

## Looking for blazars in a sample of unidentified high-energy emitting Fermi sources: Preliminary results

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**Abstract.** It is expected that a large fraction of the unidentified sources detected at  $\gamma$ -rays are blazars. Through cross-correlation between the positions of unidentified objects from the 1FHL Fermi catalogue of  $\gamma$ -ray sources and the ROSAT, XMM Slew and Swift/XRT catalogues of X-ray objects, a sample of 38 associations was found with less than 10 arcsec of positional error. One third of them has recently been classified; the remainder, though believed to belong to the blazar class, has not yet been identified. Therefore, we aim at studying the optical spectra of the counterparts of these unidentified sources in order to find their redshifts and to analyse their nature and main spectral features. We present here our preliminary results from optical spectroscopic observations at the 3.58 m Telescopio Nazionale Galileo (TNG) for 7 of them.

### 1. Observations & Data Reduction

Searching for counterparts of high-energy sources is challenging because of the relatively large (several arcminutes) positional error ellipses of  $\gamma$ -ray objects detected with the Fermi satellite. This uncertainty means that a positional correlation with a known object is usually not enough to firmly identify a Fermi source. Cross-correlations were made (Stephen et al. 2010, Landi et al. 2015) between the positions of the 1FHL (Abdo et al. 2010) and Swift/XRT 1SXPS catalogues (Evans et al. 2014), and the ROSAT (Voges et al. 1999) and XMM-Newton surveys (Saxton et al. 2008). A strong level of correlation between unassociated 1FHL objects and soft X-ray sources was found, leading to better positions for all correlated sources; this is evident for the association of a number of gamma-ray objects with a soft X-ray counterpart (Landi et al. 2015). However, 24 of these unassociated 1FHL sources still lack an optical spectroscopic identification. Hence, the need for optical follow-up work is clear.

Seven of these objects were observed with TNG from April to June 2015 (see Table 1) within the framework of our ongoing program dealing with the identification of the nature of  $\gamma$ -ray sources (Masetti et al. 2013), to obtain medium-resolution spectra from  $\sim 3700$  to  $8000 \text{ \AA}$ . The spectra were reduced,

wavelength and flux calibrated using standard IRAF<sup>1</sup> packages. The wavelength calibration has an estimated error of 3 Å.

