The Effects of Primordial Binary Destruction on X-ray Sources in Globular Clusters

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KITP Formation & Evolution of Globular Clusters

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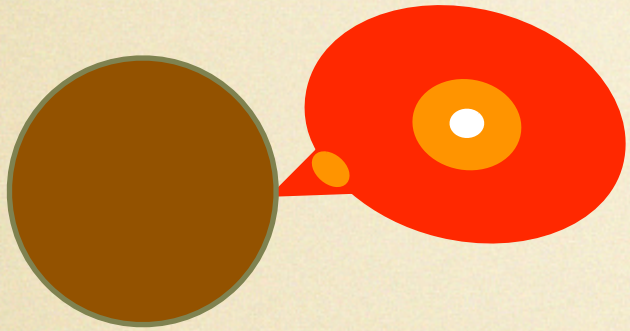
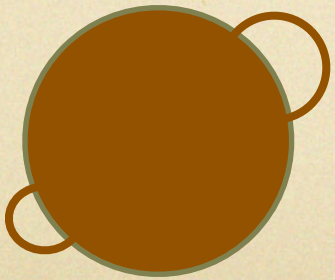
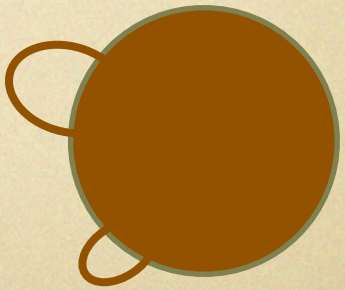
X-ray sources



- Accreting objects: NS (in LMXB) or WD (in CV), accreting from WD, MS, or RG
- Coronally active stars (ABs): both MS, or evolved

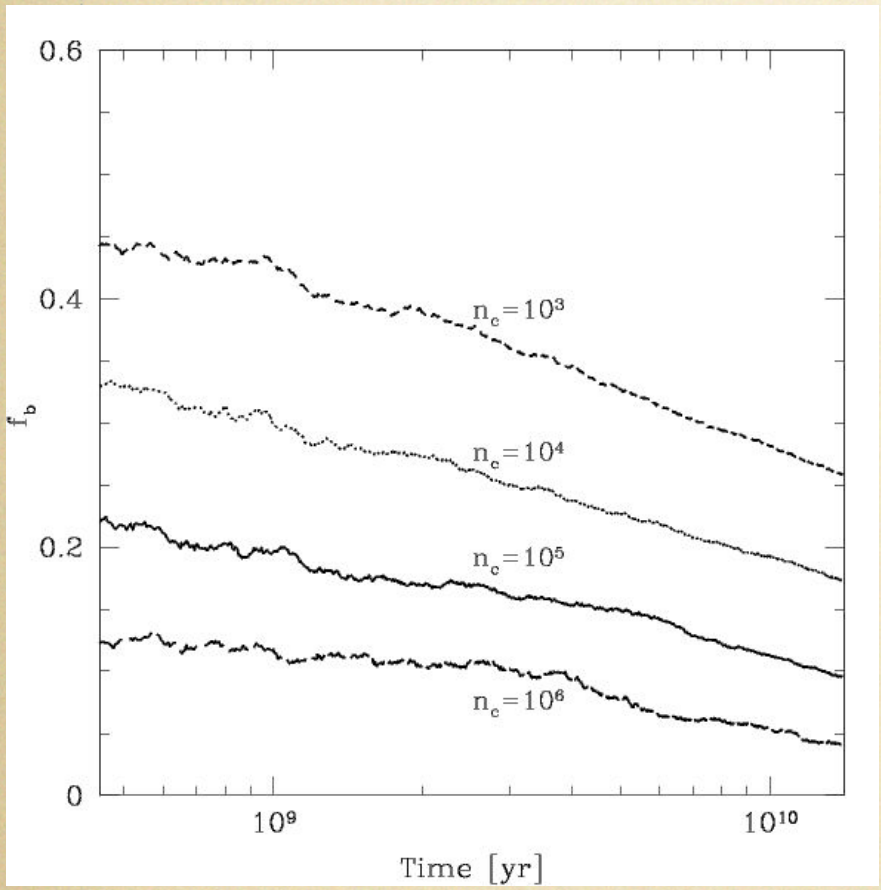




Exotic binary production

- Tidal capture (Fabian+75)
- Binary exchange (Hills76)
- Red giant/NS or RG/WD collisions (Verbunt+87)
- Encounter rate (Verbunt & Hut 87); $\Gamma = \rho^2 r_c^3 / \sigma_c \sim \rho^{1.5} r_c^2$.

