Long term analysis of high-mass X-ray binaries with MAXI

J. J. Rodes, J. M. Torrejón, T. Mihara, S. Nakahira, Á. Giménez-García, G. Bernabéu

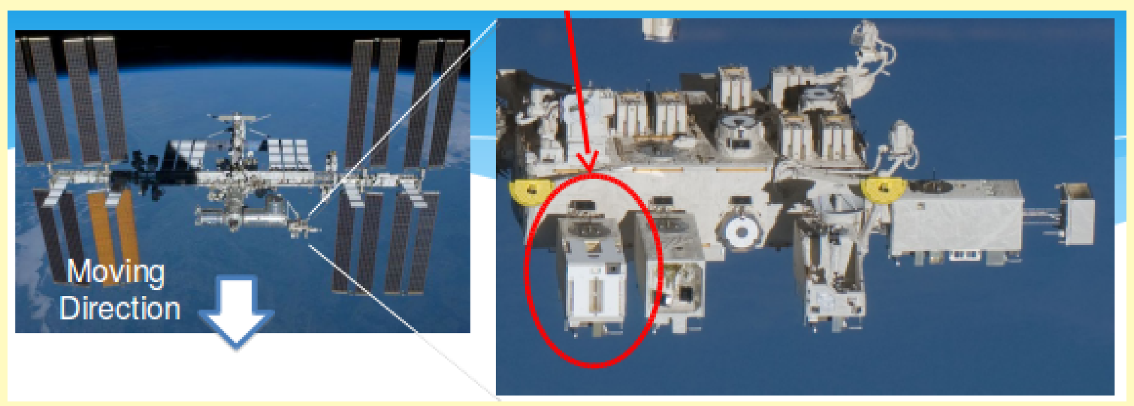
Universitat d'Alacant
Universidad de Alicante

Abstract

We present an analysis of the long term X-ray observations of the high-mass X-ray binary 4U 1538−52, a wind accreting neutron star with a supergiant companion. The source was scanned every 90 minutes by the *MAXI/GSC* on the International Space Station during 5 years. We analyse both the light curves and the orbital phase resolved spectroscopy to study the permanent structures in the stellar wind and the circumstellar environment needed to correctly interpret the accretion flow onto the neutron star in these systems.

Introduction

The Monitor of All-sky X-ray Image (*MAXI*) allow us to analyse long term X-ray variability of win-fed pulsars as well as to observe transient X-ray binary pulsars [1]. Most of these sources with compact objects are variable due to interactions between the stellar wind and the neutron star.

