13106 - A New Insight into Open Cluster Internal Dynamics and Neutron Star Formation

Cycle: 20, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) NGC-6819	WFC3/UVIS	1	15-Oct-2012 21:32:42.0	yes

1 Total Orbits Used

ABSTRACT

We propose a 22-ks ACIS-S3 observation of the qLMXB candidate X1 in the open cluster NGC 6819. Previous data from XMM and archival data from HST show at least two sources within the 2.14 arcsec X1 XMM position error circle. This observation will allow us to determine a sub-arcsecond position for X1, establishing the optical counterpart, a crucial step in classifying X1. For a precise astrometric match between the Chandra and HST frames we propose for one orbit of HST WFC3/UVIS/F336W data, which we will also use to search for signatures of an accretion disk. This proposal can confirm the first qLMXB in an open cluster, thereby providing important and much needed constraints for our theoretical understanding of NS formation and retention in open clusters.

OBSERVING DESCRIPTION

We propose WFC3/UVIS/F336W imaging of NGC 6819 to confirm the counterpart of the quiescent low-mass X-ray binary candidate X1 and provide additional ~U-band information for the X-ray sources in NGC 6819.

XMM-Newton observations of NGC 6819 discovered a candidate low-mass X-ray binary (qLMXB) — the first object of its kind found in an open cluster environment (Gosnell et al. 2012). If confirmed, the qLMXB (X1) will have major implications for the production and retention of neutron stars in an open cluster environment. Current theoretical and modeling efforts cannot explain how a neutron star could remain in an open cluster after formation. Confirming X1 as a qLMXB in an open cluster will provide important observational constraints on current modeling efforts. For this reason, it is imperative to determine the nature of X1, which requires knowing its optical counterpart.

Archival WFC3 images (F606W and F814W, GO 11688) of NGC 6819 revealed a possible M-dwarf (F606W = 23.4) counterpart to X1, located on the cluster main sequence. However, a separate bright optical source, probably a foreground giant, also lies within the 2-sigma X-ray position error. The low astrometrical precision of XMM data is not sufficient to determine which optical source is the true counterpart. With the joint Chandra time awarded (22 ks) we will observe X1 down to sub-arcsecond precision in order to carry out precise counterpart matching.

In order to complete accurate astrometric matching between Chandra and HST frames there must be three X-ray sources with known optical counterparts in both images (e.g., Pooley et al. 2001, Edmonds et al. 2002, Bassa et al. 2004). Three sources near X1 with optical counterparts are present in NGC 6819 — X4, X6, and X9. The current archival images of NGC 6819 include the counterparts to X4 and X6, but not X9. We therefore require additional observations. Our pointing includes the counterparts for X4, X6, and X9, as well as the potential counterparts for X1. With this image we will carry out high-precision astrometry to match the X-ray and optical frames.

The additional HST image also gives us an opportunity to increase our wavelength coverage of X1, which may provide more information about its nature. In particular, a near-U band like F336W has proven very useful in previous globular cluster studies. Edmonds et al. (2002), e.g., were able to determine that one of the qLMXBs in 47 Tuc (X5) likely has a “detached” accretion disk still surrounding it due to its location between the white dwarf cooling tracks and the lower main-sequence in a U–V CMD. If we find the M-dwarf to be the X1 counterpart and it lies in a similar region of an approximately U–V CMD, we could draw similar conclusions. This possibility is the main reason for choosing F336W. Any filter would allow us to do the frame registration with Chandra, but F336W will offer additional insight.

We note that the optical counterparts to X4, X6, and X9 are all easily detected in UVW1 (220–400nm) with the OM aboard XMM-Newton, so we will have no difficulties detecting them in F336W. Once we tie the Chandra and HST frames together, we will have measurements or deep limits on the F336W, F606W, and F814W magnitudes of X1. We will utilize the archival F606W data and create a F336W–F606W CMD, approximating U–V, to place the X1 counterpart in context with the cluster main sequence.

Specifically we propose to observe NGC 6819 for 48 minutes using WFC3/UVIS/F336W. This will require one visit with a duration of one orbit to complete. At the distance (2.3 kpc) and reddening (E(B – V) = 0.15) of NGC 6819, the online HST ETC indicates we will reach a S/N~25 for an instrumental magnitude of ~24. This is as deep as similar studies needed to detect ~U-band counterparts of qLMXBs (Edmonds et al. 2002). The RA of NGC 6819 (295 degrees) does not fall within the HST RA restriction ranges for this HST cycle.

The orientation requirements for this proposal are necessary in order to fit the optical counterparts of X4, X6, and X9 in the same image. Due to the oblique field of view of WFC3/UVIS on the sky there are orientation angles that exclude one of the optical counterparts, leaving only two on the image. Our scientific goals require three counterparts in the HST field of view in order to carry out the astrometric matching between Hubble and Chandra. We have utilized the least constrictive orientation ranges possible while keeping all three optical counterparts in the field of view.

This observation is a straightforward way achieve two goals — frame registration with Chandra and the search for a possible UV excess — with a single HST orbit. We stress that WFC3/UVIS is the only instrument available that can provide the depth and resolution necessary to allow us to classify X1.

Visit

Proposal 13106, NGC-6819 (01) Tue Oct 16 01:32:49 GMT 2012

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 17.1D TO 40.4 D; ORIENT 105.4D TO 135.8 D; ORIENT 197.7D TO 223.7 D; ORIENT 283.1D TO 313.9 D

Comments: The orientation requirements (explained in the Proposal Description) were calculated using the Aladin imager. The orientation limits ensure the optical counterparts to X4 (19:41:13.3, +40:12:48.14), X6 (19:41:22.02, +40:12:01.18) and X9 (19:41:25.89, +40:12:23.63) are always in the field of view.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-GAP-LINE	Coordinate Frame=POS-TARG		(1)
	Purpose=MOSAIC	Pattern Orientation=85.759		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=2.414	Center Pattern=true		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	NGC-6819	RA: 19 41 19.0424 (295.3293433d)		V=7.3	Reference Frame: SIMBAD
		Dec: +40 13 9.15 (40.21921d)		E(B-V)=0.15	
		Equinox: J2000			

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) NGC-6819	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W			Pattern 1, Exps 1-1 in NGC-6819 (01) (1)	900 Secs	
								[==>1432.0 Secs (Pattern 1)]	
								[==>1432.0 Secs (Pattern 2)]	*[1]*

Orbit Structure