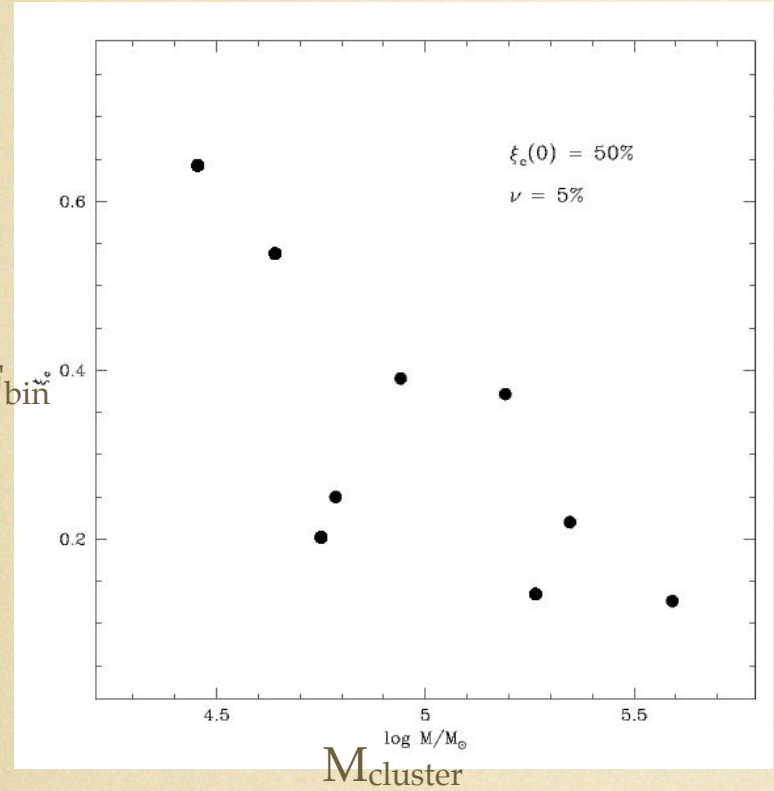
Binary destruction



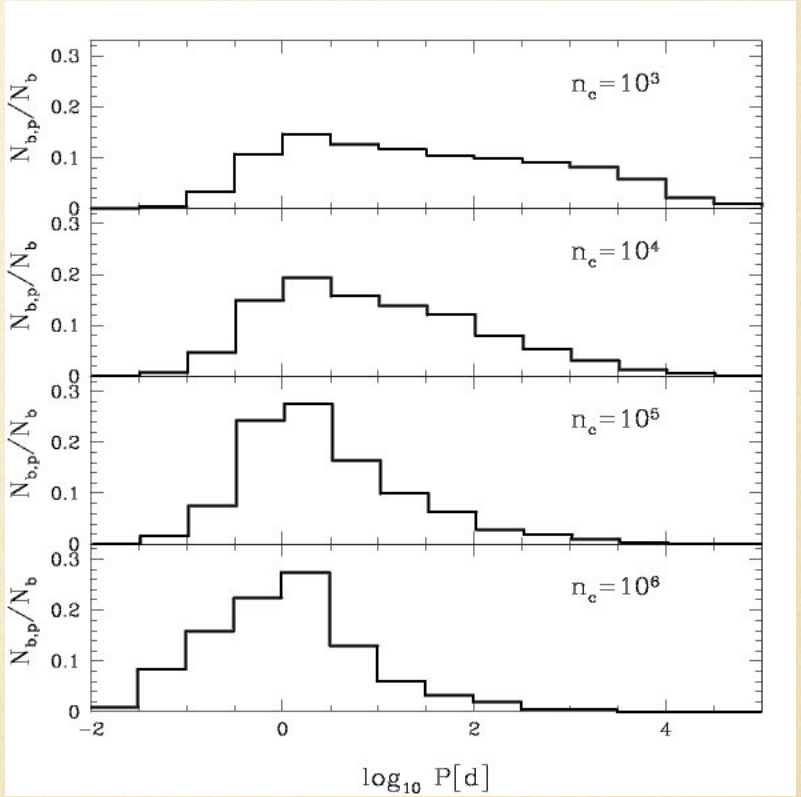
Binary fractions, Ivanova+05

- Binaries disrupted, merged, or ejected dynamically
- Continues over cluster history
- F_{Bin} reduced from 50-100% to ≤10% for dense clusters (Ivanova+05)

Binary destruction

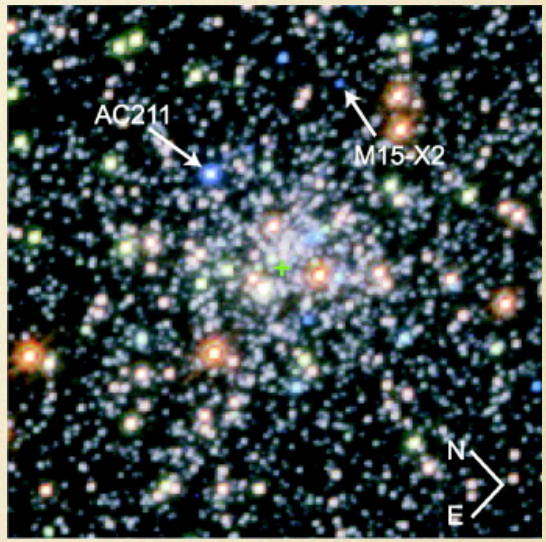


Destruction increases with cluster mass (Sollima+08)



Porb distribution changes; P>100 d rare at high ρ (Ivanova+05)

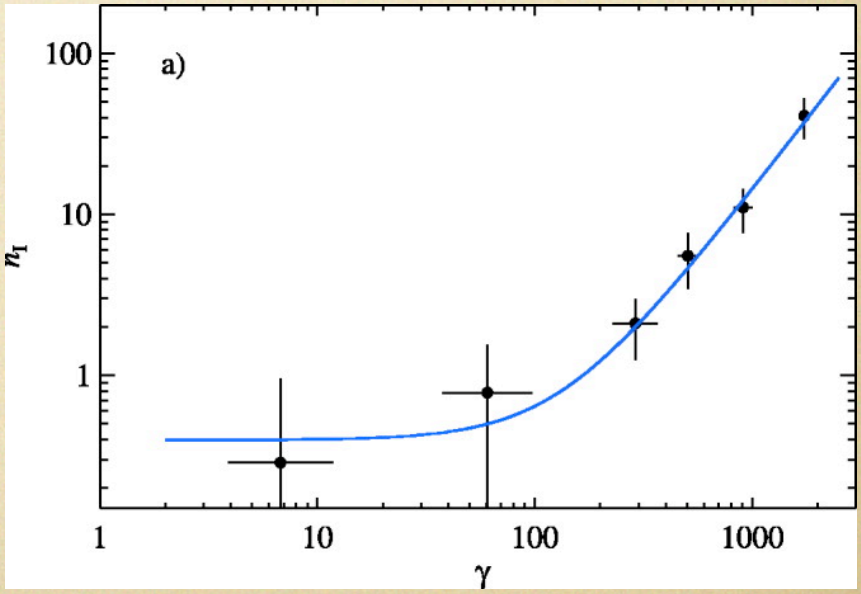
Neutron star binaries



2 NS LMXBs in M15; HST, White

- NS binaries formed in densest clusters
- NS binaries ∝ encounter rate Γ,

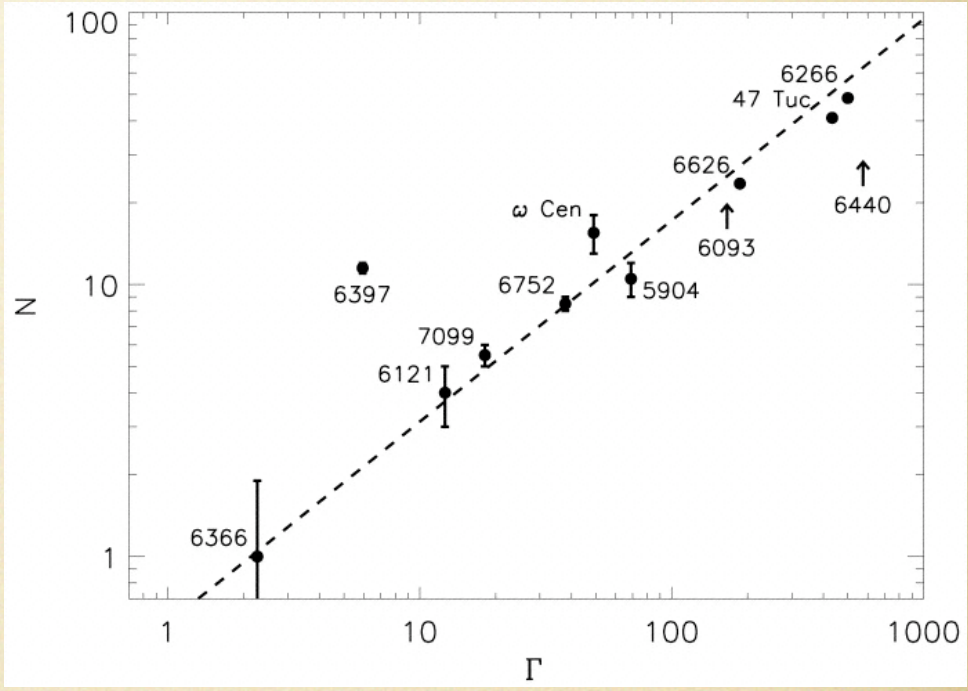
(Heinke+03, 06, Pooley+03, 06)



