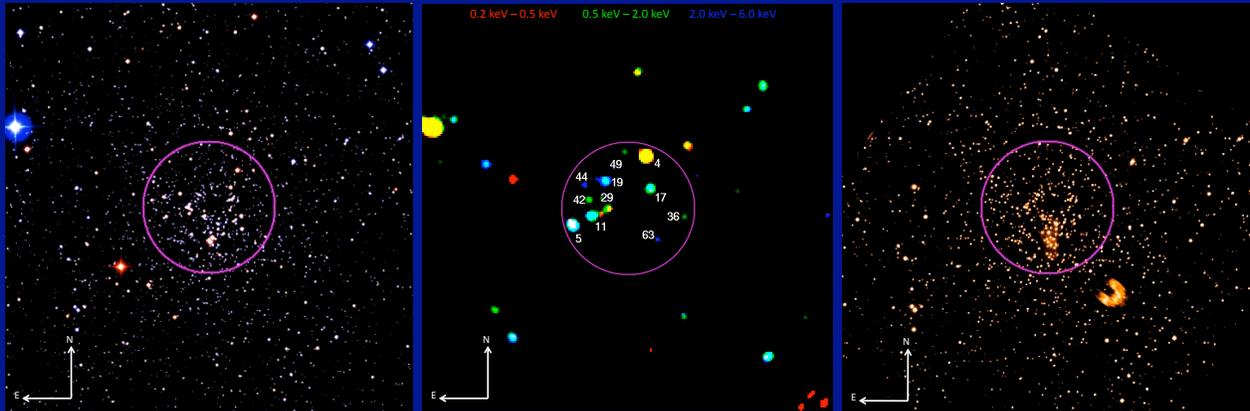


X-Ray Sources in the Rich Open Cluster NGC 6819

Natalie Gosnell¹, D. Pooley¹, A.M. Geller¹, R.D. Mathieu¹, J. Kalirai³, P. Frinchaboy², E. Ramirez-Ruiz⁴
¹University of Wisconsin – Madison, ²Texas Christian University, ³Space Telescope Science Institute, ⁴UC – Santa Cruz

ABSTRACT

We present the first study of the X-ray population of the intermediate-age rich open cluster NGC 6819, using the *XMM-Newton Observatory*. In the past decade, *Chandra* X-ray observations have shown a relationship between the X-ray population of globular clusters and their internal dynamics and encounter frequency. We will investigate whether a similar link exists in open clusters, utilizing X-ray and UV data from *XMM-Newton* along with the wealth of photometry and radial velocity data from the WIYN Open Cluster Study (WOCS). These preliminary results for the X-ray sources in NGC 6819 are the first in a group of 8 open clusters spanning a range of age and metallicities. We detect 76 X-ray sources in the field of NGC 6819 down to a luminosity of 10^{30} ergs/s for cluster members. Sources are classified by taking into account their broadband X-ray/UV/optical spectral properties, determining what types of X-ray sources have formed in NGC 6819 and ultimately whether or not they are primordial or linked to dynamics.



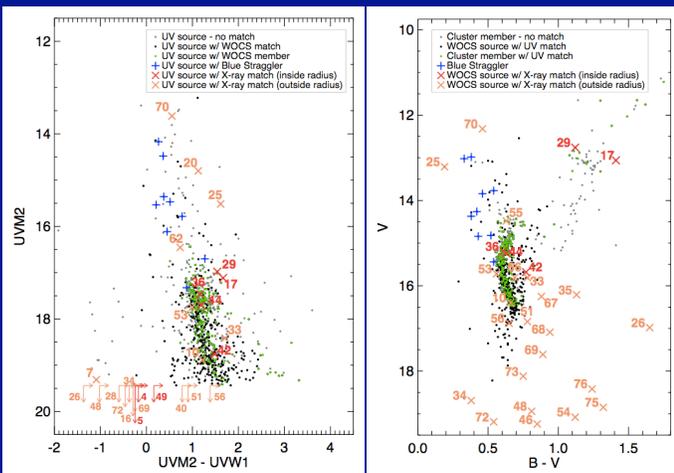
B, R, IR DSS image (left), *XMM-Newton* X-ray image (center), and Optical Monitor *UVM1* image of NGC 6819. All images are 15' x 15'. The magenta circle lies on the 5' apparent diameter of the cluster. X-ray sources within the apparent diameter in the *XMM* image are labeled by their source number.

