Identification of a new $\gamma$-ray-emitting narrow-line Seyfert 1 galaxy, at redshift $\sim 1$

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ABSTRACT

We report on the identification of a new $\gamma$-ray-emitting narrow-line Seyfert 1 (NLS1) galaxy, SDSS J122222.55+041315.7, which increases the number of known objects of this remarkable but rare type of active galactic nuclei to seven. Its optical spectrum, obtained in the Sloan Digital Sky Survey-Baryon Oscillation Spectroscopic Survey, reveals a broad H $\beta$ emission line with a width (FWHM) of 1734 $\pm$ 104 km s$^{-1}$. This, along with strong optical Fe $\Pi$ multiplets \( [R_{\lambda 570} = 0.9] \) and a weak [O $\text{iii}$] $\lambda 5007$ emission line, makes the object a typical NLS1. On the other hand, the source exhibits a high radio brightness temperature, rapid infrared variability, and a flat X-ray spectrum extending up to $\sim 200$ keV. It is associated with a luminous $\gamma$-ray source detected significantly with Fermi/LAT. Correlated variability with other wavebands has not yet been tested. The spectral energy distribution can be well modelled by a one-zone leptonic jet model. This new member is by far the most distant $\gamma$-ray-emitting NLS1, at a redshift of $z = 0.966$.

Key words: galaxies: active – galaxies: jets – galaxies: nuclei – quasars: individual: SDSS J122222.55+041315.7.

1 INTRODUCTION

With the full width at half-maximum (FWHM) of the broad H $\beta$ line less than 2000 km s$^{-1}$, narrow-line Seyfert 1 galaxies (NLS1s)$^1$ have the strongest Fe $\Pi$ emission and the weakest [O $\text{iii}$] emission among active galactic nuclei (AGNs). They occupy an extreme end of the so-called Eigenvector-I (EV1) parameter space, a set of correlations between the H $\beta$ line width and other observables (e.g. Boroson & Green 1992). It has been shown in previous work that radio loud (RL) NLS1s are rare, only $\sim 7$ per cent in fraction (e.g. Komossa et al. 2006; Zhou et al. 2006), compared to about 10–15 per cent in broad-line Seyfert 1 galaxies and quasars (e.g. Ivezic et al. 2002). The very RL NLS1s with radio loudness $R > 100$ are even rarer, accounting for only 2.5 per cent (Komossa et al. 2006). The reason for the rarity of RL NLS1s is still unclear.

In contrast to NLS1s, the bulk of RL AGNs lies at the other extreme of the EV1 parameter space, having broader H $\beta$ and weaker Fe $\Pi$ emission (e.g. Sulentic et al. 2008). As a distinct subclass, blazars are believed to be RL AGNs viewed with their relativistic jets closely aligned to the line of sight. They are characterized by flat radio spectra, compact radio cores, high brightness temperatures and rapid variability in multiwave bands (e.g. Urry & Padovani 1995).

Since NLS1s and blazars lie at the opposite extremes in the AGN parameter space, the discovery of their hybrids in the past decade (e.g. Zhou et al. 2003, 2007) has drawn considerable attention. By performing a comprehensive study of 23 very RL NLS1s, Yuan et al. (2008) pointed out the peculiarity of these objects and suggested that there exists a population of RL NLS1s possessing relativistic jets, similar to blazars. This assertion was confirmed and highlighted by the detection of several objects in the GeV $\gamma$-rays with Fermi/LAT (e.g. Abdo et al. 2009a, b; Foschini 2011; D’Ammando et al. 2012). These discoveries raised questions regarding the coupling of jet and accretion flow (Yao et al. 2015). However, further investigation of this class of objects in large numbers is hampered by their scarcity. There are only six NLS1s detected in the $\gamma$-ray band by Fermi/LAT at high significance hitherto$^2$ (PMN J0948+0022, Abdo et al. 2009a; PKS 1502+036, 1H 0323+342 and PKS 2004–447).
Abdo et al. 2009b; SBS 0846+513, D’Ammando et al. 2012; FBQS J1644+2619, D’Ammando et al. 2015), mostly from the Yuan et al. (2008) sample.