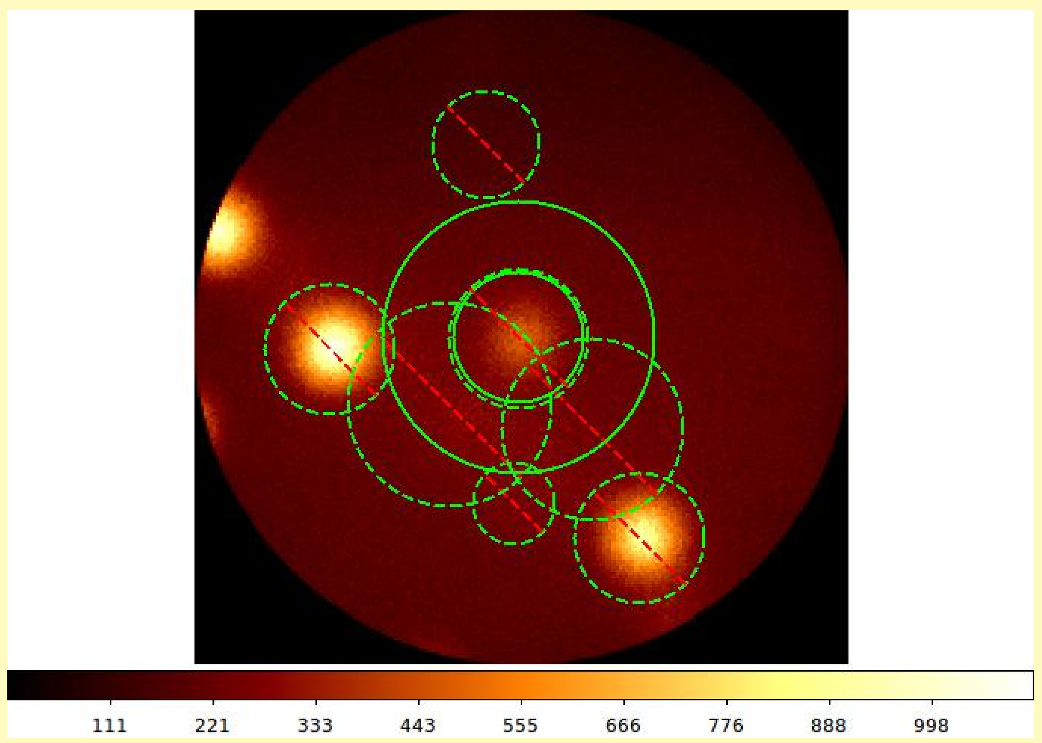


- **First astronomical** mission on ISS.
- First light was on **August 15 2009**.
- Scans every **92 minutes** with ISS rotation.
- Observing for nearly **6 years**, **recently extending until March 2018**.
- Data available at home web-page `http://maxi.riken.jp`. **GSC** and **SSC** data by on-demand.

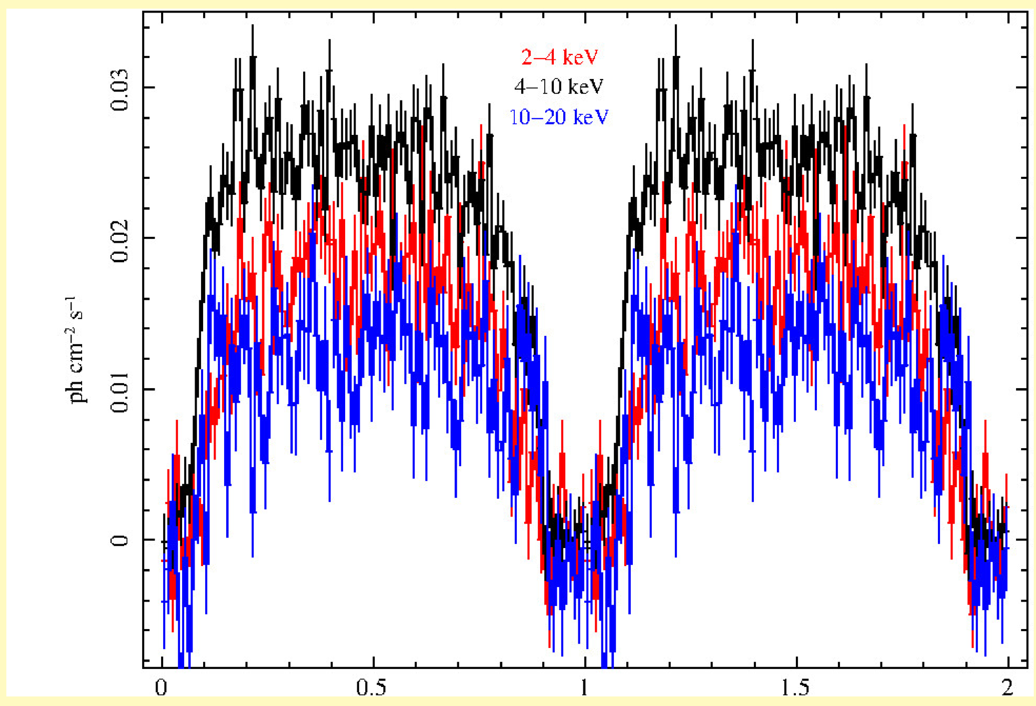
One way to study the stellar wind in HMXBs is in terms of the variability of the N_H throughout the binary orbit. Using the spectral data from *MAXI*, we study the dependence of the equivalent absorption column as a function of the orbital phase in **4U 1538−52** [2] as an example of our large scale *MAXI-UA-RIKEN* project to monitor wind fed systems with supergiant companions. *MAXI* observing strategy suppress effectively the short term variability associated with wind accreting sources and enhances the long term, permanent structures present in the stellar wind and circumsource environment [3], [4].

Timing analysis

First, we have obtained the *MAXI/GSC* 1-orbit light-curve in the 2–20 keV energy band. Then, we have searched for a period assuming a sinusoidal signal and derived a $P_{\rm orb} = 3.7285 \pm 0.0006$ days which is consistent with the value given by [5].



