LATE VARIABILITY OF FLUX AND SPECTRA OF THE TIDAL DISRUPTION FLARE SW J1644+57 FROM XMM-NEWTON DATA

A. González-Rodríguez, A.J. Castro-Tirado, M.A. Guerrero, and A. Castellón

ABSTRACT
We describe the late spectral variability and flux evolution of TDF Sw J1644+57, a Tidal Disruption Flare which left the typical potential trend proportional to $t^{-5/3}$ in 2012, maintaining a quiescent flux until nowadays. Sixteen X-ray observations of ESA satellite XMM-Newton have been used in this study, including the one performed on 17th July, 2013. A search for optical emission in BOOTES/CASANDRA database has been performed too. Late X-ray fluxes show that the source flux decline does not follow the expected TDF trend at the time of the last XMM-Newton observation. Moreover, the spectra fitting parameters, in particular the neutral hydrogen column density, $N_H$, and the power-law index, $\Gamma$, indicate that the source darkening has diminished and that the spectral shape has flattened with time. The disruption of the star could have come to an end. Nevertheless, a quiescent X-ray flux continues. Evidence for a quiescent X-ray flux is presented.

Key Words: Galaxies: Active — ISM: Jets and outflows — Stars: Flare — X-rays: Galaxies

1. INTRODUCTION
Stars in galactic nuclei can be captured or tidally disrupted by a central super massive black hole of $10^5 - 10^6 M_\odot$. The stellar debris that are not captured by the black hole are ejected at high speed, whereas the remainder will be swallowed by the hole.

This phenomenon is known as TDF, Tidal Disruption Flare, and causes a bright flare that usually lasts some years. The radiation can be detected in radio and in X-ray. That is the reason why the TDF Sw J1644+57 has been being monitored by ESA satellite XMM-Newton.

The source was discovered the 28th of March of 2011 by Swift as a new transient X-ray source, and is thought as the awakening of a quiescent black hole located in the center of the optical position of a host galaxy, at redshift $z=0.3534$ (Bloom et al. 2011; Zauderer et al. 2011; Castro-Tirado et al. 2013). During 2011 its flux followed a typical TDF potential trend proportional to $t^{-5/3}$ (Rees 1988).

2. OBSERVATIONS AND DATA REDUCTION
There are sixteen X-ray observations of the TDF Sw J1644+57 in the XMM-Newton Scientific Archive, XSA, for the coordinates (J2000): RA: 16 44 49.97; Dec: +57 34 59.7.

To make the data reduction and calibration, the Science Analysis System of XMM-Newton, SAS, and its Current Calibration Files, CCFs, were employed. X-ray light curves and spectra were extracted once the event lists were generated, cleaned and filtered against high background.

The X-ray Spectral Fitting Package of HEAsoft, XSPEC, has been used to fit the spectra and to calculate fluxes and luminosities. The spectral fittings...
3. RESULTS AND DISCUSSION

- The $N_{\text{H}}$ has decreased as Figure 1 shows, between day 188 and 549, which indicates that most of the clouds of gas and dust around the disrupted star have dissipated. The final number of $0.056 \times 10^{22} \text{cm}^{-2}$ is very close to the galactic $N_{\text{H}}$, and implies that the phenomenon is less energetic now.

- The spectral shapes have flattened with time, as Figure 2 reveals when we compare the spectrum of the first observation, performed on day 3, with the last one, taken on day 842. Besides, in late observations the maximum flux occurs at a lower energy.

- The intrinsic fluxes between 0.5 and 8.0 keV calculated from the sixteen observations of the XMM-Newton Archive, are consistent with previous works about Sw J1644+57. See Figure 3.

- Between late 2011 and 2012, the source X-ray flux started to decline, leaving the characteristic potential tendency of a TDF in 2012. Consequently, the black hole has probably used up the star that provided dust and gas clouds, or its remains have escaped from the orbit around the hole (Rees 1988).

- The object behavior has changed from an X-ray emission compatible with a TDF, to a quiescent emission that remains until nowadays and that is higher than Sagittarius A* current. We ignore if the accretion already existed before Swift triggered. Thus, the source could be the beginning of an Active Galactic Nucleus, AGN, with the jet faced on, i.e., a mini-blazar. Additional X-ray observations are needed to confirm it.

- We do find no transient optical emission (brighter than $10^{4}$mag) at the CASANDRA all-sky images taken at the different BOOTES robotic astronomical stations world wide in the period 2009-2013 when data is available (Castro-Tirado et al. 2012).

REFERENCES

Bloom, J. S., Giannios, D., Metzger, B. D. et. al. 2011, Science, 333, 203

Castro-Tirado, A. J., Gómez, J. L., Agudo, I. et. al. 2013, Revista Mexicana de Astronomia y Astrofísica, Conference Series, Vol. 42, 36–37

Castro-Tirado, A. J., Jelínek, M., Gorosabel, J. et. al. 2012, Astronomical Society of India, Conference Series, Vol. 7, 313–320

Rees, M. J. 1988, Nature, 333, 523

Zauderer, B. A., Berger, E., Margutti, R. et. al. 2013, ApJ, 767, 152

Zauderer, B. A., Berger, E., Soderberg, A. M. et. al. 2011, Nature, 476, 425