#qLMXBs vs. Γ, Pooley+06

Cataclysmic variables

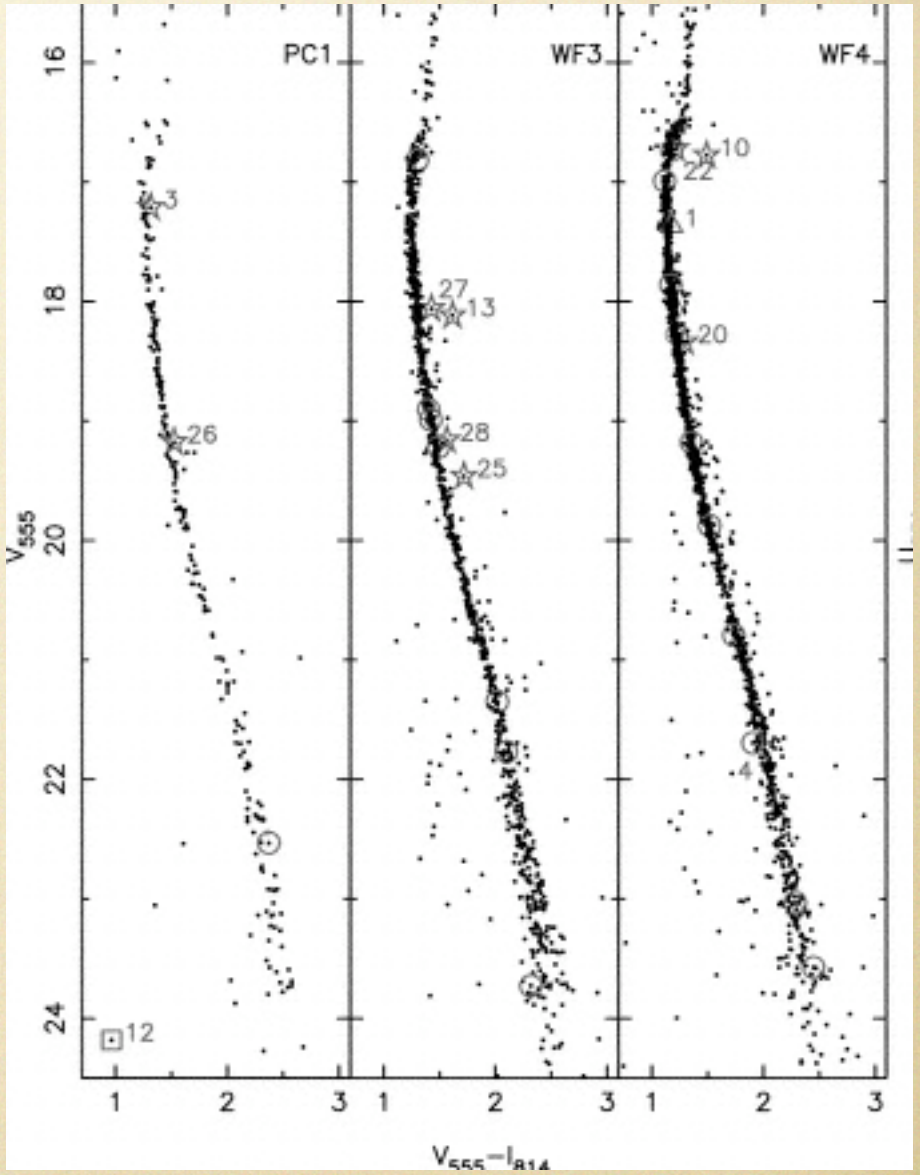
- Theory suggests part primordial, part dynamical (Davies97, Ivanova+06)
- X-ray CVs part dynamical, part primordial (Pooley+03, Heinke+06,Kong+07,Bassa +08)



X-ray sources vs. encounter rate, Pooley+03

Active Binaries

- Assumption: ABs primordial, scale with mass of cluster
- Bassa+04,08, Kong+07 find ABs in low-Γ clusters
- Is destruction significant?

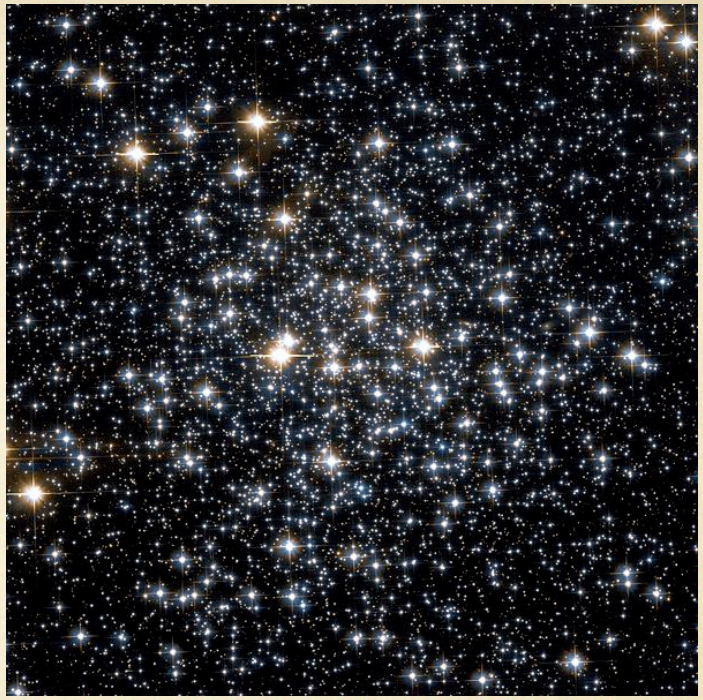


M4 CMDs, Bassa+04

Active binaries

- Bassa+04: M4 up to ~13 ABs, 6e29<Lx<6e30
- 47 Tuc up to ~88 ABs, same Lx (Heinke+05)
- M(47Tuc)/M(M4)~12;
  but #AB(47Tuc)/#AB(M4)~6
- Suggests AB destruction in denser (logρ~4.8 vs. 4.0), more massive 47 Tuc