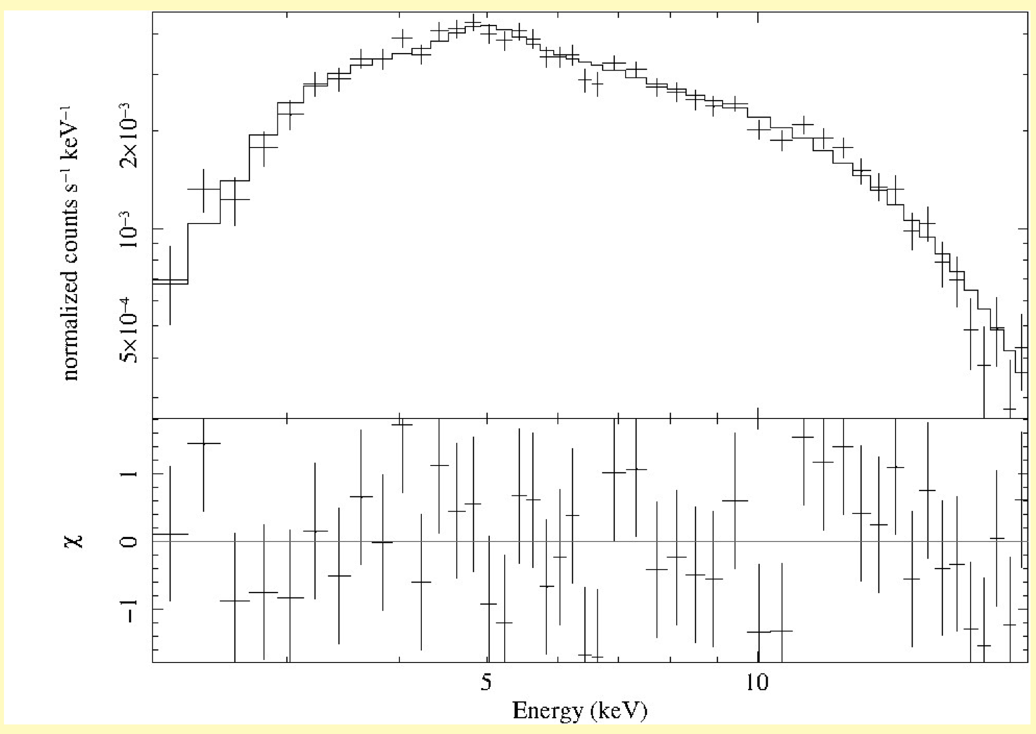
a) The extraction region



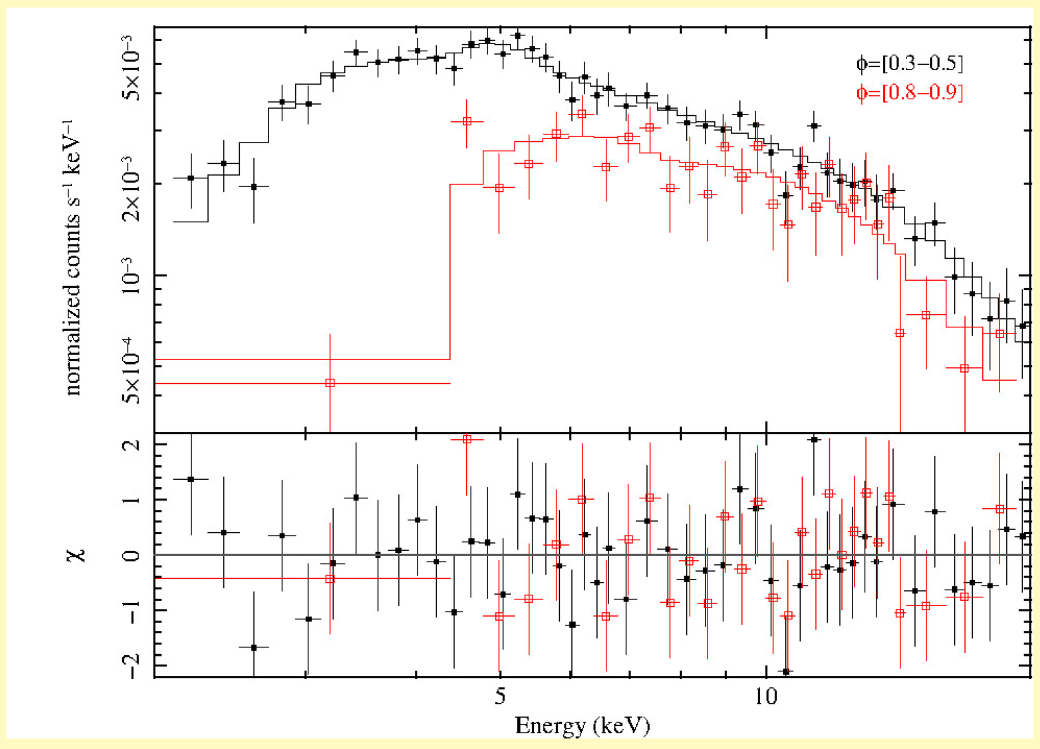
b) Background subtracted light curves

Spectral analysis

We have extracted the orbital phase averaged spectrum of 4U 1538−52 with *MAXI/GSC* using the *MAXI* on-demand processing, carefully excluding any contamination by nearby brighter sources. The best fit was attained using COMPST, in XSPEC terminology [6], modified by an absorbing column along our line of sight. The absorption columns N_H were fitted with the Tübingen-Boulder absorption model (*TBnew*) which includes the most up to date absorption cross sections and abundances [7].



