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New AGN classifications in the Swift/BAT All-Sky Hard X-ray Survey

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Through an optical campaign performed at the San Pedro Martir (Mexico) Telescope and using the 6dF archive (`http://www.aao.gov.au/local/www/6df`, Jones et al. 2004), we determine or give a better classification for 8 newly discovered Active Galactic Nuclei (AGN) in the Swift/BAT 22-months All-sky Hard X-ray Survey (Baumgartner et al. 2008, Tueller et al. 2010). All these objects have observations taken with Swift/XRT or Chandra or XMM archival data which allowed us to pinpoint their optical counterpart thanks to the precise (better than a few arcsec) soft X-ray positions afforded by these observatories. This information enabled us to obtain optical spectra of all these counterparts, since only three spectra are available on-line, but not flux calibrated, allowing us to reveal their real nature (Baumgartner et al. 2008 give only a tentative classification based upon their X-ray properties). Here we present the spectra, along with the corresponding finding charts obtained from the DSS-II red survey, of these 8 sources. We found that our sample is composed of 7 Seyfert 2 and one Seyfert 1, with redshift between 0.009 and 0.068.

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1. Introduction

The *Swift* mission was designed to study cosmic gamma-ray bursts (GRBs) in a multiwavelength context (Gehrels et al. 2004), but with its unique repointing capabilities it is also able to study and monitor other types of X-ray emitting objects. Through its payload, consisting of three instruments, i.e. the Burst Alert Telescope (BAT; Barthelmy, 2004), the X-Ray Telescope (XRT; Burrows et al. 2004) and the UltraViolet/Optical Telescope (UVOT; Roming et al. 2004), *Swift* can detect and follow up X-ray emitting objects over a wide range of wavelengths.

In this work we have classified 8 AGNs either without optical identification, or without published optical spectra, belonging to the *Swift*/BAT AGN surveys of Tueller et al. (2010), with a soft X-ray position and a tentative classification based upon their X-ray properties given by Baumgartner et al. (2008) (except for the three sources in the 6dF archive). Following the method applied by Masetti et al. (2004, 2006a,b, 2008, 2009, 2010) for the optical spectroscopic follow-up of unidentified *INTEGRAL* sources, we confirm the AGN nature and give the exact classification of these 8 objects.

2. Observations and data analysis

The optical spectroscopic data presented here (see Tab. 1) were obtained with the 2.1m telescope of the Observatorio Astrónomico Nacional in San Pedro Martir, México; we also used archival spectra from the 6dF archive [1] (Jones et al. 2004).

The SPM data reduction was performed with the standard procedure (optimal extraction; Horne 1986) using IRAF[2]. Calibration frames (flat fields and bias) were taken on the day preceding or following the observing night. The wavelength calibration was obtained using lamp spectra acquired soon after each on-target spectroscopic acquisition. The uncertainty on the calibration was ~0.5 Å for all cases. This was checked using the positions of background night sky lines. Flux calibration was performed using catalogued spectrophotometric standards. Since the 6dFGS archive provides spectra which are not calibrated in flux, we used the optical photometric information in Jones et al. (2005) and Doyle et al. (2005) to calibrate the 6dFGS data presented here. Objects with more than one observation had their spectra stacked together to increase the signal-to-noise ratio.

3. The sample

The identification and classification approach we adopt in the analysis of the optical spectra is the following: for the emission-line AGN classification, we used the criteria of Veilleux & Osterbrock (1987) and the line ratio diagnostics of Ho et al. (1993, 1997) and of Kauffmann et al. (2003); for the subclass assignation to Seyfert 1 galaxies, we used the H_β/[O III]λ5007 line flux ratio criterion as in Winkler et al. (1992).

[1] `http://www.aao.gov.au/local/www/6dF`

[2] IRAF is the Image Reduction and Analysis Facility made available to the astronomical community by the National Optical Astronomy Observatories, which are operated by AURA, Inc., under contract with the U.S. National Science Foundation. It is available at `http://iraf.noao.edu/`

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Following these criteria we found 7 type 2 AGNs and one type 1 AGN (see Fig.2). For each source we reported the finding charts (Fig.1). Concerning the type 2 AGN spectra, we found that for 5 sources the continuum is quite regular (Swift J0100.9−4750, Swift J0248.7+2626, Swift J0544.3+5910, Swift J0623.8−3215, Swift J0923.9−3143), while for the remaining objects (Swift J1246.9+5433 and Swift J2341.8+3034) the continuum is dominated by the star content of the host galaxy. In most of the spectra the [O III]λ5007 and [NII]λ6585 forbidden lines, and the Balmer H_α permitted line are well detected in emission. The spectra are not corrected for the Galactic extinction. We determine that their redshifts lie between 0.017 and 0.068.

