



# X-ray Binaries in the Local Universe

Tana Joseph

With:Tom Maccarone
Ralph Kraft
Greg Sivakoff
James Miller-Jones


UNIVERSITY OF Southampton

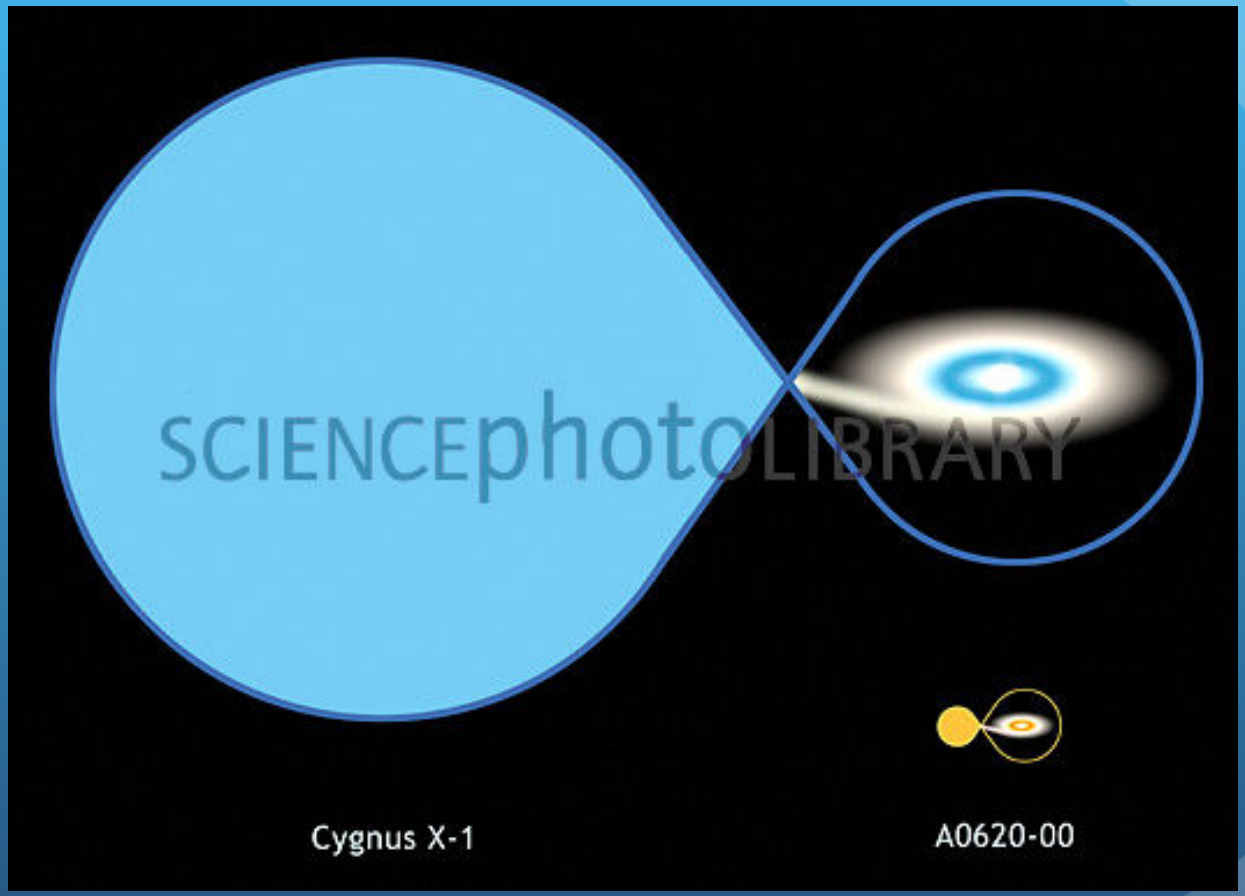
# Introduction

- PhD:  Black hole binaries in
  - NGC 4472
  - NGC 1399
  - M31
- Postdoc work : Search for
  - Black hole binaries in globular clusters
  - But sadly not for LMXBs in the SMC

# X-ray binaries

- Binary star evolution is of great interest because
  - progenitors of SNIa, pulsars, other exotic systems
  - fundamental to e.g. cosmology, gravitational wave physics
- XRBs: only type of binaries that can be observed outside Local Group
- XRBs formed in two ways:
  - end point of stellar evolution
  - N-body capture/ direct collision in globular clusters (GCs)

# X-ray binaries



# LMXBs in globular clusters

- GCs: dense, compact, old (>10 Gyr) stellar clusters that orbit galaxies
- GCs very efficient at forming LMXBs
  - E.g. in ellipticals, GCs host 20-70% of LMXBs