## 2. Results

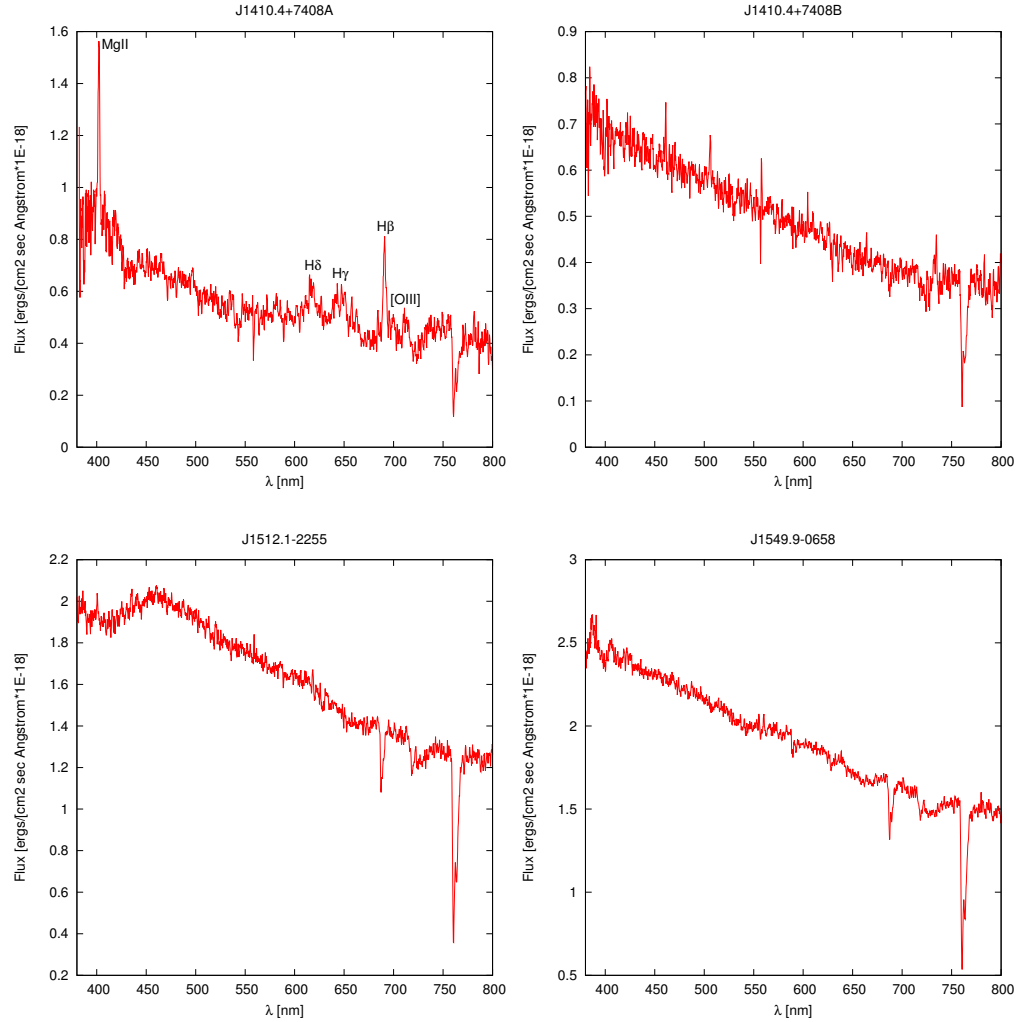


Figure 1.: Optical spectra of six sources presented in this contribution. The name of each object is reported above the corresponding panel.

<sup>1</sup><http://iraf.noao.edu>

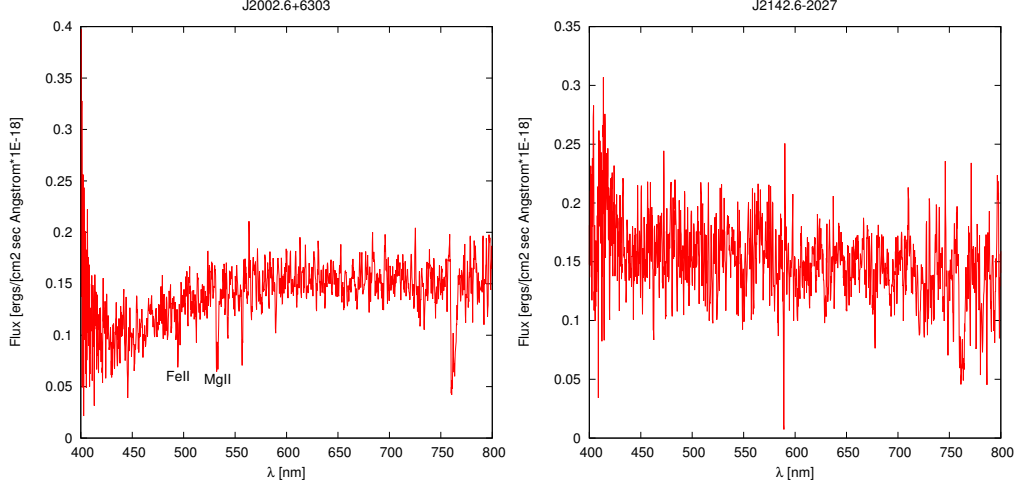


Figure 1.: Continued.

As it can be seen in Figure 1, our sample shows no spectral features other than atmospheric (telluric) ones, with the exception of 1FHL J1410.4+7408A and 1FHL J2002.6+6303. The former has strong, broad emission lines, the most prominent ones at 4021 Å and 6908 Å, which we identify with MgII and H $\beta$  at a redshift of  $z = 0.42$ , thus allowing us to classify this object as a type 1 quasar. The latter has two absorption lines at 5320 Å and 4940 Å, which we identify as MgII and FeII in an intervening foreground galaxy at  $z = 0.9$ , meaning that this object is a BL Lac lying at high redshift.

Thus, according to the criteria in Laurent-Muehleisen et al. (1998), every object in our sample presents a BL Lac-type spectrum (i.e. a continuum power-law shape and no strong emission features with equivalent width larger than 5 Å), except 1FHL J1410.4+7408A, which shows a QSO type 1 spectrum.

Object	$\lambda$ [Å]	EqW [Å]	$z$	Class
J1410.4+7408A	4021	-12	0.42	QSO 1
J1410.4+7408B	—	—	?	BL Lac
J1512.1-2255	—	—	?	BL Lac
J1549.9-0658	—	—	?	BL Lac
J1841.1+2914	—	—	?	BL Lac
J2002.6+6303	5320	6	$\geq 0.9$	BL Lac
J2142.6-2027	—	—	?	BL Lac

Table 1.: We report in column 1 the name of the object, in column 2 the wavelength for the most prominent emission/absorption line (if any), in column 3 its equivalent width, in column 4 the estimated redshift (if any), and in column 5 the resulting object type according to our criteria.

### 3. Further research

A preliminary spectroscopic analysis of the likely optical counterparts of 7 objects belonging to the 1FHL catalogue and selected through cross-correlation with soft X-ray catalogues and surveys shows that 6 of them are BL Lacs and one is a Type 1 QSO. As a continuation of this work, we aim at further analysing the main characteristics of these objects through their spectral energy distribution, built with the use of multifrequency data from available surveys. Furthermore, in order to complete our sample, we submitted an observing proposal at both Gemini telescopes, which are suitable to obtain the required signal-to-noise ratio for fainter objects. In this way we aim to conclusively pinpoint the nature of the remaining 17 unidentified sources.

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