Faint Cataclysmic Variables in the globular cluster 47 Tucanae

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ABSTRACT

We study the population of faint cataclysmic variables in the globular cluster 47 Tuc using near-ultraviolet images from the Hubble Space Telescope in combination with deep Chandra X-ray data. We present preliminary results of near-ultraviolet counterparts of X-ray sources in the globular cluster. **So far we have found 18 new cataclysmic variable candidates out of 44 X-ray unidentified sources investigated.**

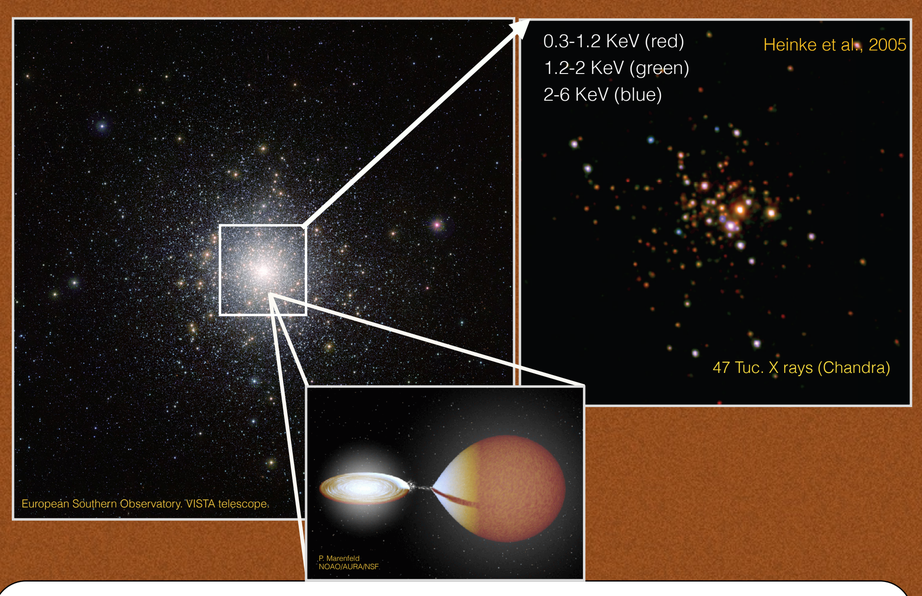

Figure 1. Back: Globular cluster 47 Tucanae in optical and X-rays. **Front:** Artistic impression of a Cataclysmic Variable. The white dwarf is accreting from the late-type companion through an accretion disk.

INTRODUCTION

As very high stellar densities can be reached in GCs (10^6 stars per cubic parsec), interactions and collisions between stars are common. In those conditions, the cores of GCs are rich sites to produce exotic binaries such as cataclysmic variables (CVs), which are systems harboring a white dwarf accreting from low mass companions (figure 1). Studying the CV population help to understand how dense environments alter the production and destruction of binaries.

The study of binaries in globular clusters (GCs) is important to understand the dynamical evolution of GCs, since binaries can help to prevent core collapse.

The globular cluster 47 Tuc is ideal to study those binaries because it is a nearby, dense, massive and low extinction cluster. Moreover, distance, stellar age and metallicity are well known for this cluster. This allows the study of a large population of interacting binaries an their descendants such as CVs, millisecond pulsars (MSPs), low mass X-ray binaries (LMXBs), blue stragglers (BSs) and active binaries (ABs).

GOALS OF OUR SURVEY

1. Identify faint CVs in 47 Tuc by looking for counterparts to Chandra X-ray sources in near ultraviolet (NUV).

2. Obtaining the deepest measurements of the CV luminosity function of 47 Tuc.

3. Comparing the CV luminosity function of 47 Tuc with those measured in the field and in the core collapsed cluster NGC 6397. Based on the spatial distribution and unusually flat (compared to the field) CV optical luminosity function in NGC6397, Cohn et al. (2010) found that the CV population in this cluster is dynamically altered. In this context we want to test whether the CV luminosity function of NGC 6397 is unusually flat or if is typical for globular cluster CVs.