In this Letter, we report the identification of a Fermi/LAT detected flat-spectrum radio quasar (FSRQ) with a new γ-ray-emitting NLS1, SDSS J122222.55+041315.7 (z = 0.966, hereafter J1222+0413). This object was found to be an NLS1, and the only NLS1 associated with a Fermi/LAT γ-ray source, in the course of our ongoing program to search for RL NLS1s from the Sloan Digital Sky Survey-Baryon Oscillation Spectroscopic Survey (SDSS-BOSS; Ahn et al. 2014). J1222+0413 was classified as an FSRQ in previous surveys mainly based on its broad Mg II emission line (e.g. Torrealba et al. 2012). However, its NLS1 nature was not known due to the lack of a spectrum covering the H β line given its relatively high redshift. Here we present an analysis of its optical spectrum obtained from SDSS-BOSS whose bandwidth extending to ~10 000 Å covers the redshifted H β region. This finding increases the number of the very rare γ-ray-emitting NLS1s to seven. Throughout this work a cosmology is assumed with H₀ = 70 km s⁻¹ Mpc⁻¹, Ω₀ = 0.73 and Ωₘ = 0.27.

2 OPTICAL SPECTROSCOPY

The spectrum (Fig. 1) is first corrected for Galactic extinction with E(B−V) = 0.016 mag (Schlafly & Finkbeiner 2011) and an Rᵥ = 3.1 extinction law, and then are transformed into the source rest frame at a redshift of z = 0.966 provided by the SDSS spectroscopic pipeline. The host galaxy contribution is negligible.

We adopt a similar approach as in Dong et al. (2008) to fit simultaneously the continuum, the Fe II multiplets and other emission lines of the spectrum in the ranges of 2690–3100 Å and 4200–5100 Å. A single power law is used to model the sum of the thermal continuum emission and the contribution from non-thermal emission of the jet. The optical and ultraviolet Fe II are modelled using the same templates as in Dong et al. (2008) and Wang et al. (2009), respectively.

To fit the Balmer lines, H β and H γ are assumed to have the same redshift and profile. The broad component of each is accounted for by either a single Lorentzian or concentric double-Gaussian. In addition, another Gaussian with constraint of FWHM ≈ 900 km s⁻¹ is used for modelling the narrow component of the Balmer lines. In a first step, the [O III] λλ4959, 5007 doublet is modelled with a single Gaussian for each line. The flux ratio of [O III] λλ4959, 5007 is fixed at the theoretical value of 1:3. Each of the two lines of the Mg II λλ2796, 2803 doublet is modelled with two components, one Lorentzian for the broad component and one Gaussian for the narrow. The broad components of the Mg II doublet are set to have the same profile, with their flux ratio fixed at 1:2:1 assuming an entirely thermalized gas for simplicity (e.g. Laor et al. 1997). The same prescription is applied to the narrow components of Mg II with an additional constraint of FWHM < 900 km s⁻¹.

Then the models of the continuum, the Fe II and the emission lines are fitted simultaneously to the spectrum. We find that the total H β line is similarly well fitted with either Lorentzian-Gaussian profile or double-Gaussian+Gaussian profile. In the former case, the width of the broad component is FWHM (H β broad) = 1734 ± 104 km s⁻¹ while in the latter case FWHM (H β broad) = 2264 ± 350 km s⁻¹. A direct measurement of the total H β line gives FWHM (H β total) = 1576 km s⁻¹. These widths put J1222+0413 within the NLS1 regime, near the border line between NLS1 and normal broad-line Seyfert 1 (BLS1). In the following we use the Lorentzian representation of the broad component, because it has been shown that the broad H β line of NLS1s is generally better fitted with a Lorentzian profile (e.g. Véron-Cetty, Véron & Gonçalves 2001; Zhou et al. 2006). In this case, the narrow component of H β is relatively faint, with FWHM ≈ 800 km s⁻¹. The line ratio of [O III] λλ5007 to H β total is ≈ 0.2. The Fe II is strong, R₅₀₇₀ ≈ Fe II λ4570/H β total ≈ 0.9 where Fe II λ4570 is calculated by integrating from 4434 to 4684 Å. These features clearly fulfill the conventional definition of a NLS1.