# LMXBs in GCs

- Red (metal rich/older) GCs 3 times more likely to host LMXB than blue (metal poor/younger) GCs
  - Age/metallicity effect? (e.g. Kundu et al. '03, Maccarone et al. '04)
  - Dynamical effects? (e.g. Jordan et al. '04, Kim et al. '06b)

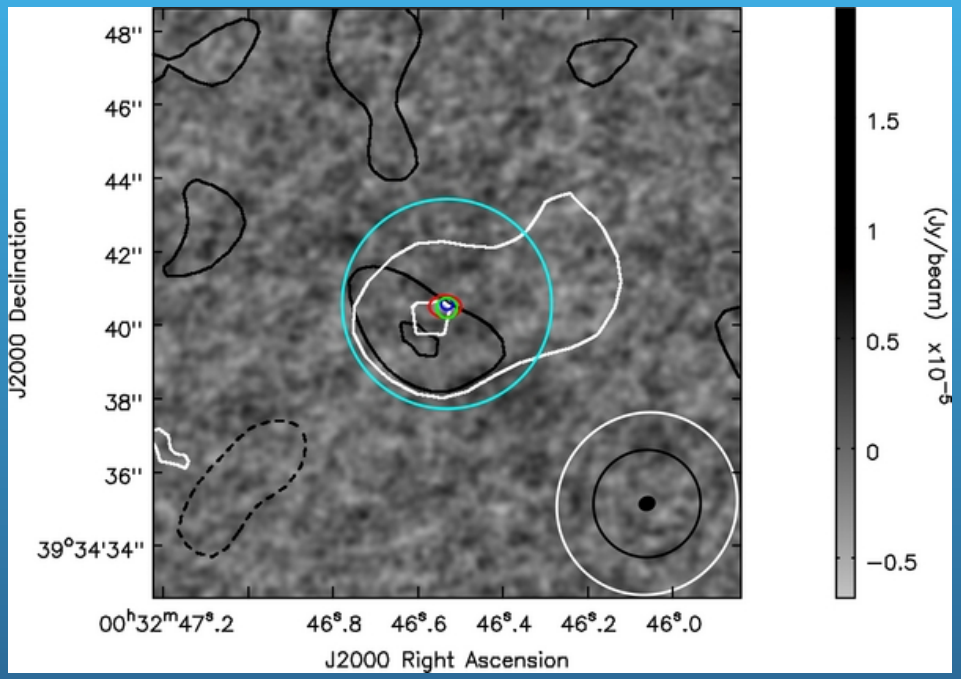
# BHs in GCs

- Long thought that BHs in GCs would cause GC to evaporate (Spitzer ’69)
- Or that BHs formed in GCs would be dynamically ejected (e.g. Sigurdsson et al. ’93)

# IMBHs in GCs

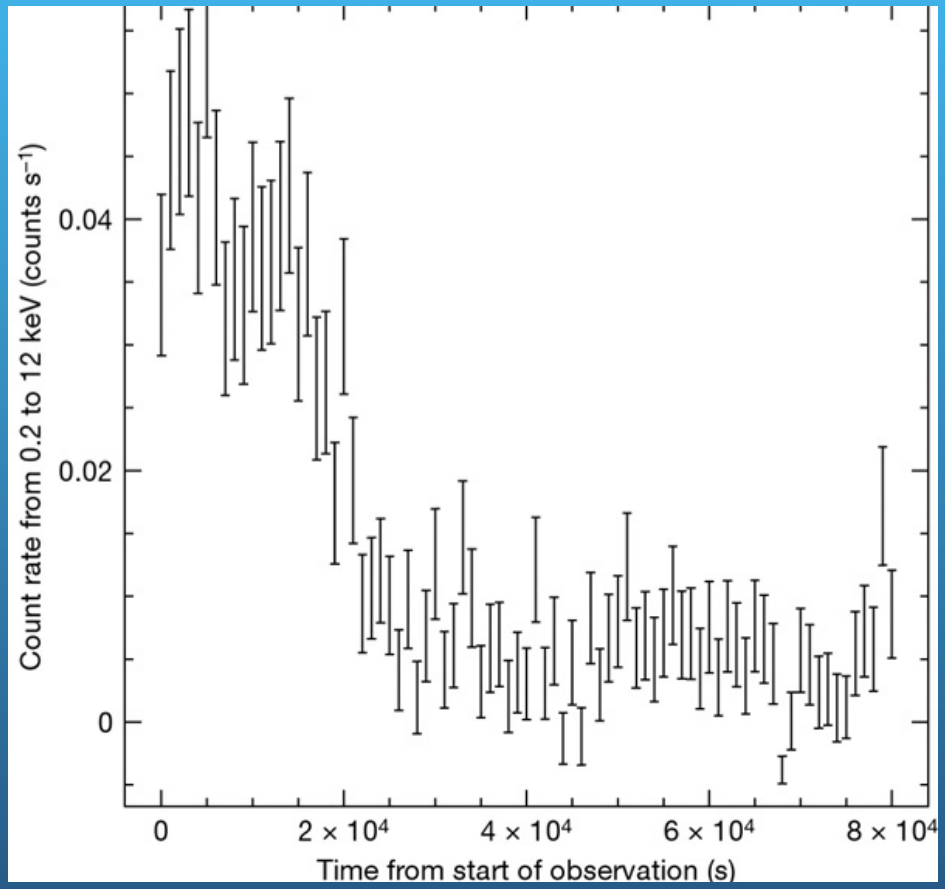
- GCs thought to be hosts of IMBHs, i.e. BHs with $100 < M_{BH} < 10^5 M_\odot$ (e.g. Miller et al. ’02, Portegies Zwart et al. ‘04)
- IMBHs in GCs thought to be strong sources of gravitational waves (e.g. Miller ’02)