ANALYSIS AND RESULTS

In our survey we are using near-ultraviolet images of the globular cluster 47 Tuc taken in the wavelengths 280.7 nm and 392.1 nm with the Wide Field Camera 3 on the Hubble Space Telescope (HST).

Combining our data with the catalog of Chandra sources in this cluster (Heinke et al. 2005, completeness limit $L_{(0.5\text{-}2.5\ keV)}$=8e29 erg/s), we are identifying the NUV counterparts of 241 Chandra sources that are in our FOV, including 116 previously unclassified sources. **We have identified 18 new faint CV candidates so far.** Figure 2 shows the position of the new CV candidates in the color magnitude diagram (CMD) of 47 Tuc in NUV. An identification of a CV with blue colors in the 3-sigma error circle of Chandra source is shown in figure 3. In figure 4 we observe that the new identifications have X-ray luminosity an order of magnitude deeper than the previously identified CVs by other authors (Edmonds et al., 2003).

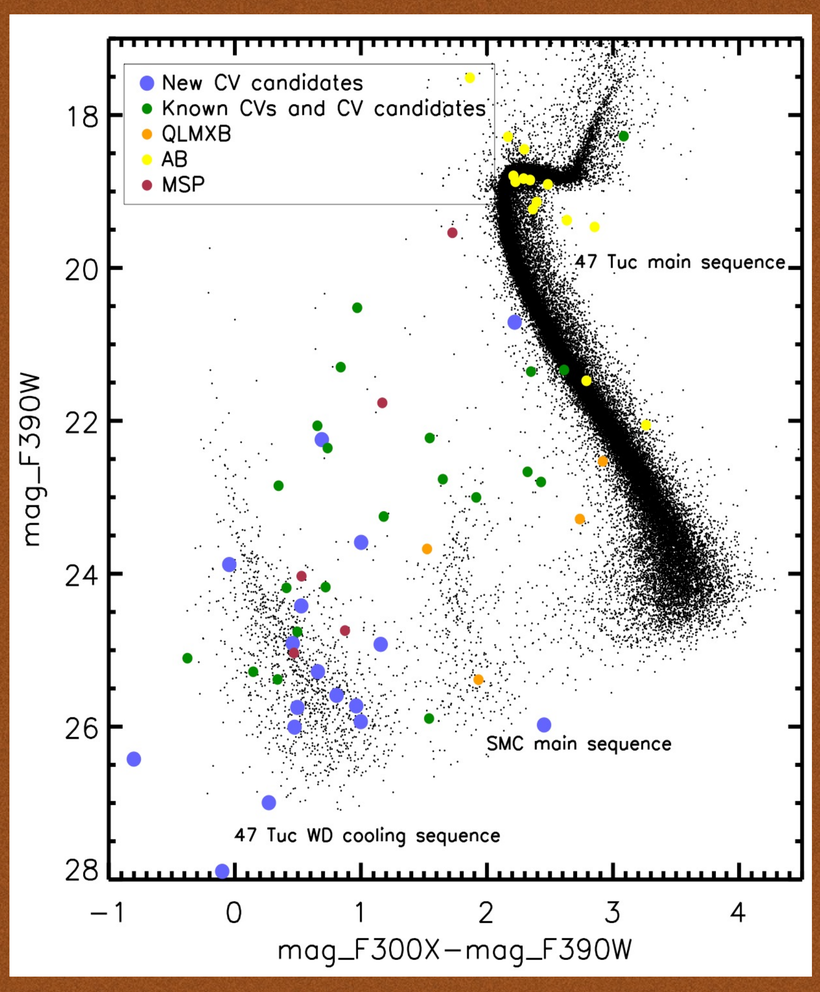

Figure 2. CMD of 47 Tuc in the wavelengths 280.7 nm and 392.1 nm. The sequence on the right is the main sequence of 47 Tuc and the one on the left is the cluster's white dwarf cooling sequence. Since 47 Tuc is located partially in front of the Small Magellanic Cloud (SMC), the intermediate sequence is the main sequence of SMC. The magnitudes given are instrumental and not calibrated yet.