Fig. 2 shows the residuals of the spectrum after subtracting the power-law continuum and the Fe II model. We notice that an asymmetric blue wing of H β is present. We also notice that [O III] λλ5007 is relatively broad when fitted by a single Gaussian (FWHM ≈ 1400 km s⁻¹). This may be the effect of an outflow in J1222+0413. It was shown in previous studies that NLS1s often show strong blue wings and blueshifts in [O III] (e.g. Komossa & Xu 2007). Thus, in a second step, we used two Gaussians to model each line of the [O III] doublet, one for a core and the other for a blueshifted wing.
Table 1. Parameters of the main optical emission lines.

| Line        | Model | FWHM (km s$^{-1}$) | Flux (erg s$^{-1}$cm$^{-2}$) |
|-------------|-------|--------------------|-------------------------------|
| H$\beta_{\text{broad}}$ | L     | 1734 ± 104        | $8.1 \times 10^{-15}$         |
| H$\beta_{\text{broad}}$ | 2G    | 2264 ± 350        | $6.1 \times 10^{-15}$         |
| H$\beta_{\text{core}}$     | D     | 1530              | $8.6 \times 10^{-15}$         |
| [O iii]5007$\lambda_{\text{core}}$ | G     | 791 ± 125         | $1.0 \times 10^{-15}$         |
| [O iii]5007$\lambda_{\text{wing}}$ | G     | 1841 ± 671       | $9.0 \times 10^{-16}$         |
| Mg$\beta_{\text{broad}}$    | L     | 1638 ± 45         | $1.21 \times 10^{-15}$        |

Notes: *Models used for fitting the emission lines are: one Lorentzian profile (L), one Gaussian profile (G) or a Double-Gaussian profile (2G). 'D' stands for the direct integration over the observed line profile.  
^aFWHMs are not corrected for instrumental resolution.

component, while the continuum and other emission lines are not corrected for instrumental resolution.

3 BLAZAR-LIKE PROPERTIES

3.1 Radio emission

J1222+0413 was detected in several radio surveys. The spectral index between 1.4 and 4.85 GHz is flat, $\alpha_{\text{rad}} = 0.3$ ($S_{\nu} \propto \nu^\alpha$, White & Becker 1992). The core flux density at 1.4 GHz is 0.6 Jy (Kharb, Lister & Cooper 2010), corresponding to a radio power of $P_{\text{1.4GHz}} \sim 1 \times 10^{27}$ W Hz$^{-1}$. Pushkarev & Kovalev (2012) investigated the very long baseline interferometry images at 2.3 and 8.6 GHz, and estimated a core brightness temperature of $1.43 \times 10^{12}$ and $4.34 \times 10^{12}$ K, respectively, clearly indicating Doppler-boosted emission. As a blazar, J1222+0413 is expected to be variable in the radio band. We have checked the radio data in NASA/IPAC Extragalactic Database (NED) and literatures. The total flux densities varied in a range of $\sim 0.66-0.8$ Jy at 1.4 GHz and in a range of $\sim 0.49-1.08$ Jy at 5 GHz on time-scales from years to decade. The most intensive radio monitoring of J1222+0413 was performed at 15 GHz with cadence as short as two days, yielding the maximum variability amplitude of 24 per cent within 405 d (206 d in the object’s rest frame, see Richards et al. 2011).

To estimate the radio loudness $R_{\text{GHz}} = f_{\nu}(5 \text{GHz})/f_{\nu}(4400 \text{ Å})$, we use the 5 GHz core flux (665 mJy; Laurent-Muehleisen et al. 1997) and the SDSS g-magnitude, by considering the k-correction with radio spectral index $\alpha_{\text{rad}} = 0.3$ and the optical spectral index $\alpha_{\text{opt}} = -0.72$ obtained from the spectral fitting (Section 2). The result is $R_{\text{GHz}} \sim 1700$. Even considering the radio variability, J1222+0413 is still a very RL AGN.

3.2 Rapid infrared variability

J1222+0413 was observed with the Wide-field Infrared Survey Explorer (WISE; Wright et al. 2010) in four bands w1, w2, w3 and w4 centred at 3.4, 4.6, 12 and 24 μm, respectively. The variability flag in the WISE All-Sky Source Catalog var_flag of ‘9910’ indicates that this source has a very high probability of being variable in the w1 and w2 bands (e.g. Jiang et al. 2012).

Figure 3. WISE light curves in the w1, w2, w3 and w4 band (from top to bottom panel) constructed from profile-fit magnitudes with 1σ error.