M71

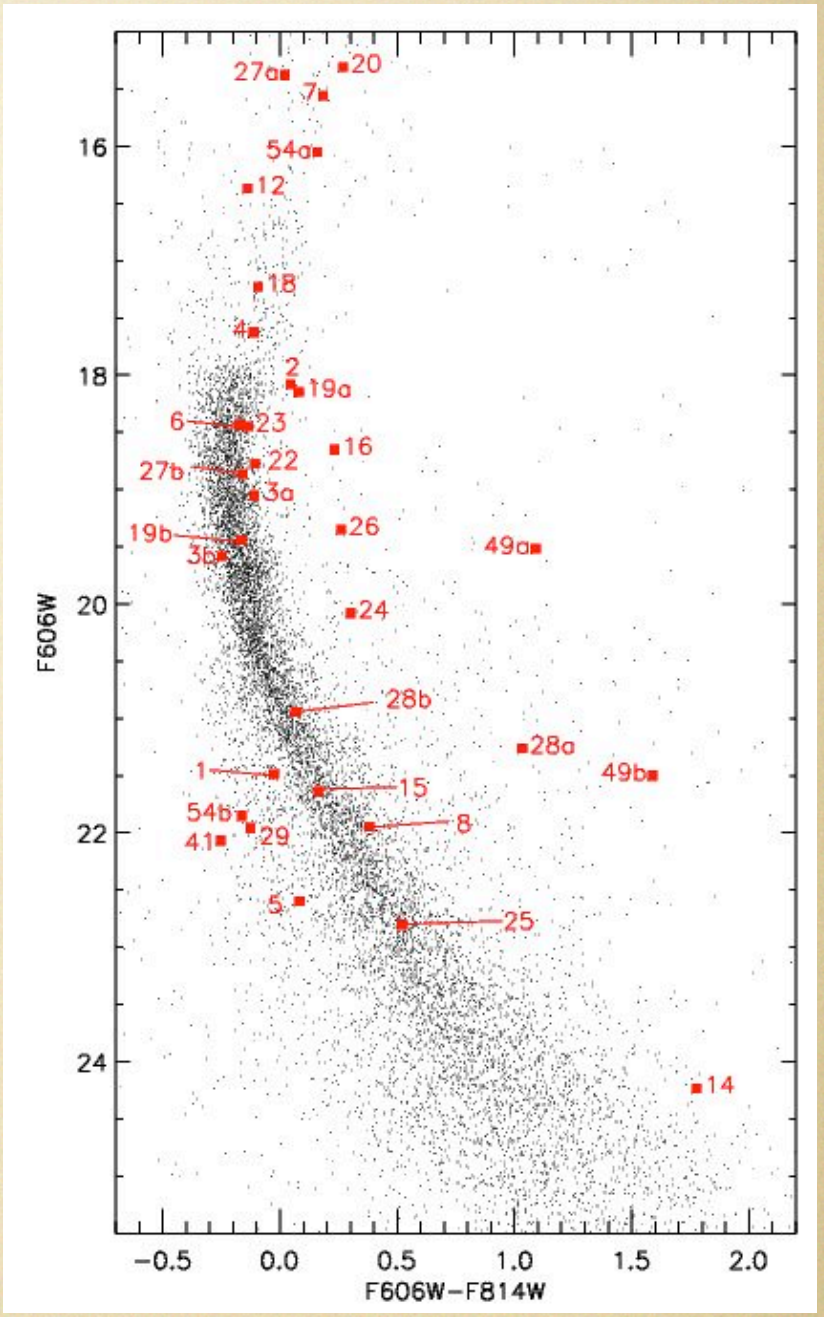


M71, HST

- Sparse, low mass, low density cluster
- 18±6 Chandra cluster srcs (Elsner+08) from radial distribution
- More faint Chandra sources (ABs?) than predicted

M71 with HST

- 10 optical counterparts with $L_X > 4*10^{30}$
- Total 15 poss. ABs, 4 poss. CVs.

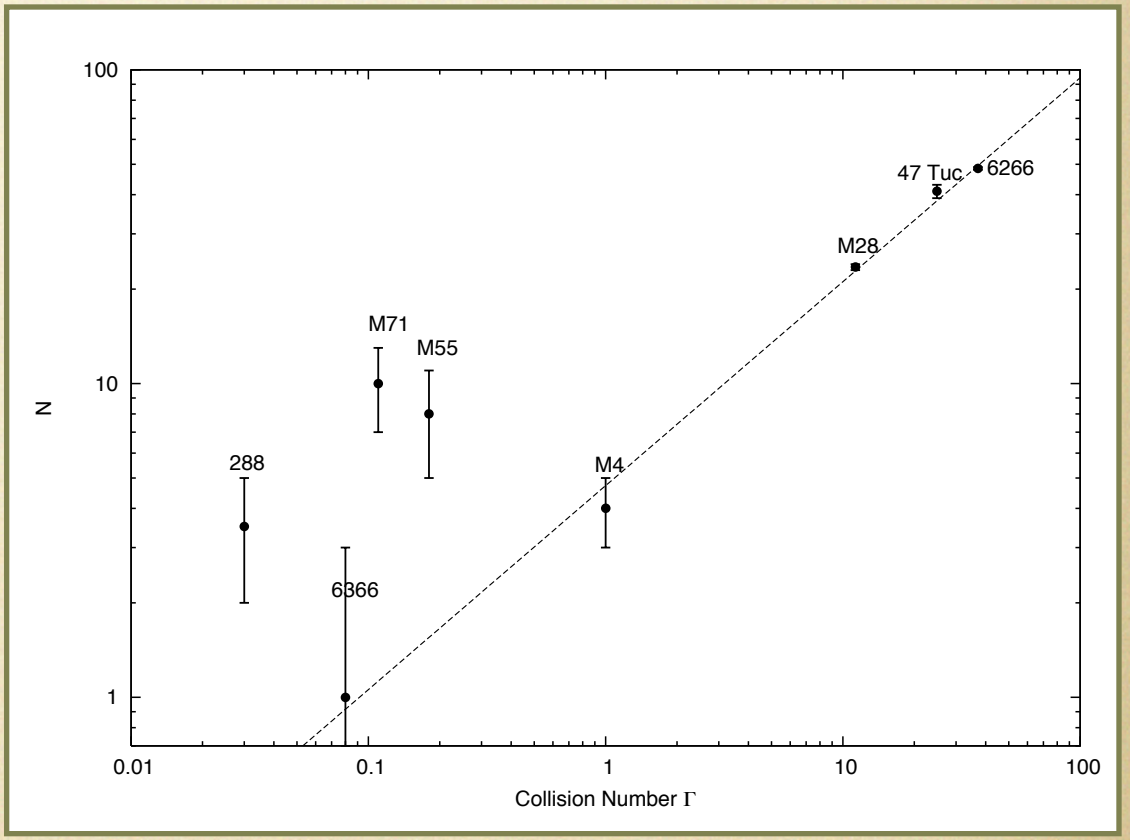


R. Huang+08

Compare clusters

N 6266: ρ~5.1
47 Tuc: ρ~4.8
M28: ρ~4.8
M4: ρ~4.0
M71: ρ~3.1
N 6366: ρ~2.4
M55: ρ~2.2
N 288: ρ~1.8