The single type 1 AGN (Swift J0543.7−2741) shows broad H_α+[NII] complex in emission, the Balmer series up to H_δ in emission as well, the [OIII] and [SII] forbidden narrow emission lines, and HeI broad emissions. The narrow lines enabled us to calculate the redshift of this object, that is 0.009. The continuum is not regular, contaminated by the star content of the underlying galaxy.

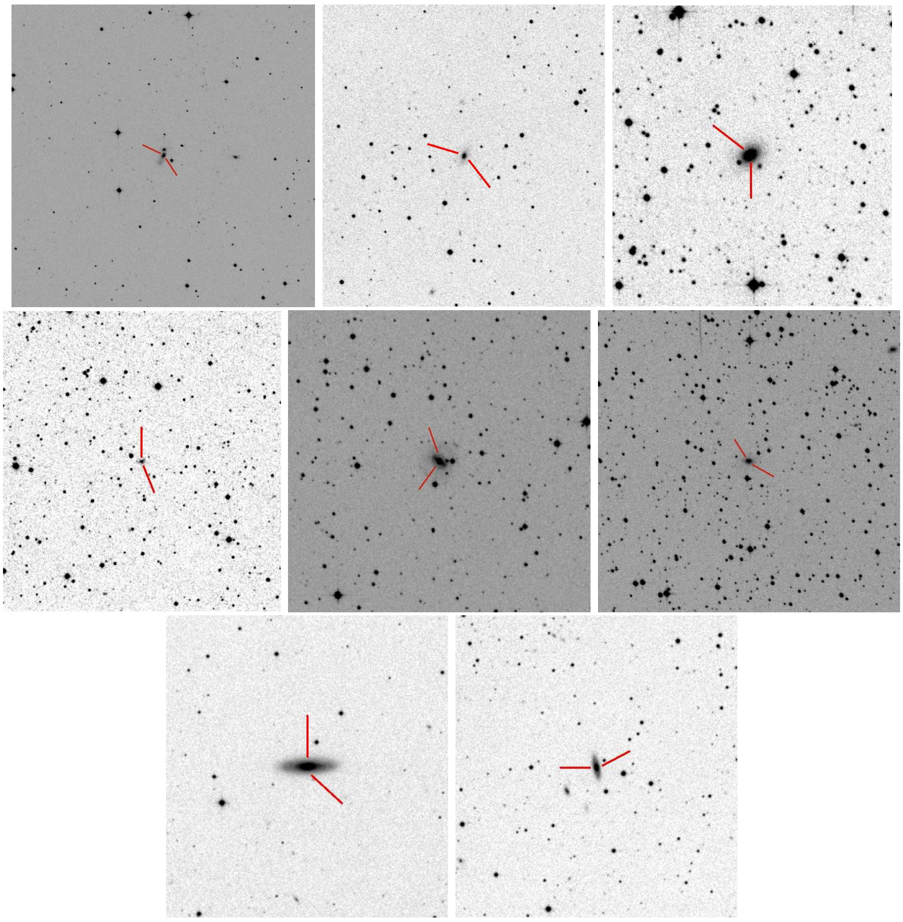

Figure 1: From left to right and top to bottom: optical images of the fields of Swift J0100.9−4750, Swift J0248.7+2626, Swift J0543.7−2741, Swift J0544.3+5910, Swift J0623.8−3215, Swift J0923.9−3143, Swift J1246.9+5433 and Swift J2341.8+3034. The optical counterparts of the *Swift* sources are indicated with tick marks. Field sizes are $5' \times 5'$ and are extracted from the DSS-II-Red survey. In all cases, North is up and East to the left.