Its light curves are constructed from the PSF profile-fit photometric magnitudes and converted to fluxes (Wright et al. 2010) after excluding the data whose S/N is marked as ‘null’. We also exclude those data with S/N < 10 for the w1 and w2 bands, and S/N < 5 for the w3 and w4 bands, and those with reduced $\chi^2$ of the profile-fit photometries larger than 2. The light curves are shown in Fig. 3.

Variability in the w1, w2 and w3 light curves are significantly detected within one day, with p-values of $P < 0.1$ per cent using the $\chi^2$-test against the null hypothesis of no variation. This time-scale restricts the size of the emitting region to $\lesssim 8 \times 10^{-4}$ pc, much smaller than the scale of the torus but consistent with the size of the jet-emitting region. The variability of w4 is not detected possibly due to the lower S/N and much larger photometric errors than the other three bands.

3.3 Hard-energy emission

Using the XMM–Newton and INTEGRAL data, de Rosa et al. (2008) found a hard power-law continuum with a photon index of $\Gamma \sim 1.2$ for the object’s X-ray spectrum in the broadband 2–150 keV band. A soft X-ray excess was also found below 2 keV which can be described by a blackbody with $kT \sim 0.15$ keV.

Swift performed six observations on J1222+0413 from 2007 August to 2011 June. We reduced the data using Swift/FTOOLS in HEASOFT v6.15 following the standard procedures (e.g. Yao et al. 2015). Due to relatively poor statistics, the X-ray telescope (XRT) spectra are consistent with a single power law with absorption fixed at the Galactic value ($N_{\text{H}}^{\text{Gal}} = 1.63 \times 10^{20}$ cm$^{-2}$; Kalberla et al. 2005). The photon indices, $\Gamma = 1.1-1.5$, are too flat for normal radio-quiet NLS1s ($\Gamma \sim 2-4$, e.g. Grupe et al. 2010; Ai et al. 2011), but very similar to the other γ-ray-emitting NLS1s ($\Gamma < 2$, e.g. Abdo et al. 2009b). The 0.3–10 keV fluxes varied by a factor of 2 during the observations, but the correlation between the observed indices and the fluxes are not detected. This object is also detected with the Swift/BAT in the 14–195 keV band, as given in the Swift/BAT 70 Month Catalog (Baumgartner et al. 2013). The average hard X-ray spectrum is also flat, with a photon index of $\Gamma = 1.3$. Compared to the previous INTEGRAL observations taken several years ago (de Rosa et al. 2008), the hard X-ray data show almost no significant variability (see Fig. 4). Such a flat spectrum extending to the hard X-ray band is characteristic of relativistic jet emission.
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by either a single or double peak, due to either lack of the hard X-ray detection for PMN J0948+0022 and the adoption of different models of EC/torus and EC/BLR cases (see D’Ammando et al. 2015 and Sun et al. 2015 for details). The bulk Lorentz factor of the jet for J1222+0413, $\Gamma_{\text{jet}} = 35$, according to our best-fitting model (or $\Gamma_{\text{jet}} = 26$ in the EC/BLR case) is similar to the value derived by D’Ammando et al. (2015, $\Gamma_{\text{jet}} = 30$) in the EC/torus case for PMN J0948+0022, slightly higher than those in other $\gamma$-ray detected NLS1s ($\Gamma_{\text{jet}} \leq 15$, e.g. Abdo et al. 2009b; D’Ammando et al. 2012). Discoveries of more $\gamma$-ray-emitting NLS1s, especially at higher redshifts, will provide us with new constraints on the physics of the formation of relativistic jets in this intriguing class of objects and their cosmic evolution.

