

A STUDY OF NEUTRON STARS IN GLOBULAR CLUSTERS FROM NEW SWIFT X-RAY OBSERVATIONS

Scientific Report -- Short-Term Scientific Mission (STSM) -- NewCompStar COST Action MP1304

Grantee: Dr. Manuel Linares, Instituto de Astrofísica de Canarias, Spain.
Host: Dr. Jerome Chenevez, DTU Space, Denmark.
Period: May 4-11, 2015.

1. Goals

Globular clusters (GCs) are efficient factories of X-ray binaries and millisecond pulsars (MSPs). We have recently initiated a Swift-XRT monitoring of three selected GCs (Terzan 5, M28 and 47 Tuc), in order to: i) find new low-luminosity transient LMXBs, ii) detect short and faint outbursts from known transient NS LMXBs and iii) monitor the X-ray activity of the known MSP population to search for more MSP-NS-LMXB transition pulsars.

The purpose of this STSM was develop an automated pipeline to analyze in real time our Swift-XRT observations of the three GCs. This is instrumental to react quickly to sudden changes in the luminosity or spectrum of any of the systems, allowing prompt triggers of multi-wavelength observations. We also planned to make the results of our campaign available to the community through a dedicated public website (the first outcome of this STSM, upon completion of the visit). The second outcome, expected for late 2015, will be an article reporting the results of the first year of Swift monitoring of GCs.

2. Work

During this STSM in Copenhagen, at the host institution DTU Space, we developed the necessary software to automatically download, process and analyze every Swift-XRT observation from our GC monitoring program. The software developed consists of a set of scripts to extract the necessary information from the Swift "quicklook" data (images, light curves, fitted spectra and observation metadata). We folded into the analysis specific parameters for each of the GCs: distance, absorbing column density, as well as half-light and core radii. The resulting pipeline was installed after being extensively tested.

We also carried out a full reanalysis of all the existing Swift-XRT data of the three GCs currently in our program, using the same software specifically designed for this project. This provides context for the new coming observations, which are being taken at the moment at the rate of typically one 4ksec-long Swift observation every 2-4 weeks. Finally, we put together the results in a public website which is currently under construction (see <https://sites.google.com/site/swift47tuc> for a preliminary version).

3. Results

Figure 1 shows the latest Swift-XRT image of M28, taken on May 28 within our monitoring program. A source is clearly detected near the edge of the GC core, with an X-ray luminosity of 4×10^{33} erg/s and a photon index of 2.2 ± 0.4 . This is only the second observation of our program on M28, which started in May 2015, but clearly the newly developed tools will allow us to efficiently characterize the low-level activity and react promptly to any changes or new outbursts.

The long-term light curve of the GC Terzan 5 is shown in Figure 2, obtained with our specifically designed pipeline. The ongoing outburst is clearly seen (X-ray luminosity of 10^{37} erg/s on June 9, 2015), and it obviously prevents any study of the low-level activity in the cluster. However, as soon as the outburst is finished, our campaign will yield

the first monitoring of the fainter source activity in Terzan 5 (note the current lack of data at luminosities below 10^{34} erg/s).

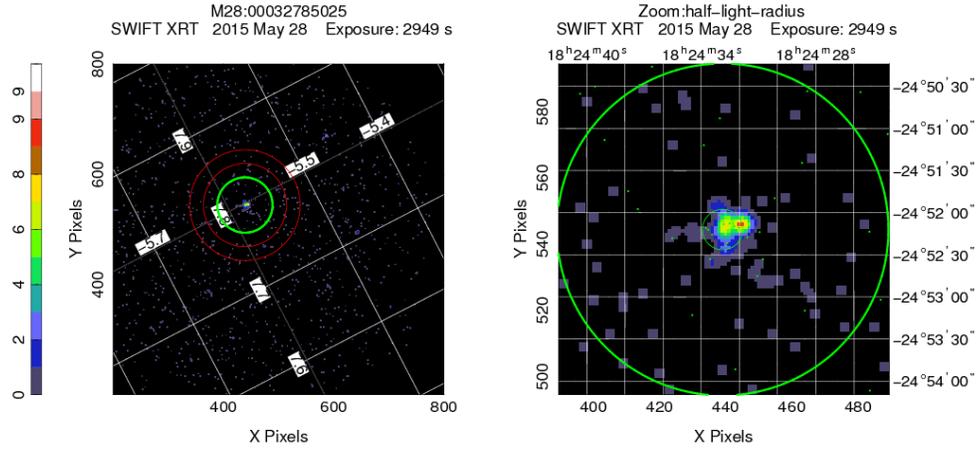


Figure 1: Latest Swift-XRT 0.3-10 keV image of the globular cluster M28, smoothed with a 1.5 pixel Gaussian. Observation ID, date and exposure are noted, and the color scale shows the image counts. *Left:* full XRT image, in Galactic coordinates. The red annulus shows the background extraction region, and the green thick circle the cluster half-light radius. *Right:* XRT, in equatorial coordinates, centered on the optical center and zoomed to show the half-light radius (thick green circle). The thin inner circle shows the core radius, and the green dots show the known faint X-ray sources from deep Chandra observations (Heinke et al. 2005).

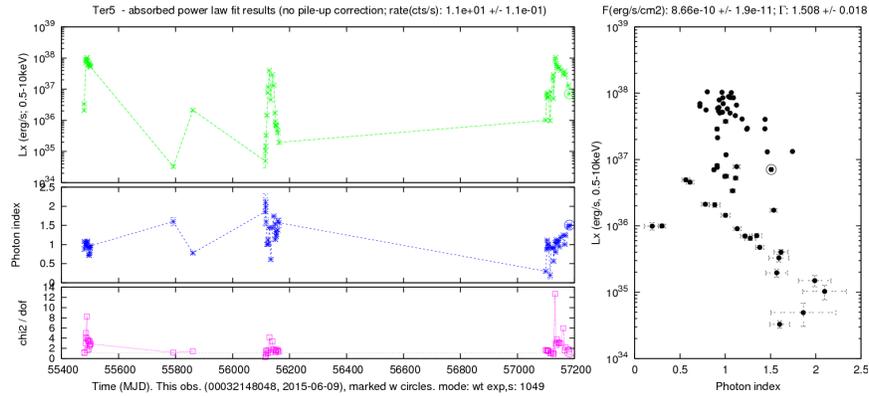


Figure 2: Long-term lightcurve and spectral evolution of the globular cluster Terzan 5, from all Swift-XRT observations available on June 9, 2015. Panels on the left show the time evolution of (from bottom up) reduced chi-squared, photon index and X-ray luminosity. The right panel shows the luminosity-photon index plane. The latest observation is marked with a circle, and shows the ongoing outburst of one of the three known neutron star transients in Terzan 5.

4. Future

We continue to work together, the grantee M. Linares and host J. Chenevez, in order to i) finalize, optimize and publicize the website with the results of the Swift monitoring of GCs, ii) extend our monitoring to the next Swift observing cycle and to more GCs, iii) publish the results of our first year program as soon as the corresponding observations have been performed. Thus we foresee at least one publication in a high-impact journal during the next year reporting the details and results of this program, directly resulting from this STSM.

The host J. Chenevez, copied in this scientific report notification, confirms on behalf of the host institution DTU Space that this was a successful and fruitful STSM.