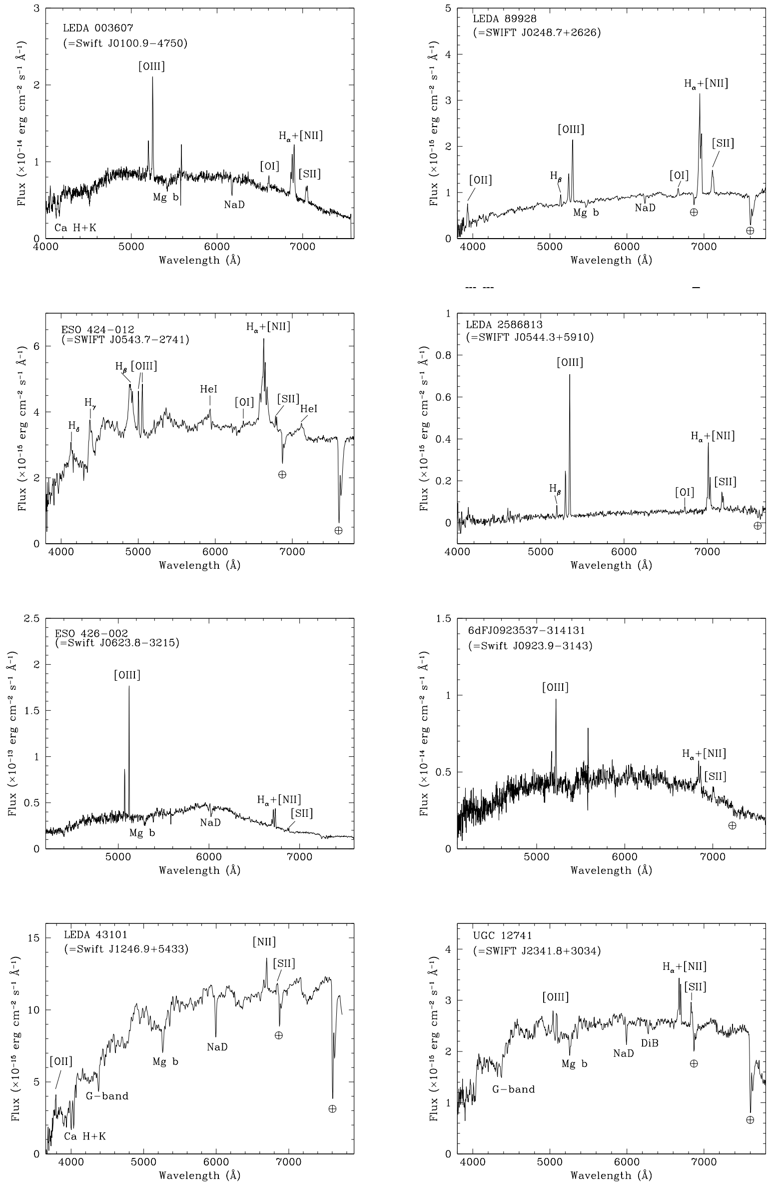

Figure 2: Spectra (not corrected for the intervening Galactic absorption) of the optical counterpart of AGNs Swift J0100.9−4750, Swift J0248.7+2626, Swift J0543.7−2741, Swift J0544.3+5910, Swift J0623.8−3215, Swift J0923.9−3143, Swift J1246.9+5433 and Swift J2341.8+3034.

4. Conclusion

In this work we have either given for the first time (Swift J0248.7+2626, Swift J0543.7−2741, Swift J0544.3+5910, Swift J1246.9+5433, Swift J2341.8+3034), or presented a better classification (Swift J0100.9−4750, Swift J0623.8−3215, Swift J0923.9−3143) of, the optical spectroscopic identification for 8 Swift AGNs belonging to the Swift/BAT 22-months All-sky Hard X-ray Survey. This was achieved through an observational campaign in Mexico, at the San Pedro Martir Telescope

Table 1: Main results obtained from the analysis of the optical spectra of the 8 AGNs of the present sample

Object	Opt. counterpart	Class	z	Opt. telescope or archive
Swift J0100.9−4750	2MASX J01003490-4752033	Seyfert 2	0.048	AAT+6dF
Swift J0248.7+2626	2MASX J02485937+2630391	Seyfert 2	0.057	San Pedro Martir
Swift J0543.7−2741	MCG -05-14-012	Seyfert 1.2	0.009	San Pedro Martir
Swift J0544.3+5910	2MASX J05442257+5907361	Seyfert 2	0.068	San Pedro Martir
Swift J0623.8−3215	ESO 426-G 002	Seyfert 2	0.022	AAT+6dF
Swift J0923.9−3143	2MASX J09235371-3141305	Seyfert 2	0.042	AAT+6dF
Swift J1246.9+5433	NGC 4686	Seyfert 2	0.017	San Pedro Martir
Swift J2341.8+3034	UGC 12741	Seyfert 2	0.017	San Pedro Martir

The typical error on the redshift measurement is ±0.001 but for 6dFGS spectra we can assume an uncertainty of ±0.0003.

and with the use of the 6dF archive. We found that our sample is composed of 8 AGNs (7 Seyfert 2 and one Seyfert 1), with redshift between 0.009 and 0.068.

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