SDSS J124602.54+011318.8: A Highly Variable AGN, Not an Orphan GRB Afterglow

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ABSTRACT

The optically variable source SDSS J124602.54+011318.8 first appears in Sloan Digital Sky Survey (SDSS) data as a bright point source with nonstellar colors. Subsequent SDSS imaging and spectroscopy showed that the point source declined or disappeared, revealing an underlying host galaxy at redshift 0.385. Based on these properties, the source was suggested to be a candidate “orphan afterglow”: a moderately beamed optical transient, associated with a gamma-ray burst (GRB) whose highly beamed radiation cone does not include our line of sight. We present new imaging and spectroscopic observations of this source. When combined with a careful re-analysis of archival optical and radio data, the observations prove that SDSS J124602.54+011318.8 is in fact an unusual radio-loud AGN, probably in the BL Lac class. The object displays strong photometric variability on time scales of weeks to years, including several bright flares, similar to the one initially reported. The SDSS observations are therefore almost certainly not related to a GRB. The optical spectrum of this object dramatically changes in correlation with its optical brightness. At the bright phase, weak, narrow oxygen emission lines and probably a broader Hα line are superposed on a blue continuum. As the flux decreases, the spectrum becomes dominated by the host galaxy light, with emerging stellar absorption lines, while both the narrow and broad emission lines have larger equivalent widths. We briefly discuss the implications of this discovery on the study of AGNs and other optically variable or transient phenomena.

Subject headings: galaxies: active, BL Lacertae objects: general, gamma rays: bursts
1. Discovery and Basic Properties

SDSS J124602.54+011318.8 was discovered in Sloan Digital Sky Survey (SDSS) data obtained during March 1999. Full details are given by Vanden Berk et al. (2001; hereafter VB01). Being an $r' \approx 17$ mag point source, with nonstellar colors and a radio counterpart from the FIRST survey, the object was flagged as a candidate active galactic nucleus (AGN). Subsequent SDSS imaging and spectroscopy during April–May 2000 and January 2001 revealed that the source had faded considerably to $r' \approx 19.5$ mag, became marginally resolved, and appeared to have a normal galactic spectrum.

These remarkable changes triggered the subsequent study by VB01. From the SDSS data available to VB01, the source appeared as a bright optical transient (OT) that erupted during 1999 and later declined, revealing the underlying host galaxy in spectra and images obtained over a year later. VB01 suggest that the object is indeed an OT similar to ones associated with gamma-ray bursts (GRBs), but do not rule out the possibility that this object is an unusual AGN. Within the astrometric errors of the SDSS images, the location of the point source is consistent with the galaxy nucleus. Combining the SDSS data with archival images from the Digitized Sky Survey, VB01 claim that the source shows no evidence for past variability, and is therefore less likely to be a highly variable AGN. They advocate future optical monitoring to further check this issue.

Following the suggestion of VB01, we observed SDSS J124602.54+011318.8 in the $R$ band with the Wise Observatory 1-m telescope. Combining our new data, the results reported by VB01, and a careful re-analysis of publicly available archival images of the field, we find that SDSS J124602.54+011318.8 is in fact a highly variable object, and not a transient phenomenon. As our January 2002 photometry showed that this object was in a bright ($R \approx 18$ mag) state, we have obtained optical spectra of SDSS J124602.54+011318.8 using the Shane 3-m telescope at Lick Observatory and the Keck-I 10-m telescope in Hawaii.
In striking contrast to the data presented by VB01, the spectra show a blue continuum with weak broad lines, suggestive of an AGN. The redshift ($z = 0.385$), measured from narrow nebular emission lines, is identical to the one found by VB01 from the galactic spectrum they obtained. The combination of the strong optical variability and the spectral information leads us to conclude that SDSS J124602.54+011318.8 is indeed an unusual radio-loud AGN that might be classified as a blazar, probably akin to the BL Lac subclass. Since this object displayed several flares similar to the one observed by the SDSS, there is no reason to suspect that a GRB, or any other sort of non-AGN optical transient, has occurred in this active galaxy.

In the following sections, we present the analysis of the optical photometry (§ 2) and spectroscopy (§ 3) of this object, its radio and X-ray properties (§ 4), and their implications (§ 5).