# Possible IMBH in a GC




- X-ray/radio source in G1 best GC IMBH candidate so far
- Radio/X-ray data show IMBH less likely than LMXB (Miller-Jones et al. ‘12)
- But optical data still point to IMBH (Gebhardt et al. ‘05)

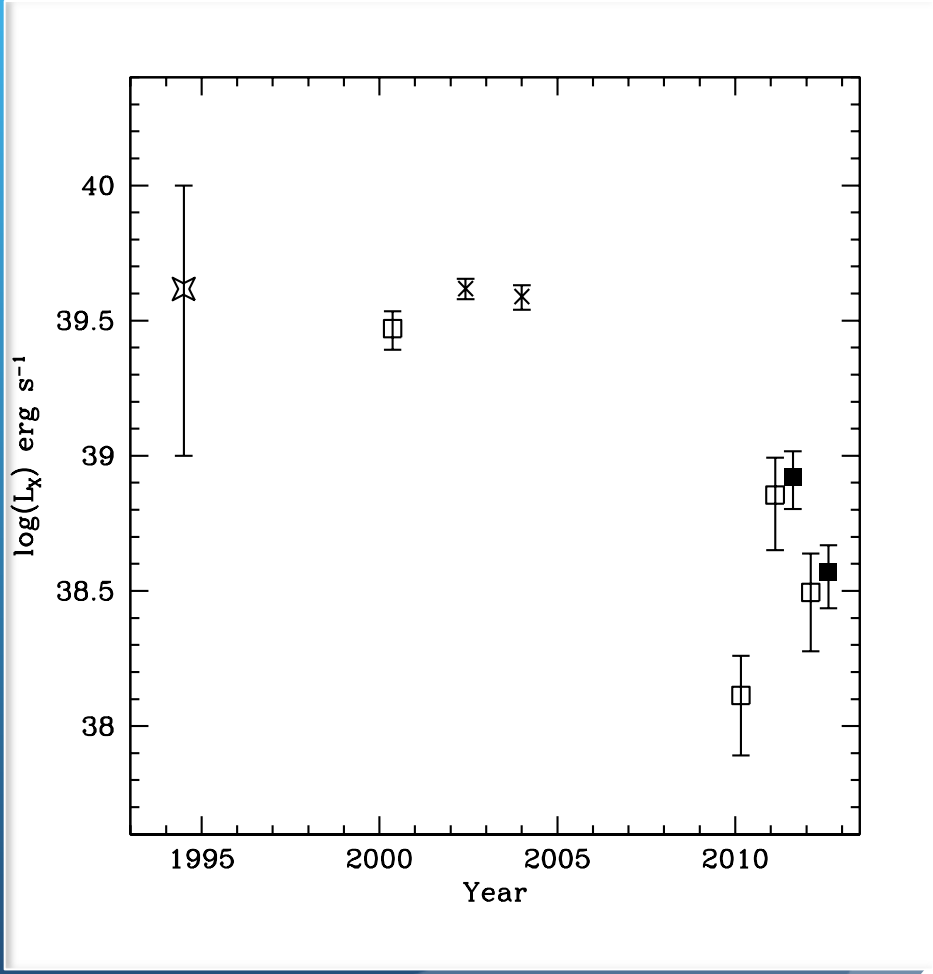
# First BH in a GC




- First stellar mass BHB in a GC discovered via X-ray variability (Maccarone + '07, see also Shih '08, Maccarone '10)
- This source is a ULX
  - Non-nuclear BHB with $L_X > 1.3 \times 10^{39}$ erg $s^{-1}$, i.e. $L_X >$ Eddington luminosity of a 10 $M_\odot$ BH, assuming isotropic emission