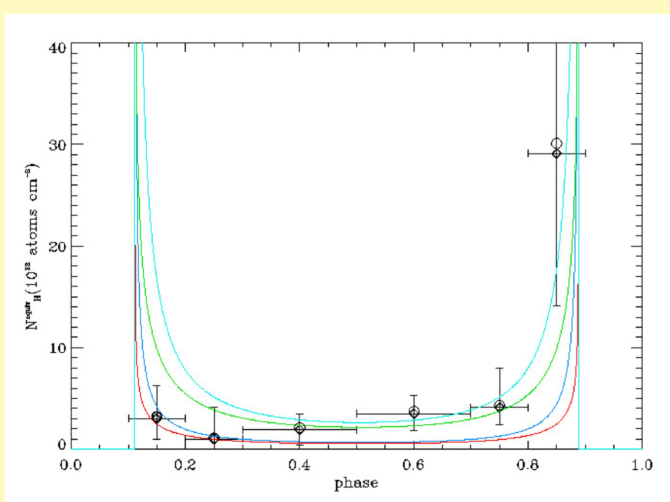
a) Averaged spectrum



b) Phase-resolved spectra

Then We have obtained orbital phase resolved spectra of the HMXB pulsar 4U 1538−52 accumulating the 60 s duration scans into six ≈0.5 day orbital phase bins outside of eclipse. We have fitted the orbital phase resolved spectra with the same model we used in the orbital phase averaged spectrum. The unabsorbed flux along the orbit has no significant evolution, $(7.2-8.8)\times10^{10}$ erg cm^{-2} s^{-1} in the fitting energy range (2-20) keV, showing that **the accretion rate is quite stable**, in the phase bins considered.

The stellar wind in 4U 1538−52



$\dot{M}$ $(M_\odot\,{\rm yr}^{-1})/v_\infty$ (km s^{-1}). **Red line**: $\beta = 0.8$ and $(\dot{M}/v_\infty)_{\rm max} = 3.4\times10^{-10}$; **Blue line**: $\beta = 1.2$ and $\dot{M}/v_\infty = (\dot{M}/v_\infty)_{\rm max}$; **Green line**: $\beta = 0.8$ and $\dot{M}/v_\infty = 4\,(\dot{M}/v_\infty)_{\rm max}$; **Turquoise line**: $\beta = 1.2$ and $\dot{M}/v_\infty = 4\,(\dot{M}/v_\infty)_{\rm max}$.

Conclusions

Based on our analysis we have estimated:

- $P_{\rm orb} = 3.7285\pm0.0006$ days; $L_X = (3.8\pm0.5)\times10^{36}$ erg s^{-1}; and $\dot{M} = (0.85\pm0.17)\times10^{-6}\,M_\odot\,{\rm yr}^{-1}$.
- The slight asymmetric accretion column distribution between eclipse-ingress and eclipse-egress seen by *MAXI* was also found by *RXTE* and *BeppoSAX* [5], suggesting that a trailing wake of material around the neutron star seems to be a permanent structure in this source.

References

[1] Matsuoka, M., Kawasaki, K. et al. 2009 *PASJ, 61, 999*
[2] Rodes-Roca, J. J., Mihara, t. et al. 2015 *A&A, submitted*
[3] Doroshenko, V. et al. 2013 *A&A, 554, A37*
[4] Islam, N. & Paul B. 2014 *MNRAS, 441, 2539*
[5] Mukherjee, U., Raichur, H. et al. 2006 *JAA, 27, 411*
[6] Sunyaev, R. A. & Titarchuk, L. G. 1980 *A&A, 86, 121*
[7] Wilms, J., Allen, A. & McCray, R. 2000 *ApJ, 542, 914*

Funding

This work was supported by the projects AYA2010-15431, ESP2013-48367-C2-2P, GRE12-35, and GV2014/088. JJRR acknowledges the support by the Matsumae International Foundation Research Fellowship No14G04.