### 2. Photometry

Figure 1 shows an $R$-band image of the field of SDSS J124602.54+011318.8, obtained on 10 January 2002 (UT dates are used throughout this paper) with the Wise Observatory 1-m telescope. The object, at $R \approx 18$ mag, is marginally resolved. In Figure 2 we plot $R$-band magnitudes of this object measured from new and archival data from 1956 to date. We have transformed SDSS $r'$ magnitudes to Cousins $R$ using the prescription of Smith et al. (2002) and have taken $E$ (red) magnitudes from Palomar Observatory Sky Survey (POSS) plates to be equal to Cousins $R$, albeit with a large uncertainty of $\pm 0.2$ mag, following the analysis of Ofek (2000). Unfiltered observations from the LONEOS photometric database (Rest et al. 2001) are tied to the $R$ band (A. Miceli, private communication). One can see that the object is variable with a peak-to-peak amplitude of more than 2.5 mag. High states were detected during 1991, 1999, and again in our new data. The SDSS images from 2000
and 2001 were apparently taken during a period of very low activity. Examining the blue data from the SDSS, presented by VB01, and analogous archival $O$ (blue) plates, we find a higher amplitude of variability ($\sim 4$ mag), probably because the blue bands are dominated by the variable AGN while the light from the host galaxy contributes more to the $R$ band.

We have analyzed archival unfiltered observations of this field obtained by the NEAT project (Pravdo et al. 1999), and made available through the skymorph\textsuperscript{2} website. Data of good quality were obtained during February–April of 2000 and 2001. Figure 3 (top panel) shows the unfiltered magnitude of SDSS J124602.54+011318.8 relative to the magnitude of a nearby bright star (marked as Star 1 in Fig. 1). One can see that the object shows large-amplitude variations (peak to peak variability of more than 1 mag) over time scales of weeks and months. Some variability on a time scale of days is also evident, but needs to be verified by higher-quality photometry. We have tested the reality of the measured variability by performing the same measurement on a nearby star (marked as Star 2 in Fig. 1) with similar flux. The results (plotted in the bottom panel of Fig. 3) show that the measured flux is generally constant, with a dispersion of $\sim 0.05$ mag around the mean, making the variability of SDSS J124602.54+011318.8 a 20$\sigma$ effect. Since the host galaxy of SDSS J124602.54+011318.8 may become dominant when the AGN is weak, thus introducing seeing dependence into our flux measurement, we repeated our photometry test with a nearby resolved galaxy (marked as Galaxy 1 in Fig. 1). The results, also given at the bottom panel of Figure 3, show that while the scatter in flux is indeed somewhat larger for this object ($\sim 0.1$ mag), the variability of SDSS J124602.54+011318.8 is still highly significant (10$\sigma$). We conclude that SDSS J124602.54+011318.8 is beyond doubt a variable object, with large fluctuations in flux on time scales of weeks to years.

\textsuperscript{2}http://skys.gsfc.nasa.gov/skymorph/skymorph.html
3. Spectroscopy

We obtained optical spectra of SDSS J124602.54+011318.8 twice to assess its spectral variability. The first observation was a 45-minute exposure taken on 14.5 January 2002 with the Kast double spectrograph (Miller & Stone 1993) on the Shane 3-m telescope at Lick Observatory. The second spectrum was a 5-minute observation taken on 17.7 January 2002 with the Low Resolution Imaging Spectrometer (LRIS; Oke et al. 1995) mounted on the Keck-I 10-m telescope. The long, 2" wide Lick Kast slit and 1" wide Keck LRIS slit were both aligned with the parallactic angle to minimize light losses due to atmospheric dispersion (Filippenko 1982). The standard IRAF\(^3\) routines were used for two-dimensional image processing and optimal spectral extraction (Horne 1986). We used our own IDL routines (Matheson et al. 2000) to do the flux calibration and atmospheric band removal (Wade & Horne 1988). In each case, the spectral range was 3500–10000 Å. The Lick spectrum had an anomaly, probably resulting from an imperfect join between its blue and red sides (whose light is split with a dichroic filter), that prevented accurate continuum calibration in the range 4800–6000 Å, so that region has been excised from Figure 4.