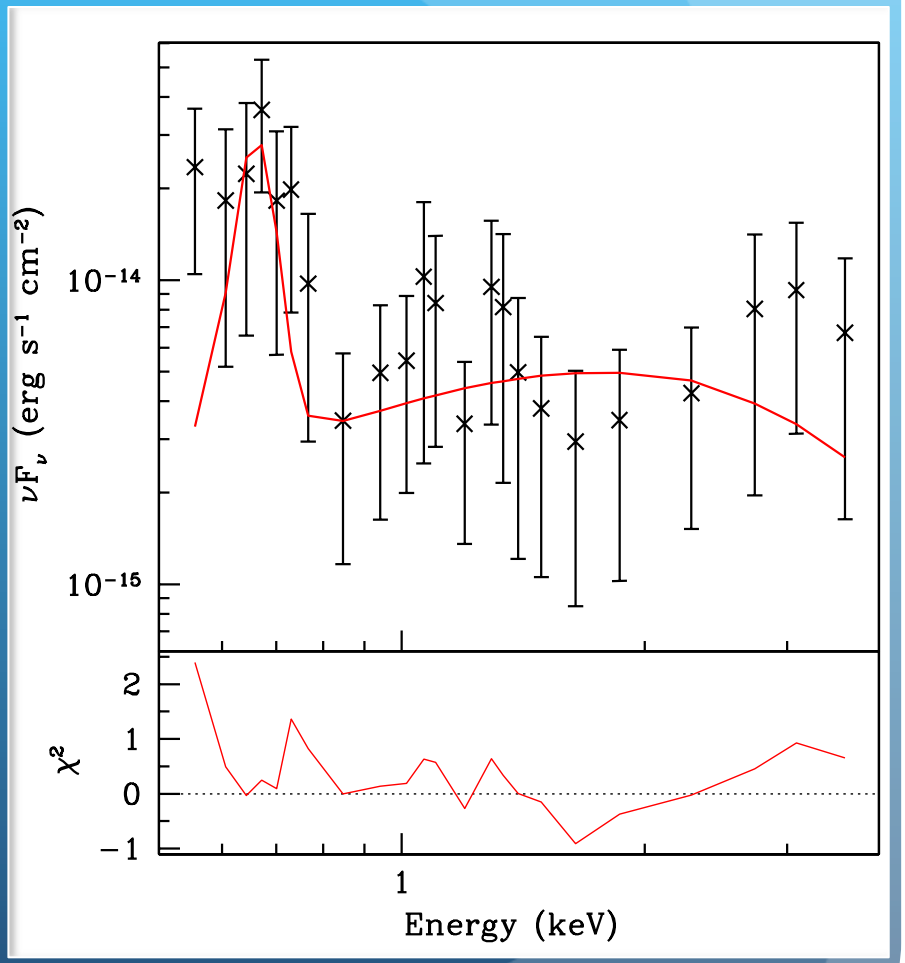
# XMMU J122939.7+075333

- Long term lc shows source persistently bright ($L_x$ > $10^{38}$ erg/s)
  - Companion either RG or WD
- Optical data shows lots of O[III] (Zepf + '07,'08, Steele, '11, Peacock, '12)
  - Companion probably WD
  - BH is not IMBH



