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THE FIRST TWO MONTHS IN THE LIFETIME OF THE NEWLY BORN JET ASSOCIATED TO SWIFT J1644+57

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RESUMEN

Describimos la evolución de Swift J1644+57, cuyas propiedades únicas se han interpretado como claves en el desgarre de una estrella al caer en las cercanías de un agujero negro supermasivo residente en una galaxia con corrimiento al rojo de $z = 0.3545$, determinado con GTC. Las observaciones multirrango han sido fundamentales para revelar la naturaleza de la emisión a largo plazo de la fuente. En particular, hemos podido identificar por vez primera las propiedades de un chorro relativista en formación. En nuestra interpretación del fenómeno, presentamos una interpretación adicional: el despertar de un núcleo galáctico en fase de hibernación, aunque la confirmación precisa de observaciones a largo plazo en rayos-X y radio (milimétricas y centimétricas).

ABSTRACT

We describe the evolution of of Swift J1644+57, whose unique X-ray properties have led several groups to interpret its behavior as corresponding to an extraordinary event of tidal disruption of a star by a supermassive black hole in the nucleus of a ($z = 0.3545$) galaxy, as derived by GTC. Multiwavelengths observations are proving to be essential to reveal the long term nature of the emission in this source. In particular, we identify for the first time the properties of a forming relativistic jet. In our interpretation of the phenomenon, we leave the still open possibility that it may correspond to the onset of a dormant AGN, but this may only be tested with longer term X-ray, millimetre and centimetre monitoring.

Key Words: galaxies: nuclei — galaxies: starburst — gamma rays: general — ISM: jets and outflows

1. INTRODUCTION

On 2011 March 28 *Swift* triggered on a newly discovered transient, which was initially thought to be a new gamma-ray burst (dubbed GRB 110328A; Cummings et al. 2011). However, a second *Swift* trigger on this source (Barthelmy et al. 2011) started to cast doubt on the GRB nature of this source, suggesting that instead it may correspond to a new class of hard X-ray transient. This was confirmed by the pre-outburst optical detection in Palomar (Cenko et al. 2011), which strongly disfavored a cosmological long-duration GRB. Furthermore, spectroscopic observations (Levan et al. 2011, Thoene et al. 2011) revealed the extragalactic nature of the source.

Subsequent radio observations with the EVLA (Zauderer et al. 2011), CARMA (Zauderer et al. 2011), MRAO (Pooley et al. 2011), and PdB (Castro-Tirado et al. 2011) confirmed the existence of a radio source, coincident with the optical position of the nucleus of a host galaxy, with flux densities at cm and mm wavelengths of 5–25 mJy, with indication of long term evolution (Figure 1).

All this observational evidence points towards the possibility that the source is a very peculiar new type of X-ray transient (Levan et al. 2011), which may be interpreted (Bloom et al. 2011) by a tidal disruption of a main sequence star by a black hole of 10^{6-7} solar masses at the center of the observed host galaxy, leading to the formation of a "mini-blazar" with the jet seen face-on. This is also supported by energetic and variability arguments, which suggest that the jet is at least mildly relativistic, presents high collimation, and a spectrum dominated by synchrotron and inverse Compton emission (Bloom et al. 2011).

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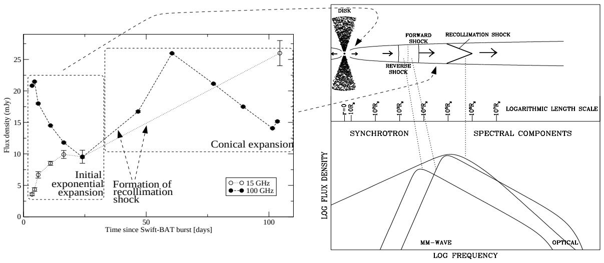

Fig. 1. The proposed scenario to explain the light curves of Sw 1644+57, following Castro-Tirado et al. (2012). Left: Millimeter and radio light curves of Swift 1644+57. After the initial decay, the mm lightcurve displays a second bursting episode, reaching a maximum flux density even higher than the one observed after the initial Swift detection. Right: Sketch of the main features of the proposed scenario to explain the light curves of Sw 1644+57. The length scale is given in terms of Schwarzschild radii. After the forward shock passes the location where the external pressure becomes nearly constant (rather than increasing toward the black hole), a conical recollimation shock forms and collimates the jet further. Electrons are accelerated to highly relativistic energies at all three shock fronts, creating the three spectral components sketched on the bottom.

However, follow-up observations by the *Swift* satellite reveal that the X-ray emission has remained in a plateau, contrary to the expected decay in the case of a single event associated with a tidal disruption flare (TDF). Furthermore, our observations with PdB (Figure 1) show that, after an initial decay, the flux at mm wavelengths is showing a significant increase by a factor of more than 2 during the last month (May 2011). These observations have led us to suggest that the peculiar X-ray transient Sw 1644+57 may correspond to the onset from a dormant AGN (Castro-Tirado et al. 2012), instead of a single event associated with the tidal disruption of a star by a supermassive black hole. In the case of the AGN onset, we expect that the jet originated by the flaring event that triggered the Swift satellite should conserve its mm and radio emission on relatively long time scales (of several months more).

2. DISCUSSION

The late epoch 10.4 m GTC optical spectrum shows emission lines of Hα, Hβ, [O III], [S II] from which a redshift $z = 0.3545 \pm 0.0007$ is derived, confirming the value proposed in Levan et al. (2011), also based on earlier epoch GTC data. See Figure 2, None of the emission lines display a broad component, as it would be expected for active Seyfert galaxies. No variations in the line fluxes of the lines have been registered on June 26, when comparing to previous measurements [8], which supports that the line emission is formed in outer star-forming regions existing in the Galaxy.

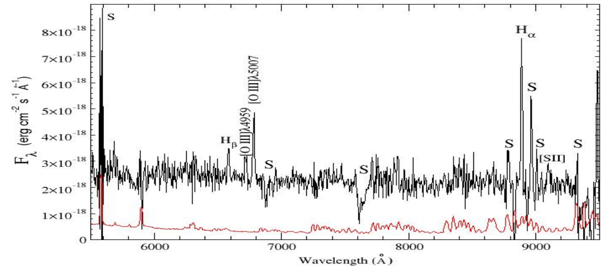

Fig. 2. A spectrum was obtained on 26 June with the 10.4 m GTC using the R500R grism (3x900s exposures) in the OSIRIS imaging spectrograph. The R500R grism was used with a spectral range of 5300–10000 Å and a dispersion of FWHM = 2.4 Å/pix and a resolution of 634 (both at 7319 Å). The 1″ wide slit was positioned on the location of the transient source and a 2×2 binning mode was used.

In conjunction with other multi-wavelength observations (like *Swift* which are being performed routinelly), ongoing (and near future) observations of Swift 1644+57 will allow:

- to determine whether the nature of Swift J1644+57 is related to a short time range tidal disruption flare of a star by a supermassive black hole, or to a longer term phenomenon as the onset of a dormant AGN as proposed in Castro-Tirado et al. (2012).
- to perform a detailed study of the long term evolution of the multi-wavelength afterglow emission over the first ∼8 months after the event. This will enable us to trace the evolution of the characteristic synchrotron self-absorption frequency, and the radio-mm spectral index, that will help help us to constrain among different jet models.

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