	52%	47^{+6}_{-9}%	E
NGC4365	2.1 +/- 0.6	62%	49^{+6}_{-10}%	E
NGC1332	2.2 +/- 0.7	63%	30^{+11}_{-9}%	S0
NGC1399	4.7 +/- 1.0	78%	68^{+8}_{-9}%	E

$$\text{Predicted \%} = \frac{(L_X/L_B)_{\text{globular}}}{(L_X/L_B)_{\text{total}}} = \frac{A * S_N}{A * S_N + B}$$

Conclusions

- While many LMXBs within early-type galaxies are formed in globular clusters, a significant fraction of LMXBs are formed in the field.

- "Pollution" of globular cluster LMXBs into the field has been more prevalent in S0 galaxies than in ellipticals, possibly because of stronger globular cluster-disk interaction in S0s.