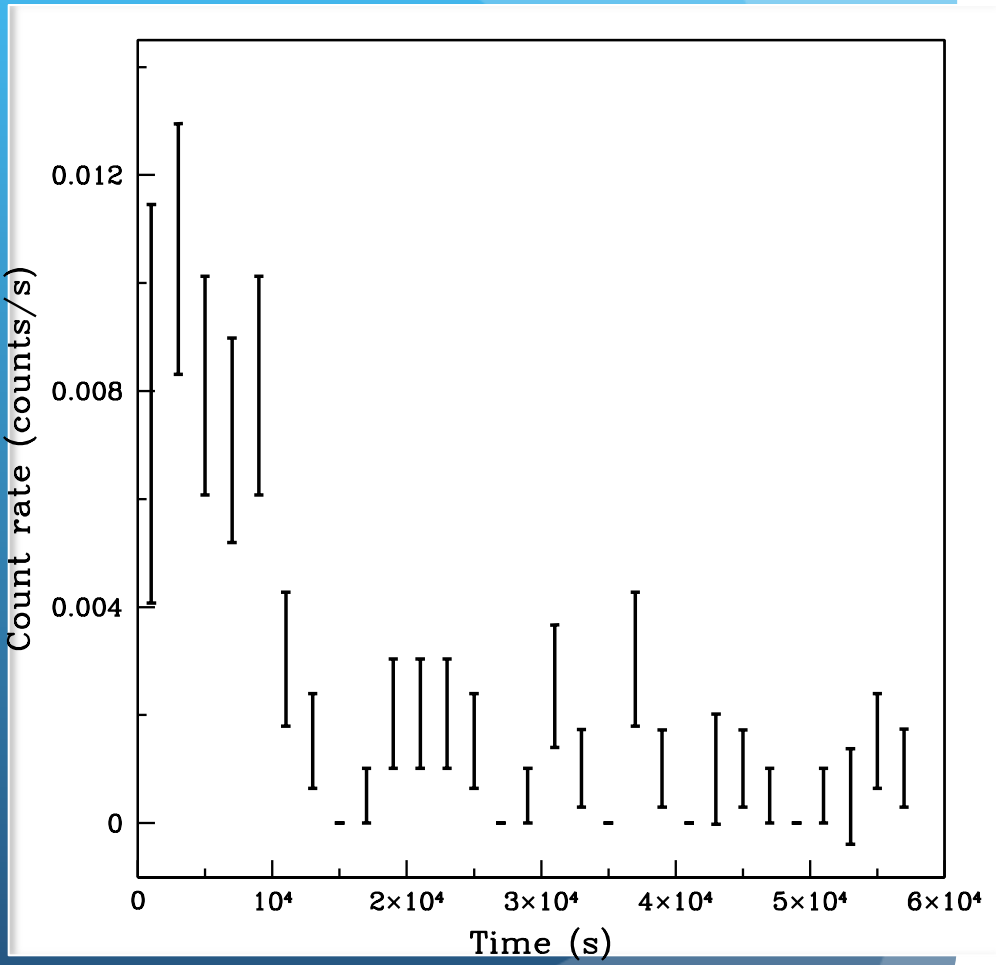
# XMMU J122939.7+075333

- X-ray spectra show soft excess at ~0.65 keV
  - Could be from O VIII, modeling as line emission gives good fits
  - But std. diskbb+PL model also gives acceptable fits
- Better spectra needed

