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Reference: ECOST-STSM-MP1304-011016-080065 API, University of Amsterdam
Host: Dr. Nathalie Degenaar Starting Date: 01/10/16
Institution: Institute of Astronomy, U. Cambridge End Date: 01/12/16

Short Term Scientific Mission Report

Hubble Space Telescope UV spectroscopy of quiescent X-ray binaries

Purpose of the STSM

Transient low-mass X-ray binaries (LMXBs) provide the opportunity to investigate accretion disks around stellar-mass black holes and neutron stars over a wide range of physical parameters. LMXBs are often discovered in short and bright episodes (outbursts) where its X-ray luminosity can rise up to the Eddington limit, L_{edd}. These systems often drop down to quiescence (usually 2-3 orders of magnitude in X-ray luminosity) where the spectral energy distribution of cold accretion disks is expected to peak at UV wavelengths. Despite observational challenges, it has been possible to carry out UV observations of a handful of quiescent LMXBs (e.g. McClintock & Remillard, 2000; Plotkin et al., 2016). However, the number of sources with high-quality UV data is very limited and hence no clear picture has emerged yet. The purpose of this STSM was to analyse an interpret the HST far-ultraviolet (FUV) spectra of two quiescent X-ray binaries: EXO 0747676 and Swift J1357.20933, each harbouring a neutron star and a black hole, respectively.

Description of the work and main results

The data consisted of two 9 orbit datasets (20.5 ks each) FUV (1100-2700Å) time-tag spectroscopy. Despite both systems being high-galactic objects (i.e. low absorption column), the spectra were hardly detected in the individual orbits. We re-processed the data to obtain a higher signal-to-noise spectrum of each object. For Swift J1357.20933, I was able to detect a faint continuum signal between the very bright geo-coronal emission lines. Using data from the literature (Plotkin et al., 2016), I was able to construct a spectral energy distribution (SED) for the system, shown in the left panel of Figure 1. The data optical and UV data is consistent with a blackbody with a $T_{eff} = 7100 \pm 400$ K. However, the blackbody fit does not reproduce the observed flat emission in the NIR, which has been attributed to the presence of a jet in the system (Shahbaz et al., 2013; Plotkin et al., 2016).

The average spectrum of EXO 0747676 revealed a much stronger detection of the continuum and clear broad C IV 1550 Å in emission, shown in the right panel of Figure 1. The data set is mostly dominated by very strong geo-coronal lines. The combined provides evidence of residual accretion during its quiescence states. Overall, these observations are the first detections in the far-UV of these X-ray binaries.

During my stay at the IoA, we got a target of opportunity of another quiescent X-ray binary, IGR J17062–6143. This object has been a persistent X-ray source at very low luminosity 0.1% L_{edd}. Our collaborators in Argentina (V. Cúneo and M. N Gómez) were able to obtain a 2 hr optical spectrum at the Gemini South observatory, through the fast turnaround program. We prompted other collaborator s to obtain as much coverage in order to construct full picture of the system. Following the data acquisition, I reduced and analyse the data. Surprisingly, the data presents a blue continuum with no evidence of emission/absorption lines. The lack of a Hα line is suggestive of a hydrogen depleted donor, usually associated to ultra-compact binaries (in't Zand et al., 2007).