MOTIVATION

Using *Chandra*, Pooley et al. (2003) found that the number of X-ray sources (all of which are close binaries or their descendants) above $\sim 4 \times 10^{30}$ ergs/s in globular clusters scales with the encounter frequency of the cluster, and Pooley & Hut (2006) found that the number of sources does not scale with mass. This points to a dynamical history for close binaries in clusters. We are investigating if this relationship extends to clusters of lower mass by studying the X-ray population of 8 rich open clusters, including NGC 6819.

NGC 6819 Parameters

Position	Age	Apparent Diameter	Reddening	Metallicity	Distance	Distance Modulus
19 ^h 41 ^m 17.7 +40 ^s 11'17"	2.5 Gyr	5 arcmin	$E(B-V) = 0.1$	$[Fe/H] = -0.05$	2.8 kpc	$(M-m) = 12.3$



UV CMD (left) and a $B-V$ optical CMD (right). X-ray sources within the NGC 6819 apparent diameter are red. Other X-ray sources are shown in orange, with an arrow to denote limiting color when necessary. The varying length of arrows is for labeling purposes only.

DATA AND ANALYSIS

The open clusters we examine with *XMM-Newton* already have a wealth of optical data from the WIYN Open Cluster Study (WOCS) (Mathieu 2000) and the CFHT Open Cluster Study (Kalirai et al. 2001). WOCS gathers radial velocity data for stars in an open cluster field, collecting information about binaries and determining cluster membership kinematically, ultimately allowing for accurate X-ray counterpart classification. We also utilize ultraviolet data from the Optical Monitor (OM) aboard *XMM* using the *UVM2* (200-275nm) and *UVM1* (250-370nm) filters.

Using the SAS routine EMLDETECT, we find 76 sources in a 25 ks exposure centered on NGC 6819. We matched the X-ray position error circles to sources detected in the *UVM2* and *UVM1* images and the WOCS catalog. The WOCS membership cuts are made using radial velocity data, which can only be gathered for stars brighter than $V=16.5$, hence the cutoff in the optical CMD main sequence. Using the combination of the UV CMD, optical CMD, and broadband X-ray spectra we can attempt to classify the X-ray sources of NGC 6819.

X-RAY SOURCES

Out of the 76 sources detected in the field of NGC 6819 there are 38 with a counterpart: 29 have a WOCS counterpart, 17 of which also have a UV counterpart. 9 sources have only a UV counterpart. 11 of the 76 total sources lie within the cluster apparent diameter, where we only expect 2 or 3 background sources using the $\log N - \log S$ relationship from Giacconi et al. (2001). These 11 sources have a luminosity range of 5×10^{30} ergs/s to 5×10^{31} ergs/s. Sources 29 and 44 are kinematic member binaries and source 42 is a rapid rotator member. The actual extent of NGC 6819 goes beyond the apparent diameter. Source 53 (outside the apparent diameter) has a member optical counterpart. The cluster membership of the other 18 optical counterparts will be determined through future observations. All sources are being studied using their spectra and photometry. Dieball et al. (2007) showed that a UV CMD can help discern different stellar populations, specifically CVs. Source 7 lies in the UV excess on the UV CMD, and if associated with NGC 6819, could be a CV candidate. The optical CMD shows that the X-ray sources in NGC 6819 are not confined to one evolutionary stage.

SUMMARY

- NGC 6819 is the first of 8 rich open clusters we will study with *XMM-Newton* in order to classify cluster X-ray populations based on optical, UV, and X-ray data
- We detect 11 sources within the apparent diameter of NGC 6819, an excess over the background, showing there are sources associated with the cluster
- X-ray sources associated with NGC 6819 have a luminosity range of 5×10^{30} ergs/s to 5×10^{31} ergs/s

References:

Dieball, A., et al., 2007, *Apl*, 670, 379
 Giacconi, R., et al., 2001, *Apl*, 551, 624
 Hole, K., et al., 2009, *AJ*, 138, 159
 Kalirai, J., et al., 2006, *AJ*, 122, 257
 Pooley, D., et al., 2003, *Apl*, 591, L131
 Pooley, D. and Hut, P., 2006, *Apl*, 646, L143
 Mathieu, R.D., 2000, *ASP*, 198, 517