- M71 mass & Γ both low
- Less binary destruction?
- Not a clear pattern;
  6366 has few X-ray srcs



Huang+09

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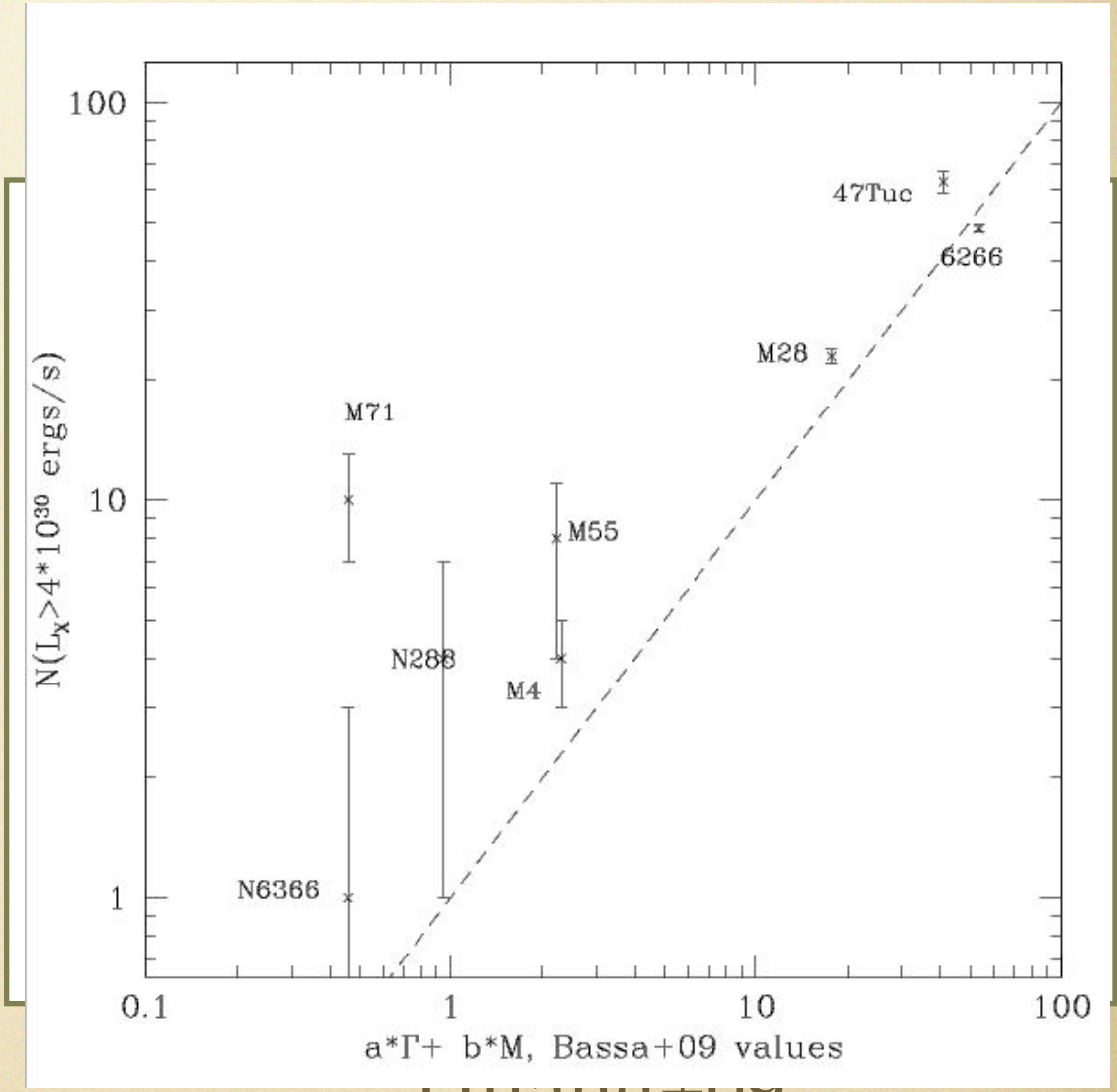