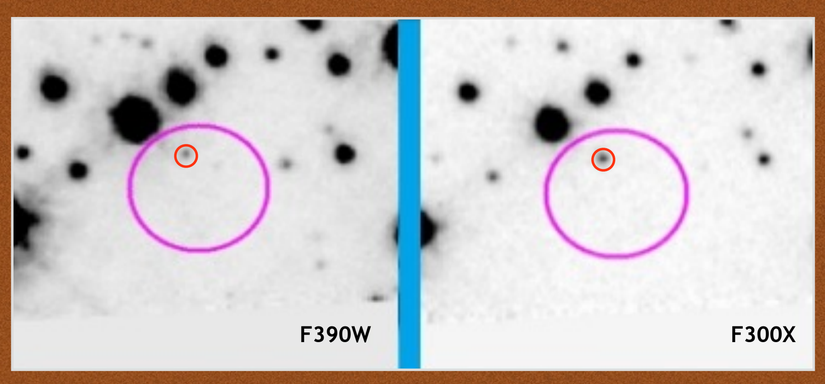

Figure 3. HST finding charts in filters F390W (392.1 nm) and F300X (280.7 nm) for a new identification. Error circles (magenta circles) are centered on the X-ray source and have radii of 3 sigma. Red circles indicate the near ultraviolet counterpart. Both images are 3''x 3''.

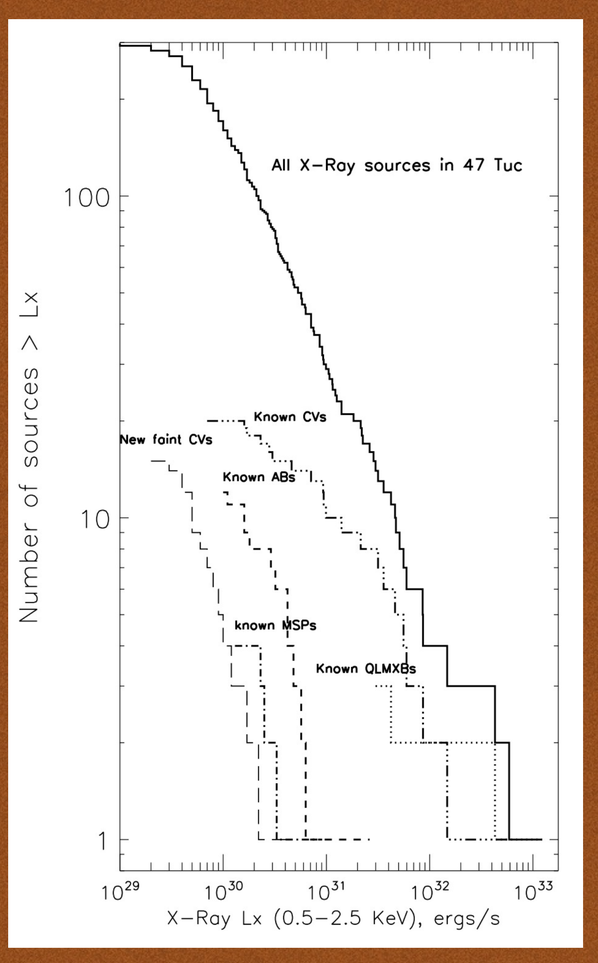

Figure 4. Cumulative X-ray luminosity functions for the different classes of sources in 47 Tuc with counterparts found in NUV. The new CV candidates analyzed so far, have the lowest X-ray luminosities compared with other classes of known X-ray sources in 47 Tuc, like MSPs, ABs, QLMXB and previously identified CVs. X-ray values were taken from Heinke et al. (2005).

SUMMARY

Using a catalog of X-ray sources and NUV colors, we have found 18 new candidate CVs so far out of 44 unclassified sources investigated.

New faint sources show blue colors and many of them are on the white dwarf sequence.

The new CV candidates have the lowest X-ray luminosities compared with other classes of known X-ray sources in 47 Tuc for which we have found their counterpart in NUV, such as MSPs, QLMXBs, ABs and previously identified CVs by other authors.

PLANS FOR THE FUTURE

Identifying more CVs candidates using the CMD, X-ray source positions and proper motions to exclude non cluster objects.

Comparing our results with the measured CV luminosity function in the field and in other globular clusters like the core collapsed globular cluster NGC 6397.

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