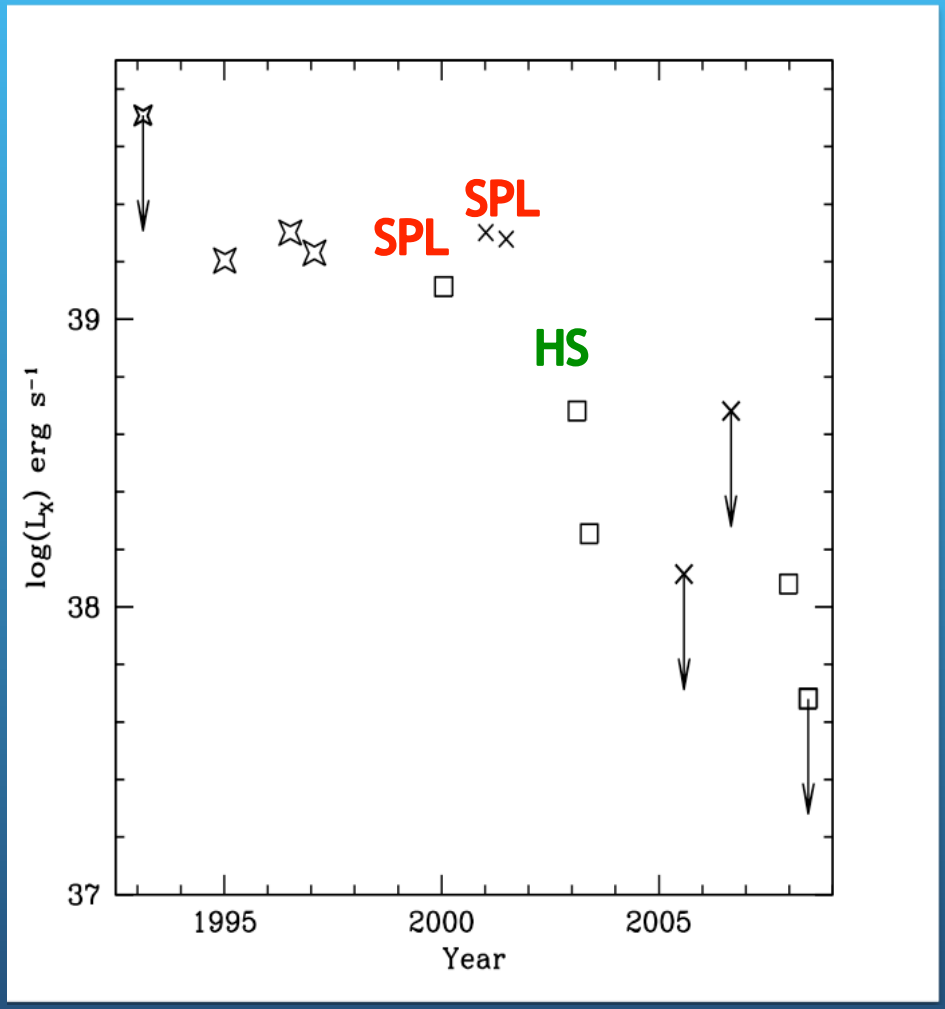


# GC BH in NGC 1399

- Second BH in GC found via X-ray variability (Shih et al. ‘10 )

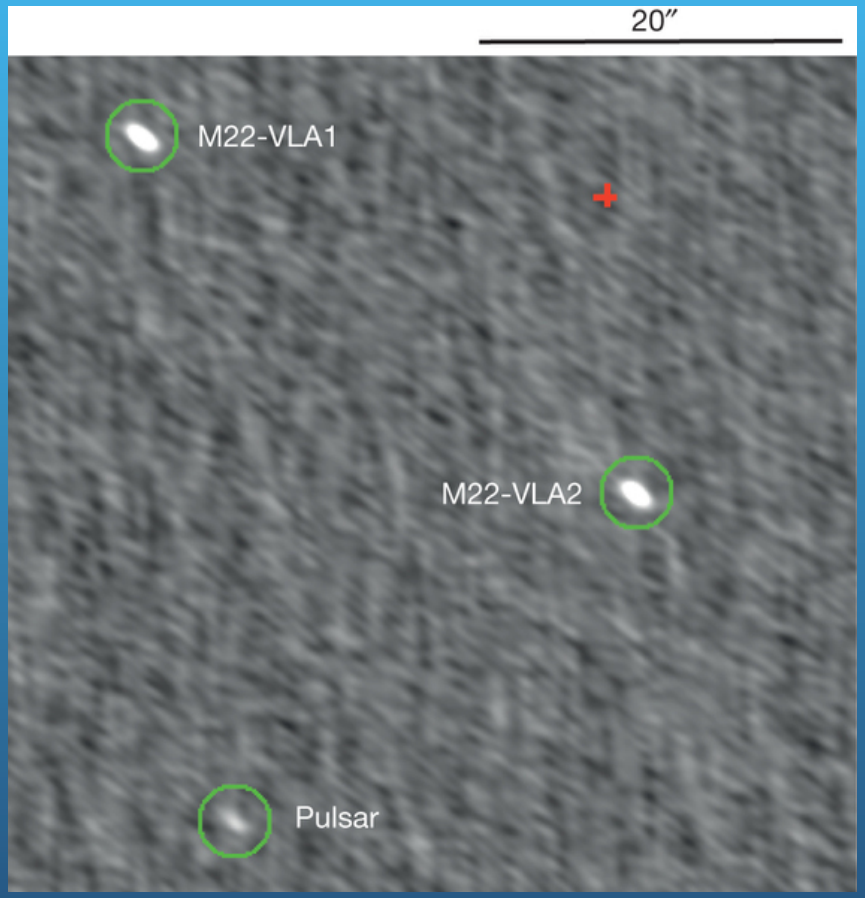


# GC BH in NGC 1399




- Source is ULX, not persistently bright
- Spectral state transitions like Galactic BHBs