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REFERENCES

Abdo A. A. et al., 2009a, ApJ, 699, 976
Abdo A. A. et al., 2009b, ApJ, 707, L142
Ackermann M. et al., 2015, ApJ, 810, 14
Ahn C. P. et al., 2014, ApJS, 211, 17
Ai Y. L., Yuan W., Zhou H. Y., Wang T. G., Zhang S. H., 2011, ApJ, 727, 31
Baumgartner W. H., Tueller J., Markwardt C. B., Skinner G. K., Barthelmy S., Mushotzky R. F., Evans P. A., Gehrels N., 2013, ApJS, 207, 19
Boroson T. A., Green R. F., 1992, ApJS, 79, 331
Cleary K., Lawrence C. R., Marshall J. A., Hao L., Meier D., 2007, ApJ, 660, 117
D’Ammando F. et al., 2012, MNRAS, 426, 317
D’Ammando F. et al., 2015a, MNRAS, 446, 2456
D’Ammando F., Orienti M., Larsson J., Giroletti M., 2015b, MNRAS, 452, 520
de Rosa A., Bassani L., Ubertini P., Malizia A., Dean A. J., 2008, MNRAS, 388, L54
Dong X., Wang T., Wang J., Yuan W., Zhou H., Dai H., Zhang K., 2008, MNRAS, 383, 581
Fender R. P., Belloni T. M., Gallo E., 2004, MNRAS, 355, 1105
Foschini L., 2011, in Luigi F., Monica C., Luigi G., Dirk G., Stefanie K., Karen L., Smita M., eds, Proc. Sci., Evidence of powerful relativistic jets in narrow-low Seyfert 1 galaxies. SISSA, Trieste, PoS(NLS1)024
Foschini L. et al., 2012, A&A, 548, A106
Foschini L. et al., 2015, A&A, 575, A13
Giommi P. et al., 2012, A&A, 541, A160
Grupe D., Komossa S., Leighly K. M., Page K. L., 2010, ApJ, 187, 64
Ivezić Z. et al., 2002, AJ, 124, 2364
Jiang N. et al., 2012, ApJ, 759, L31
Kalberla P. M. W., Burton W. B., Hartmann D., Arnal E. M., Bajaja E., Morras R., Pöppel W. G. L., 2005, A&A, 440, 775
Kaspi S., Smith P. S., Netzer H., Maoz D., Jannuzi B. T., Giveon U., 2000, ApJ, 533, 631
Kharb P., Lister M. L., Cooper N. J., 2010, ApJ, 710, 764
Komossa S., 2008, Rev. Mex. Astron. Astrol. Ser. Conf. 32, 86
Komossa S., Xu D., 2007, ApJ, 667, L33
Komossa S., Voges W., Xu D., Mathur S., Adorf H.-M., Lemson G., Duschl W. J., Grupe D., 2006, AJ, 132, 531
Laor A., Jannuzi B. T., Green R. F., Boroson T. A., 1997, ApJ, 489, 656
Laurent-Muehleisen S. A., Kollgaard R. I., Ryan P. J., Feigelson E. D., Brinkmann W., Siebert J., 1997, A&A, 122, 235
Pushkarev A. B., Kovalev Y. Y., 2012, A&A, 544, A34
Richards J. L. et al., 2011, ApJS, 194, 29
Sbarrato T., Ghisellini G., Maraschi L., Colpi M., 2012, MNRAS, 421, 1764
Sulentic J. W., Zamfir S., Marziani P., Dultzin D., 2008, Rev. Mex. Astron. Astrol. Ser. Conf., 32, 51
Sun X.-N., Zhang J., Lin D.-B., Xue Z.-W., Liang E.-W., Zhang S.-N., 2015, ApJ, 798, 43
Torrealba J., Chavushyan V., Cruz-González I., Arshakian T. G., Bertone E., Rosa-Gonzalez D., 2012, Rev. Mex. Astron. Astrol., 48, 9
Urry C. M., Padovani P., 1995, PASP, 107, 803
Veron-Cetty M.-P., Véron P., Gonçalves A. C., 2001, A&A, 372, 730
Vestergaard M., Peterson B. M., 2006, ApJ, 641, 689
Wang J.-G. et al., 2009, ApJ, 707, 1334
White R. L., Becker R. H., 1992, ApJS, 79, 331
Woo J.-H., Urry C. M., van der Marel R. P., Lira P., Maza J., 2005, ApJ, 631, 762
Wright E. L. et al., 2010, AJ, 140, 1868
Xu D., Komossa S., Zhou H., Lu H., Li C., Grupe D., Wang J., Yuan W., 2012, AJ, 143, 83
Yao S., Yuan W., Komossa S., Grupe D., Fuhrmann L., Liu B., 2015, AJ, 150, 23
Yuan W., Zhou H. Y., Komossa S., Dong X. B., Wang T. G., Lu H. L., Bai J. M., 2008, ApJ, 685, 801
Zhang J., Xue Z.-W., He J.-J., Liang E.-W., Zhang S.-N., 2015, ApJ, 807, 147
Zhou H., Wang T., Yuan W., Lu H., Dong X., Wang J., Lu Y., 2006, ApJS, 166, 128
Zhou H. et al., 2007, ApJ, 658, L13

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