Both spectra were taken in clear skies (some very thin cirrus may have been present). We have derived \(R\)-band magnitudes by convolving the flux-calibrated spectra with the \(R\)-band response function, but the associated uncertainties could be only roughly estimated by considering the stability of the nights. The results are \(R = 16.9 \pm 0.3\) mag for the 14.5 January Lick spectrum (the uncertainty is relatively large due to variable seeing), and \(R = 18.1 \pm 0.15\) for the 17.7 January 2002 Keck spectrum. The Lick magnitude supports our suspicion, based on spectral characteristics (see below), that the object was substantially

\(^3\)IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.
brighter than during the 12 January Wise observation \( (R = 18.0 \text{ mag}) \) shown in the inset of Figure 2. The Keck magnitude is very close to the 18 January Wise measurement obtained just 12 hours later.

The SDSS spectroscopy presented by VB01\(^4\) was obtained while the object was quiescent, and is therefore dominated by the light from the host galaxy, resulting in a generally red spectrum with stellar absorption lines. However, the narrow \([\text{O III}]\) emission lines and possible broad \( \text{H}\alpha \) may suggest some AGN contribution, in accord with the radio detection. Examining more than 200 spectra of radio-loud AGNs presented by Stickel \& Kuehr (1994), Stickel et al. (1996), Kock et al. (1996), Nass et al. (1996), Perlman et al. (1998), and Landt et al. (2001), we find only two spectra (WGAJ0245.2+1047, Perlman et al. 1998; WGAJ0528.5-5820, Landt et al. 2001) that resemble that of SDSS J124602.54+011318.8. Both objects are classified as BL Lacs, but the SDSS spectrum seems to be even more “galactic” (e.g., with stronger Ca II H & K lines), so it may in fact resemble that of a radio galaxy.

In contrast, the nearly featureless Lick spectrum, shown in Figure 4, was obtained when the object was in a bright phase (Fig. 2) and is apparently dominated by a nonstellar source. The continuum is very blue, with low equivalent width emission lines of \([\text{O III}]\) and \([\text{O II}]\), and possibly broader \( \text{H}\alpha \) and \( \text{Mg II} \) lines. The spectrum is very suggestive of a BL Lac object. No stellar absorption lines from the host are visible, but the measured redshift is \( z = 0.385 \) from the narrow \([\text{O III}]\) line, matching the SDSS redshift.

The Keck LRIS spectrum, obtained \( \sim 3 \) days later and shown in Figure 5, was apparently taken when the object was at an intermediate phase (being about one third as

\(^4\)Data are publicly available through the SDSS spectral archive, http://archive.stsci.edu/sdss/spectra.html.
bright as it was when the spectrum shown in Fig. 4 was taken). The continuum is less blue, and stellar absorption lines are visible, although they are not as strong as in the SDSS spectra. The broad Hα line is now clearly visible, with equivalent width (\(W_\lambda\)) ≈ 13 Å and full width at half maximum (FWHM) ≈ 3000 km s\(^{-1}\). The emergence of broad lines during the continuum drop that accompanies the transition to a low activity state is well documented in variable radio-loud AGNs (e.g., Vermeulen et al. 1995; Koratkar et al. 1998). The strength of the “4000 Å break” is \(C \approx 0.1\), following the definition of Perlman et al. (1998). Combining our measured values for \(C\) and \(W_\lambda\) and using the classification diagram of Marchá et al. (1996) and Perlman et al. (1998), we find that this object falls on the outskirts of the BL Lac region.

Wise photometry taken ∼ 12 hours after the Keck LRIS spectrum indeed shows the object to be fainter than it was before the Lick spectrum was obtained, but still brighter than it was at the time of the SDSS spectroscopy (Fig. 2). This is consistent with the spectral analysis showing the Keck spectrum to be intermediate between the AGN-dominated Lick spectrum and the host-dominated SDSS spectra.

In conclusion, SDSS J124602.54+011318.8 shows dramatic spectral variability, apparently correlated with its optical flux. The broad lines and the blue, variable, nonstellar continuum observed in both the Lick and Keck spectra are indicative of an AGN. The combination of the spectral data from all epochs is best explained by an extreme, strongly variable BL-Lac-type object that resembles a radio galaxy during its faint phase. Since the properties of the flare reported by VB01 are fully replicated by our new observations of this AGN, there is no reason to suspect that an OT occurred during March 1999.
4. Radio and X-ray Properties

