

Optical counterparts of Swift X-ray sources

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ABSTRACT

We studied optical spectra of four x-ray sources in an object list from ATEL 1794, in which 16 new AGN have been detected in the 14-195 KeV band by the Swift/BAT All-Sky Hard X-ray Survey. The selected objects are: SWIFT J1246.9+5433, SWIFT J0544.3+5910, SWIFT J1439.2+1417, SWIFT J1453.1+2556, according to the BAT name. All these objects were classified, and redshift and bolometric luminosity were estimated.

I. INTRODUCTION

Active Galactic Nuclei (AGNs) were discovered in the mid-1950s, as powerful radio sources. Up to now, several types of AGNs have been recognised, and astronomers believe that we are simply observing the same source viewed with different orientations, according to the widely accepted Unified Model. Despite the half a century of successful works, AGNs have not yet been completely understood both in their structure and inner physics. Hence, the detection and study of new AGNs is very important, and will help astronomers to obtain a better physical model of these objects. AGNs are intensively studied in the whole wavelength range. In this paper we studied optical spectra of four unclassified X-ray sources selected from an object list appeared in ATel #1794 (<http://www.astronomerstelegam.org/?read=1794>). In this telegram, 16 new AGNs had been detected by the Swift/BAT telescope; six of them had been classified, while the remaining ones did not have optical spectra.

II. OBSERVATIONAL DATA

The observations were obtained on February 19th 2009, with the 122 cm “Galileo” telescope of the Asiago Astrophysical Observatory equipped with the Boller & Chivens spectrograph at Cassegrain focus (f/16). A 300 grooves/mm grating was employed. The spectral range was from 330 to 790 nm. HD19445 and HD74721 were the spectrophotometric standard stars employed to perform flux calibration, while wavelength calibration came from Ne and Hg-Ar comparison lamps.

The table below contains the observed objects list:

Object Swift/BAT	R.A.	Dec.	Exp. time (sec)
J0544.3+5910	05h44m23s	+59°07'36"	3600
J1246.0+5433	12h46m40s	+54°32'03"	1200
J1439.2+1417	14h39m12s	+14°15'22"	2400
J1453.1+2556	14h53m08s	+25°54'33"	2400

The objects have the following counterpart (ATel #1794)

Object name (Swift/BAT)	Counterpart
J0544.3+5910	2MASX J05442257+5907361
J1246.9+5433	NGC 4686
J1439.2+1417	2MASX J14391186+1415215
J1453.1+2556	2MASX J14530794+2554327

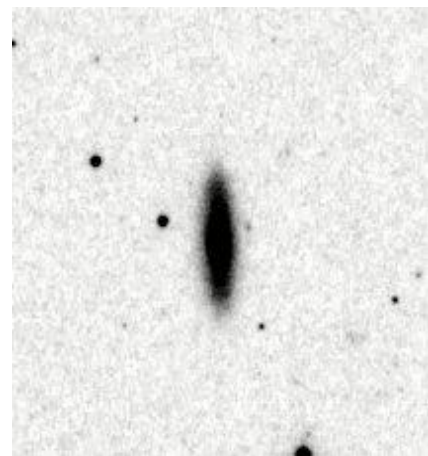


Fig. 1: NGC 4686.

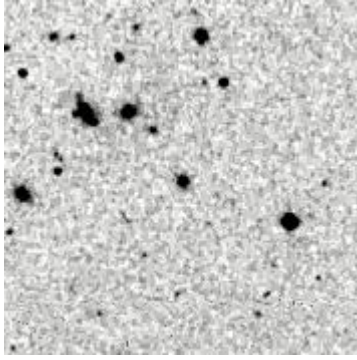


Fig. 2: J1439.2+1417.

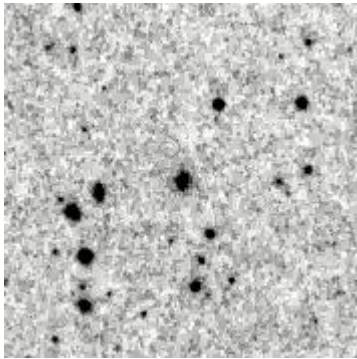


Fig. 3: Swift J1453.1+2556.

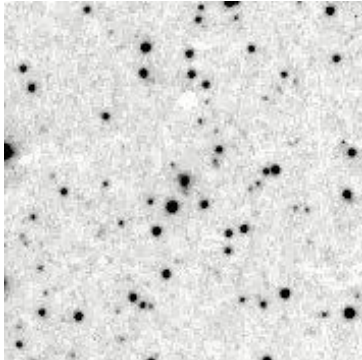


Fig. 4: Swift J0544.3+5910.

III. WORK DESCRIPTION

After the reduction and calibration of the spectra in the standard way, using IRAF software (<http://iraf.noao.edu>), we obtained monodimensional spectra. We began by comparing typical AGN spectra with ours. After the spectra comparison, we can propose the following classification:

NGC 4686: at first sight it shows the typical spectrum of a normal galaxy, with no clear evidence of emission lines in our spectral range. However, since the BAT telescope detected an X-ray event from this object, a more detailed analysis should be undertaken. Indeed, weak [N II]6583 and [O III]5007, besides absorbed H α 6563, are visible. Therefore NGC 4686 could be a LINER.