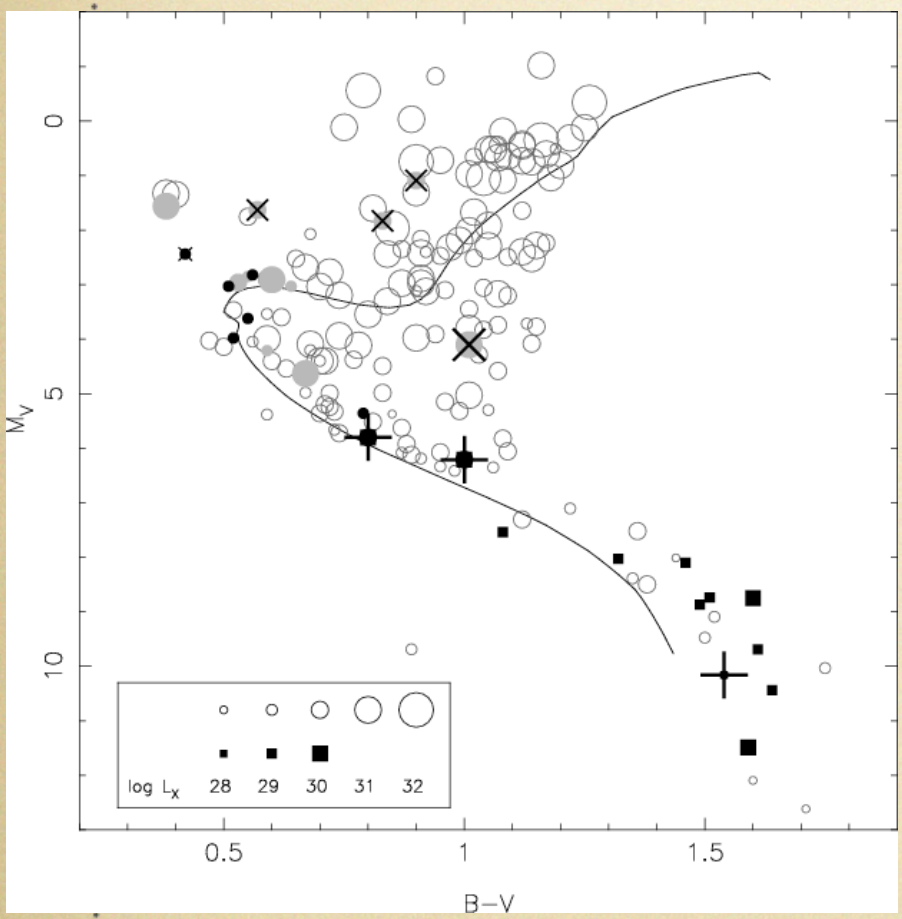
Huang+09

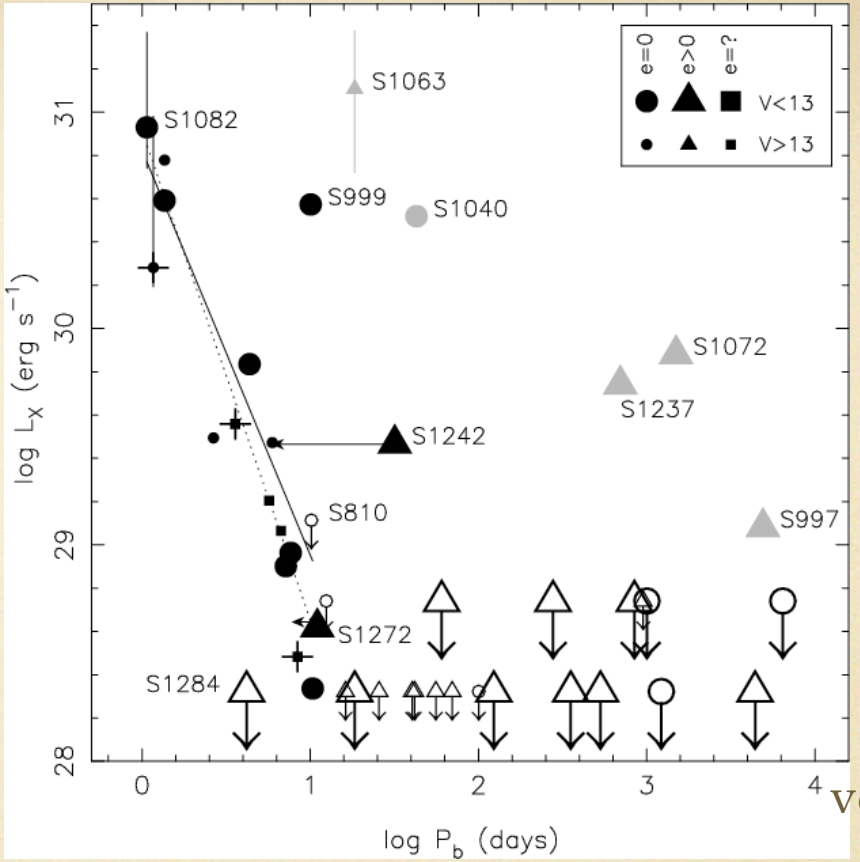
Open clusters

- M67: now 2000 stars, 40-50% binaries
- Binary fraction ~constant over time (Hurley+05, N-body)

M67, DSS2

M67 ABs





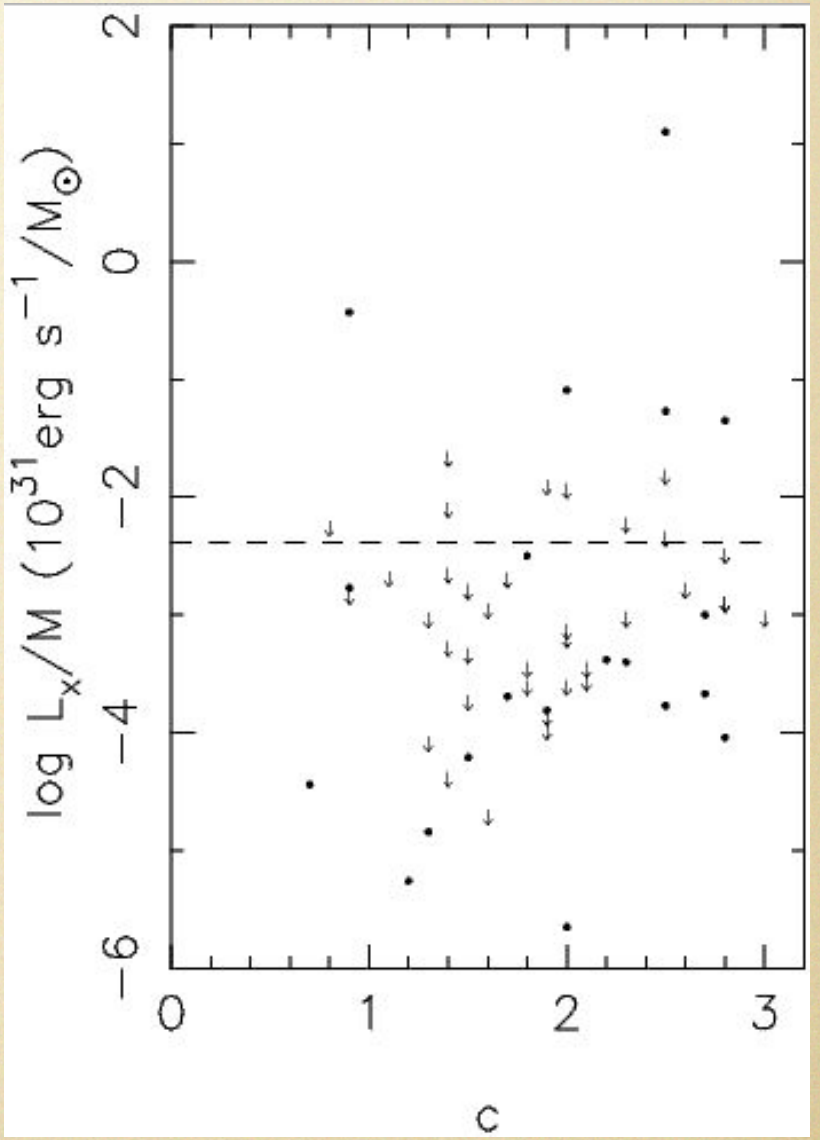
vdBerg+04

- L_X up to 1.3e31
- For L_X>3e30, P_{Orb} 1-42 days
- X-rays from long-P not understood (Belloni+98)