The FIRST 1.4 GHz radio catalog (White et al. 1997) lists only one source within 3′ of SDSS J124602.54+011318.8, coincident with the SDSS position of the optical source to ±0.3″, well below the combined astrometric errors of the SDSS and FIRST data. Therefore, one can safely identify the 79.4 ± 0.2 mJy FIRST source with SDSS J124602.54+011318.8. Comparing the FIRST detection with another 1.4 GHz survey, we find that the NVSS catalog (Condon et al. 1998) quotes a significantly lower flux measurement of 71.9 ± 2 mJy. Scanning other radio catalogs, we have found that this source was detected at 4.85 GHz by the PMN survey (Griffith & Wright 1993; 51 ± 11 mJy) sometime during 1990, while the GB6 catalog (Gregory et al. 1996; 90 ± 11 mJy) detects the source at the same frequency, in data taken during 1986–1987 (exact epochs are not currently available). We therefore conclude that this source is probably variable at radio wavelengths, with a change of up to a factor of ~ 2 in flux over several years. Such radio properties are consistent with the characteristics of radio-loud AGNs in general, and BL Lacs in particular. The object is not detected in the ROSAT all-sky survey, nor does it appear in the EGRET third catalog.

5. Discussion

The identification of SDSS J124602.54+011318.8 as an unusual AGN has several implications in various related fields, including the study of optical transients in general and optical afterglows of GRBs in particular, as well as AGN research. We briefly comment on these subjects.

Perhaps the most important lesson to be learned from the work presented above is the need for a thorough search of available archival data, when studying potentially transient or variable objects. Large amounts of high-quality astronomical data are now easily available
to the community, covering most of the sky in a wide range of wavelengths. In many cases, archival data can provide evidence for past variability, or at least constrain it. There are many peculiar stars and AGNs out there, and when large areas of the sky are searched, they are bound to appear occasionally. Without proper care, such objects may pose as transient events such as supernovae or GRB afterglows. Even when archival data are not available or show no evidence for variability, continued optical monitoring of the sites of candidate transients may be prudent, if strong conclusions are to be drawn from such events. We note that several theoretical papers on SDSS J124602.54+011318.8 have already been submitted for publication (e.g., Granot et al. 2002), and although they may still serve a useful purpose for general discussions, the specific conclusions regarding this particular “orphan GRB” clearly are not applicable.

One of the interesting applications of the accurate SDSS 5-band photometry is the possible distinction between different classes of objects by their colors (Krisciunas, Margon, & Szkody 1998; Poznanski et al. 2002). VB01 demonstrate that the optical colors of SDSS J124602.54+011318.8 in the bright phase can be fitted by a power law with index $\beta_\nu \approx 1$, and claim that these colors are similar to those of GRB afterglows and inconsistent with those of most AGNs. Our work shows that at least some AGNs have colors that are similar to those of GRBs. In fact, such colors have been measured for well-known flaring AGNs such as BL Lac (Webb et al. 1998) and the radio-loud quasar 3C 279 (Webb et al. 1990). The selection of GRB afterglows by their colors alone would therefore seem difficult. VB01 claim that the discovery of an “orphan afterglow” within the amount of SDSS data searched so far disfavors the models used in the calculations of Dalal, Griest, & Pruet (2002), which predict very few “orphan afterglows” even in deep, wide-field searches. The fact that SDSS J124602.54+011318.8 probably did not host a GRB implies that these models are as yet uncontested.
The strong spectral variability this object displays also has some implications for studies of radio-loud AGNs. Looking only at low-state optical spectra of SDSS J124602.54+011318.8, it is difficult to classify it as a blazar, since the nonstellar continuum is well below the level of the host-galaxy light. The fact that surveys for AGNs may miss a population of such low-luminosity blazars, for exactly this reason, has already been noted (Browne & Marcha 1993; see a thorough recent discussion in Perlman et al. 1998). However, besides being an extreme example of the “Browne & Marcha effect,” SDSS J124602.54+011318.8 also raises the issue of variability. The calculations presented by Browne & Marcha (1993), Marcha & Browne (1995), and Perlman et al. (1998) do not take the intrinsic variability of the sources into account. Objects similar to SDSS J124602.54+011318.8 may spend a significant fraction of their time in a low state, where they are hard to recognize, suffering an increased Browne & Marcha effect. In order to estimate how significant this might be (i.e., the incompleteness of blazar surveys), one needs to determine the duty cycle of objects like SDSS J124602.54+011318.8, as well as know their relative frequency within the entire blazar population. Both of these properties may be measured by a spectroscopic monitoring campaign of a complete sample of radio-selected AGNs.