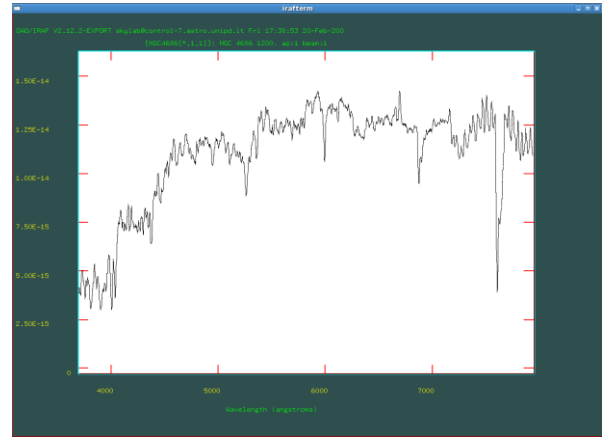


Fig. 5: NGC 4686.

Swift J0544.3+5910: we stress the strong similarities with a typical Seyfert 2 spectrum (see for example NGC 4941 spectrum for comparison). Note the narrow H α and [N II] lines (in blend), as well as the strong [O III].

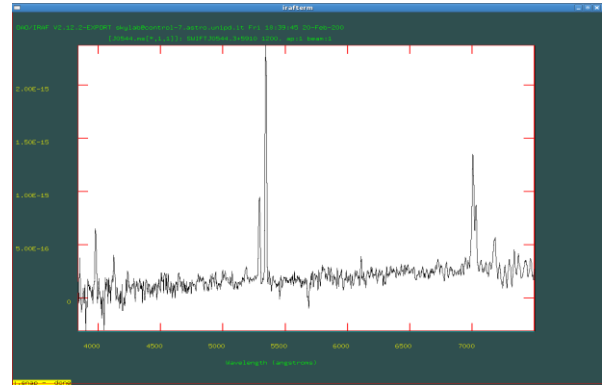


Fig. 6: Swift J0544.3+5910.

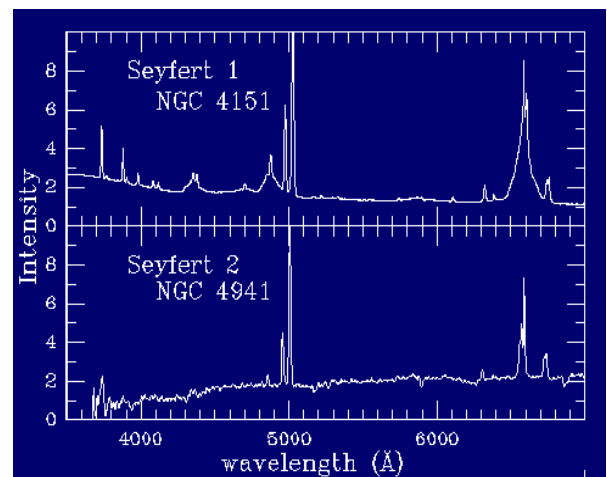


Fig. 7: Typical Seyfert galaxies spectra.

Swift J1453.1+2556: the broad H α emission line shows that this is a QSO. Note also the broad H β 4861 line and the narrow [O III].

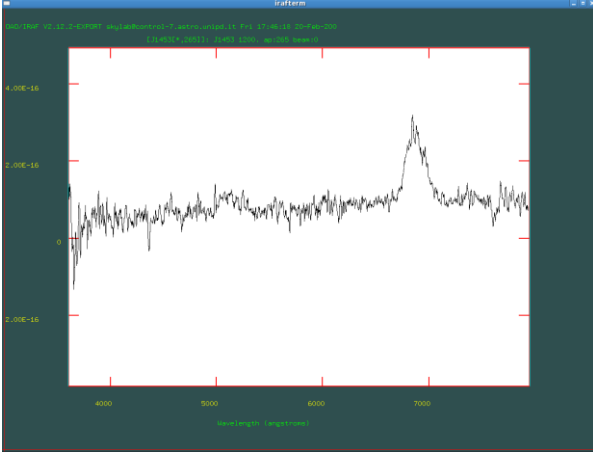


Fig. 8: Swift J1453.1+2556.

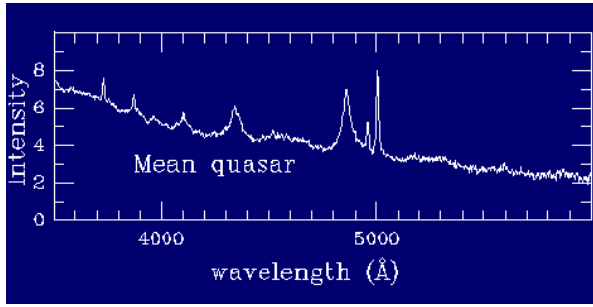


Fig. 9: generic QSO spectrum.