# BHs in GCs

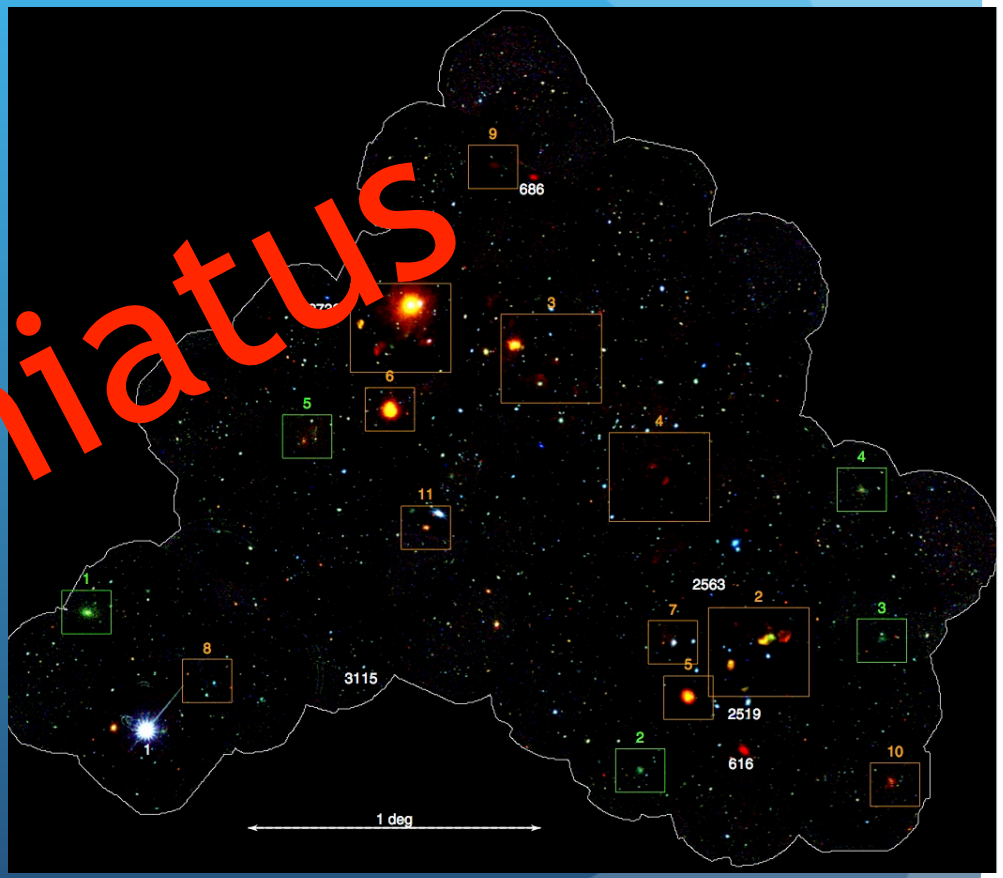



- 7 BHs in GCs known
  - 5 extragalactic sources-found using X-ray variability
  - 2 in M22- a GC of the Milky Way- found using radio observations

Strader et al. 2012

# Current research: LMXBs in the SMC

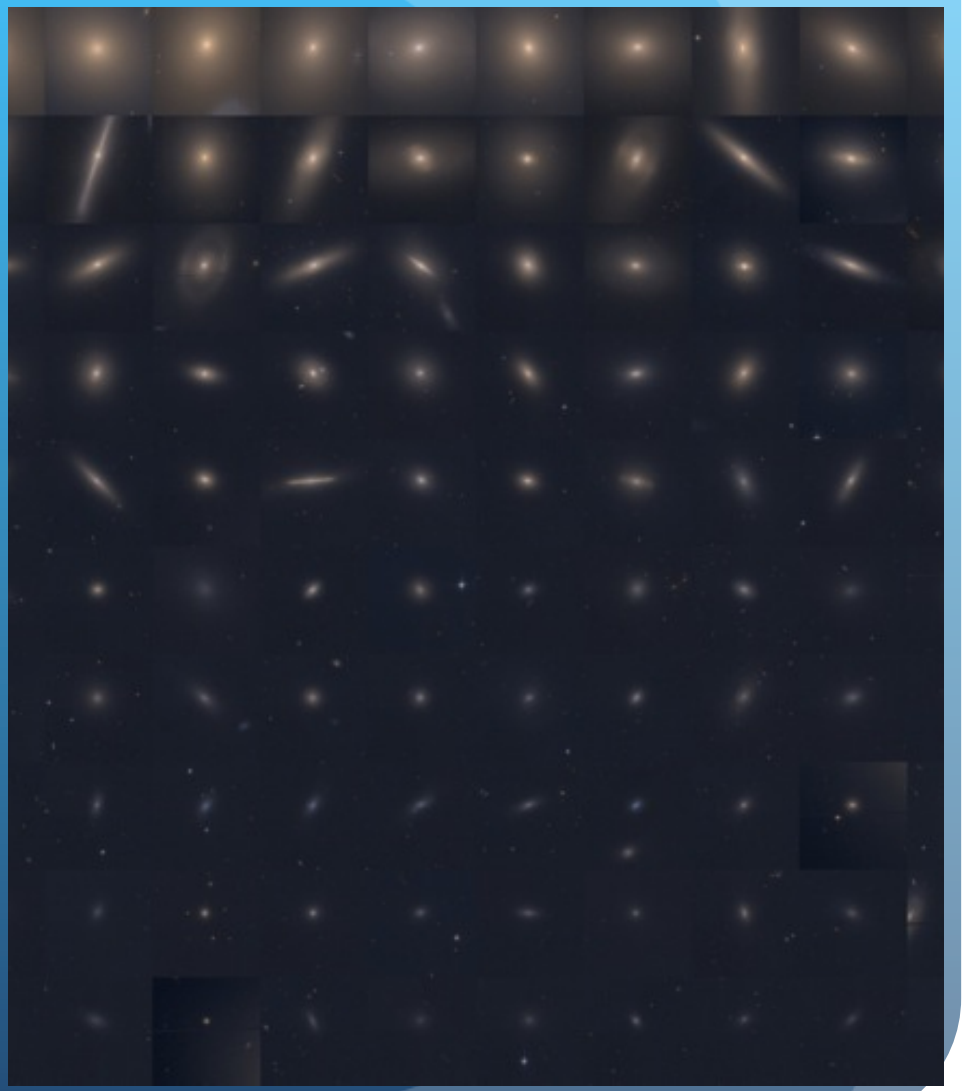
- Other X-ray source populations, e.g. HMXBs, already known (e.g. Coe et al. ‘05, ’10, Payne et al. ‘04)
- But LMXBs missing