M67 ABs vs. field ABs (open), vdBerg+04

Verbunt's comparison

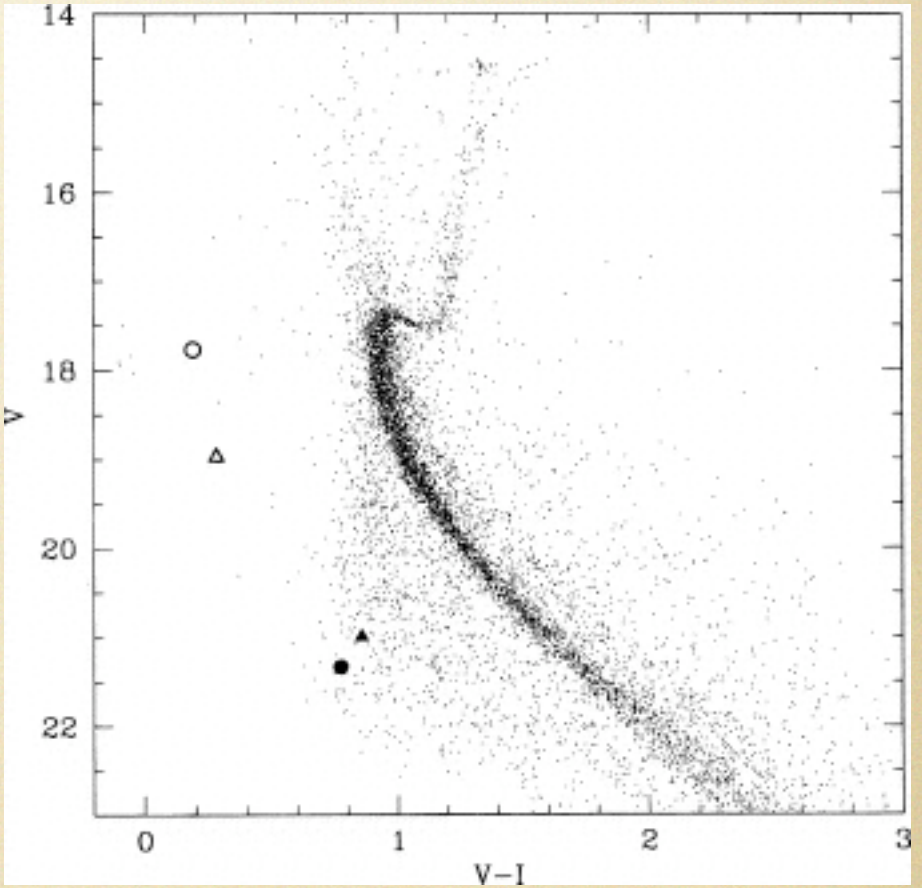
- Compare L_X/M for GCs, M67
- Mass GCs ~1000* mass M67, but L_X not 1000* 3e31 ergs/s
- Suggests binary destruction in GCs, or concentration in M67
- Single X-ray stars (FK Com)? Merged binaries, or triples.



Verbunt 99

CVs in Old Open Clusters

- 2 CVs known in NGC 6791 (Kaluzny+97), 1 in M67 (Gilliland91)
- 3rd likely CV in NGC 6791 (de Marchi+07)
- 6791 Lx~1.8e31--1.4e32; easily identified in GCs



NGC 6791 CMD (Kaluzny+97)

CVs in Old Open Clusters

NGC 6791, KPNO,Mochejska

- Mass of NGC 6791, M67 only 4000, 1000 Msun (Kinman65, Hurley+05)
- M4, $2*10^5$ Msun, only 1 CV! (Bassa+04,05) ~160 expected.
- Indicates primordial binary destruction reduces CVs (see Shara+06, Ivanova+06).

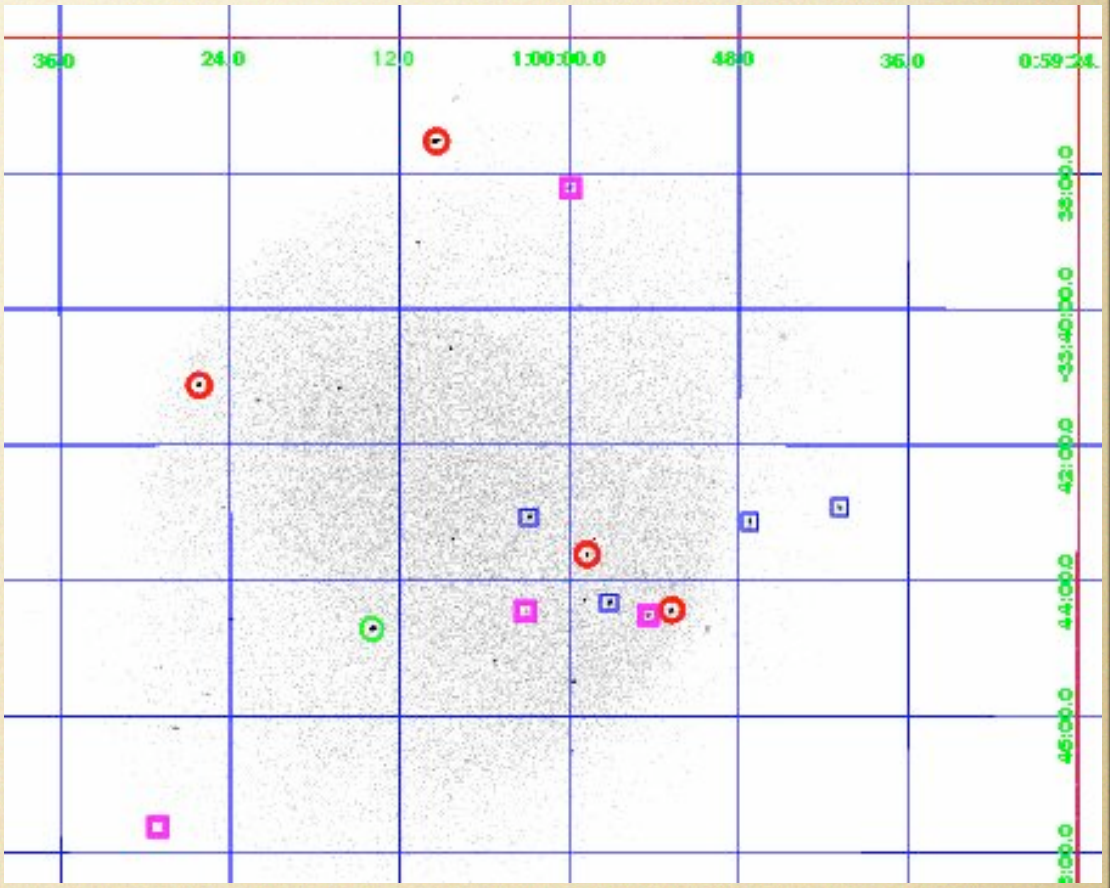
Sculptor Dwarf

- M~2e6 Msun, 8 Gyrs old, [Fe/H]=-1.4, low density
- Compare M(47 Tuc)~1.5e6, ω Cen~2e6