Swift J1439.2+1417: the optical spectrum of this object does not show emission nor absorption lines. The classification of such object is not clear. We propose it could be a BL Lac object.

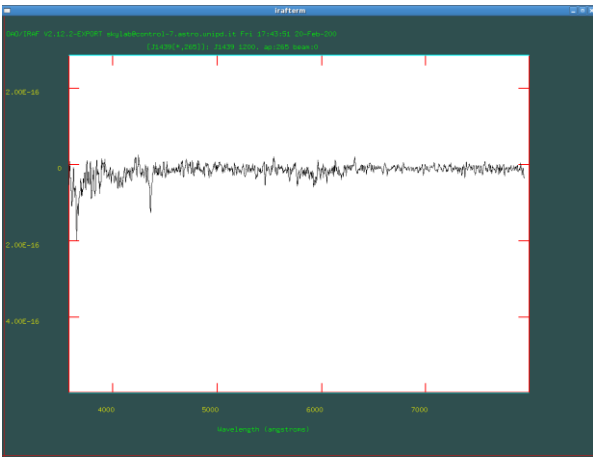


Fig. 10: Swift J1439.2+1417.

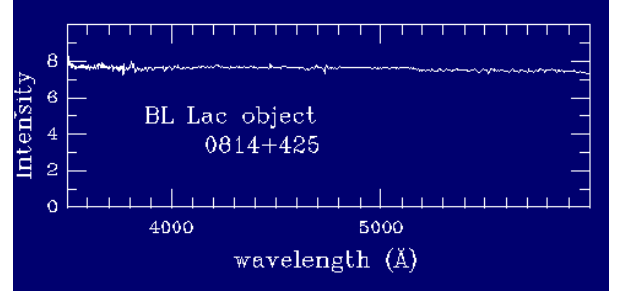


Fig. 11: BL Lac typical spectrum

Next step was to measure the redshift. After emission lines identification and peak measurement, the redshift was determined by the well known formula:

$$z = \frac{\lambda - \lambda_0}{\lambda_0}$$

We calculated for every spectrum the mean value and considered as an error estimate the root mean square. We evaluated the correction for the motions of the observer in relation to the Sun by the following formula:

$$V_{\oplus} = -V_K \cos \beta [\sin(\lambda - \lambda_{\odot}) + e \sin(\lambda_{\pi} - \lambda)]$$

where λ and β are the ecliptic coordinates of the object, $\lambda_{\odot}$ is the sun longitude at the observation date, λ_{π} is the perielium longitude, V_K is the Earth tangential velocity around the Sun and e is the Earth orbit's eccentricity. Then we calculated the velocity correction in relation to the 3 K background using the formula:

$$v_{con} = v + v_{apex} (\sin b \sin b_{apex} + \cos b \cos b_{apex} \cos(l - l_{apex}))$$

where l and b are Galactic coordinates of our objects, V is the uncorrected velocity and l_{apex} and b_{apex} are the Galactic coordinates of the Sun motion's apex with respect to the 3 K background.

Object Swift/BAT	Heliocentric correction (km/s)	3K background correction (km/s)
J1246.0+5433	3.24	159.53
J0544.3+5910	-20.90	-8.56
J1439.2+1417	23.25	207.10
J1453.1+2556	19.88	166.86

The velocity (in km/s) was computed according to the formula

$$V = z \cdot c$$

The Hubble law allowed to estimate the distance of our objects:

$$d = \frac{z \cdot c}{H_0}$$

assuming that $H_0 = 75$ km/s/Mpc.

Object Swift/BAT	Redshift (10^{-3})	Corrected velocity (10^3 km/s)	Distance (Mpc)
J1246.9+5433	15 ± 3	4.7 ± 0.9	64 ± 10
J0544.3+5910	67 ± 1	20.2 ± 0.3	268 ± 11
J1439.2+1417	-	-	-
J1453.1+2556	48 ± 1	14.5 ± 0.3	192 ± 10

Because no spectral lines were found in its spectrum, the object Swift J1439.2+1417 has not a redshift nor a distance estimate.

Finally, we estimated the bolometric luminosity of Swift J0544.3+5910 and Swift J1453.1+2556 following Collin and Huré (2001):

$$L = I_{5100} \cdot 5100 \cdot 4\pi d^2$$

$$L_{bol} \approx 9 \cdot L$$

Object	L_{bol} (erg/s)
J1246.9+5433	-
J0544.3+5910	$6.15 \cdot 10^{43}$
J1439.2+1417	-
J1453.1+2556	$2.65 \cdot 10^{44}$

IV. RESULTS

To summarize: we obtained the optical spectra of four X-ray sources. From a preliminary analysis of the data we can suggest that strong nuclear activity justifying the X-ray emission is found in three targets, a Seyfert 1, a Seyfert 2 and a LINER. The last one resemble a featureless continuum, like that observed in BL Lacs. A more detailed and quantitative analysis is published in Atel #1985 (Ciroi et al. 2009).

V. BIBLIOGRAPHY

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