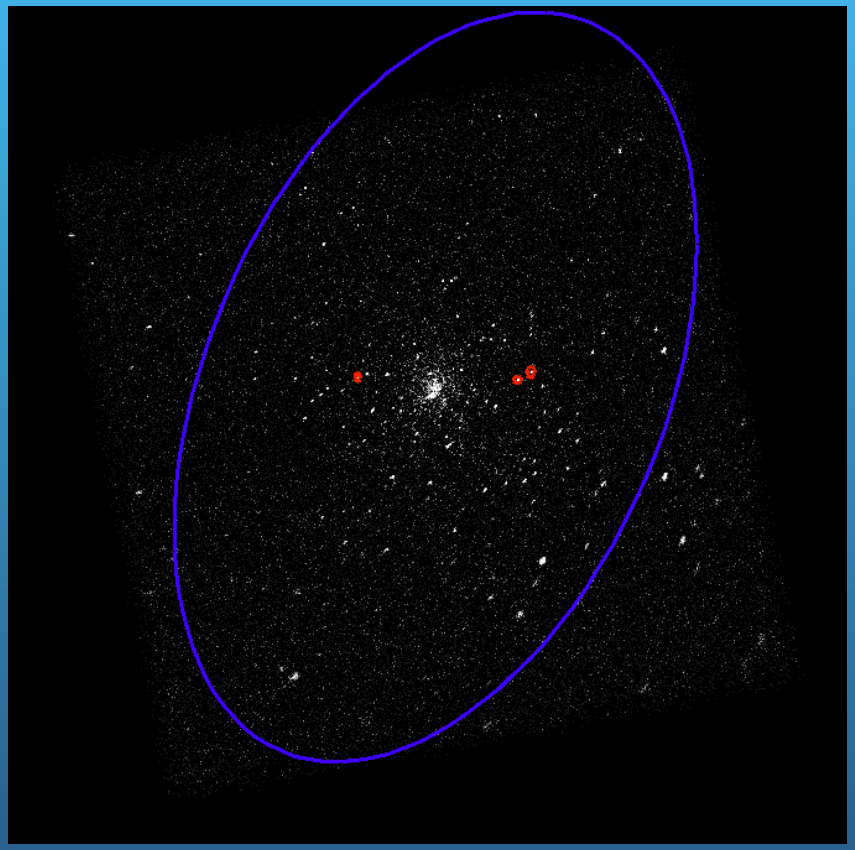

Taken from Haberl et al. 2012

# Current research: BHBs in GCs

- Carry out a specific search for BHBs in GCs
- Start with the Virgo Cluster
  - X-ray (*Chandra's* AMUSE-Virgo survey) and optical (*HST* Virgo Cluster Survey) data already available



# Current research: BHBs in GCs



- 51 ULXs found in Virgo Cluster (Plotkin et al. ‘14)
- 12 of these are coincident with GCs from *HST* VCS

# BHBs in GCs

- Create and analyse X-ray spectra and light curves for 12 sources
  - Check for variability and also spectral state transitions
- Study host GC properties

# Summary

- 7 BHBs in GCs currently known
- 12 ULXs found in Virgo Cluster GCs
  - Analysis of spectra and light curves is about to commence
- Search will also be carried out in Fornax Cluster