Sculptor, DSS2

XRBs in Sculptor Dwarf

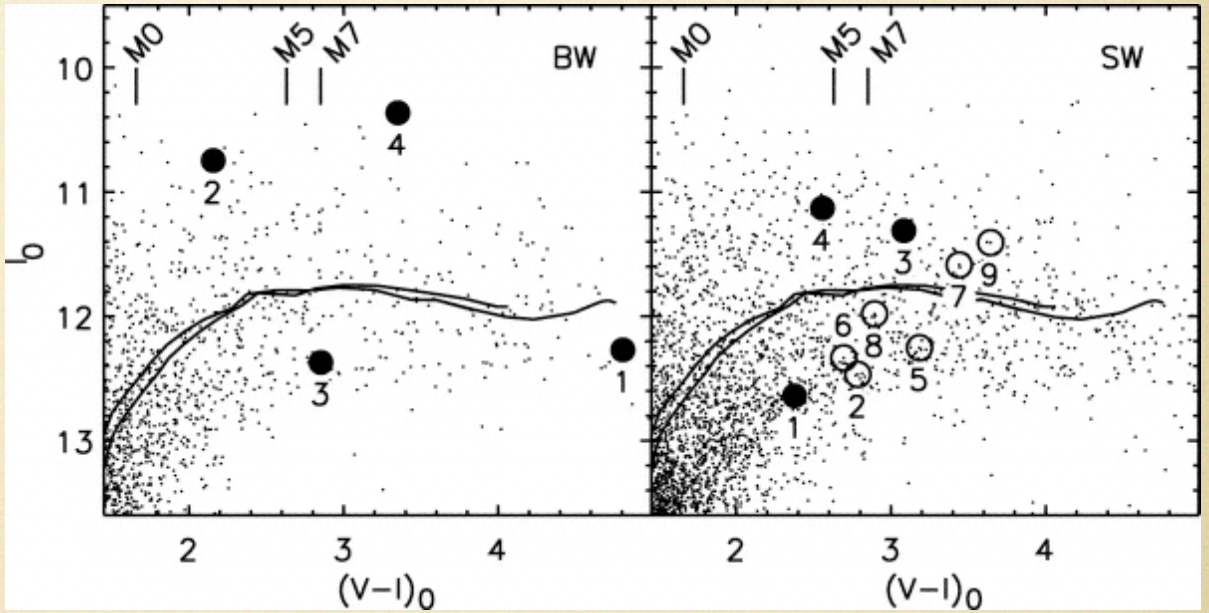
- 5 XRBs @ 1e35>L_X>6e33, must be LMXBs
- Giant, horizontal branch counterparts
- Suggests symbiotic stars
- NONE found in GCs



Chandra, Maccarone+05

Symbiotic XRBs

- L_X~1e33--1e35
- P_{Orb}~200-6000 days
- Difficult to identify

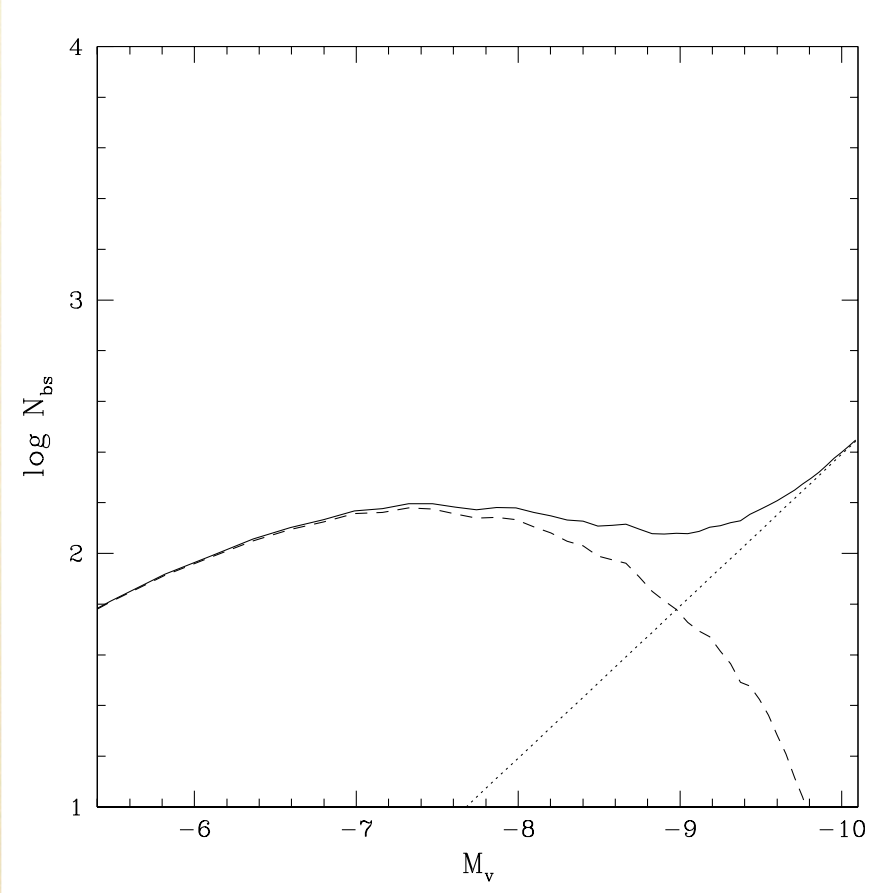


ChamPlane symbiotics,vdBerg+06

- Largest pop. of old medium-L_X systems?
- Destroyed in dense environments

Blue straggler stars

- Piotto+04: BSSs anticorrelate w/mass, except heaviest
- Davies+04: BSS from primordial binaries, dynamics
- Similar picture for ABs, CVs?



Davies+04

Conclusions

- More X-ray ABs/unit mass in sparse globular, open clusters
- More CVs/unit mass in open than globular clusters
- Symbiotics seen in field, Sculptor, not in GCs
- Binary destruction affects ALL XRBs in clusters: ABs, CVs, & LMXBs.