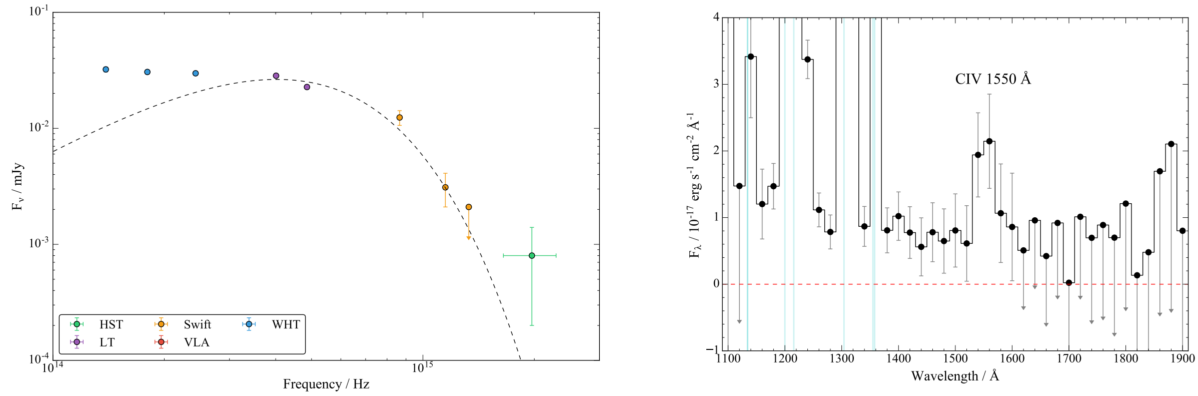

Figure 1: Left: SED of Swift J1357.20933. Right: FUV spectrum of EXO 0747676.

I combined our optical spectrum with archival X-ray data (reduced by J. van den Eijnden, IoA), NIR photometry (N. Degenaar, IoA) and optical photometry (D. M Russell, NYU) to construct a quasi-simultaneous average SED of the system, shown in the right panel of Figure 2. The SED is consistent with a bright disc accreting at a low-mass transfer rate. The accretion disc fit allow me to obtain an outer radius, which imposes an upper limit on the orbital period. Given our broad coverage of the system, I was able to use the empirical relations between X-ray and optical/NIR to determine range of possible orbital period of the system, between $0.16 - 2.5$ hr.

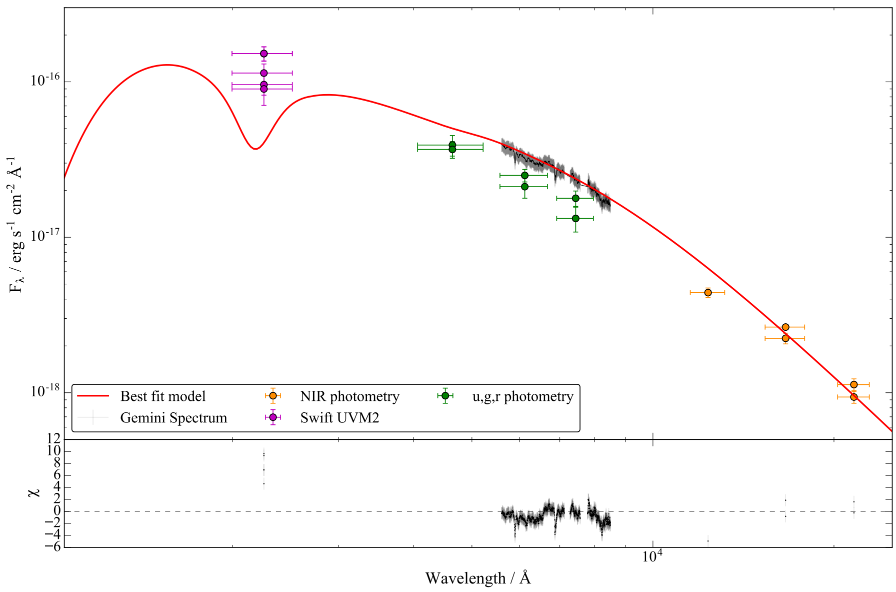

Figure 2: SED of IGR J17062–6143, modelled as a standard accretion disc (Shakura & Sunyaev, 1973).

In addition, I gave a talk to the X-ray group during my visit regarding the connection of transitional millisecond pulsars and other weakly accreting X-ray binaries (as the ones described above). This prompted useful discussions, particularly the idea of a multi-wavelength follow-up program on key sources.

Future collaboration and publications

The results presented in the previous section are being prepared in two different publications. First, I am working on a combined paper of the HST datasets. We will present the description of the observations as well as a comparison between the UV spectra of neutron star and a black hole systems. Second, we are currently working on a draft of a paper regarding the multi-wavelength observations of IGR J17062–6143, with aims to be submitted earlier next year. Since the optical spectrum was taken in a Fast turn-around program, a publication is expected soon after the observations are taken. Support from COST Action MP1304 will be acknowledge in both publications. We are also planning further photometric NIR observations in order to determine the orbital period of IGR J17062–6143.

References

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