A similar aspect of the extreme variability of this object is the pronounced change in its apparent optical morphology, from a bright, star-like point source to a faint resolved galaxy. If such objects are not very rare, programs using optical morphology to select candidate AGNs may be strongly affected. As an example, Wallace et al. (2002) searched for the blazar counterpart of the unidentified EGRET source 3EG J2006-2321, using radio and optical data. In order to decide between the two most probable radio sources that fall within the EGRET error contour, they examine deep optical images of this field. One of the sources appears like “a normal-looking galaxy” while the other is stellar. The authors use this to rule out the galactic-looking source. In this particular case, the decision was probably
well justified, as the remaining source shows spectral and polarization properties that are characteristic of blazars. But a population of objects similar to SDSS J124602.54+011318.8, with variable apparent morphology, may hinder the use of object morphology as a selection method in similar studies.

Finally, we note that SDSS J124602.54+011318.8 presents an opportunity to study the properties of the stellar population in the nucleus of an AGN host galaxy; when in the low state, the AGN is faint and does not obstruct the observations of the host, unlike the case for its brighter counterparts.

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REFERENCES

Browne, I. W. A., & Marchä, M. J. M. 1993, MNRAS, 261, 795

Condon, J. J., Cotton, W. D., Greisen, E. W., Yin, Q. F., Perley, R. A., Taylor, G. B., & Broderick, J. J. 1998, AJ, 115, 1693

Dalal, N., Griest, K., & Pruet, J. 2002, ApJ, submitted, astro-ph/0103436

Filippenko, A. V. 1982, PASP, 94, 715

Granot, J., Panaitescu, A., Kuman, P., & Woosley, S. E. 2002, ApJ, submitted, astro-ph/0201322

Gregory, P. C., Scott, W. K., Douglas, K., & Condon, J. J. 1996, ApJS, 103, 427

Griffith, M. R., & Wright, A. E. 1993, AJ, 105, 1666

Horne, K. 1986, PASP, 98, 609

Kock, A., Meisenheimer, K., Brinkmann, W., Neumann, M., & Siebert, J. 1996, A&A, 307, 745

Koratkar, A., Pian, E., Urry, C. M., & Pesce, J. E. 1998, ApJ, 492, 173

Krisciunas, K., Margon, B., & Szkody, P. 1998, PASP, 110, 1342

Landt, H., Padovani, P., Perlman, E. S., Giommi, P., Bignall, H., & Tzioumis, A. 2001, MNRAS, 323, 757

Marchä, M. J. M., & Browne, I. W. A. 1995, MNRAS, 275, 951

Marchä, M. J. M., Browne, I. W. A., Impey, C. D., & Smith, P. S. 1996, MNRAS, 281, 425
Matheson, T., Filippenko, A. V., Ho, L. C., Barth, A. J., & Leonard, D. C. 2000, AJ, 120, 1499

Miller, J. S., & Stone, R. P. S. 1993, Lick Obs. Tech. Rep., No. 66

Nass, P., Bade, N., Kollgaard, R. I., Laurent-Muehleisen, S. A., Reimers, D., & Voges, W. 1996, A&A, 309, 419

Ofek, E. O. 2000, MSc Thesis, Tel Aviv University

Oke, J. B., et al. 1995, PASP, 107, 307

Perlman, E. S., Padovani, P., Giommi, P., Sambruna, R., Jones, L. R., Tzioumis, A., & Reynolds, J. 1998, AJ, 115, 1253

Poznanski, D., Gal-Yam, A., Maoz, D., Filippenko, A. V., Leonard, D. C., & Matheson, T. 2002, PASP, submitted, astro-ph/0202198

Pravdo, S. H., et al. 1999, AJ, 117, 1616

Rest, A., et al. 2001, BAAS, 199.101.10

Smith, J. A., et al. 2002, AJ, in press, astro-ph/0201143

Stickel, M., & Kuehr, H. 1994, A&AS, 105, 67

Stickel, M., Rieke, G. H., Kuehr, M., & Rieke, M. J. 1996, ApJ, 468, 556

Vanden Berk, D. E., et al. 2002, ApJ, submitted, astro-ph/0111054 (VB01)

Vermeulen, R. C., et al. 1995., ApJL, 452, L5

Wade, R. A., & Horne, K. 1988, ApJ, 324, 411
Wallace, P. M., Halpern, J. P., Magalhaes, A. M., & Thompson, D. J. 2002, ApJ, in press, astro-ph/0112568

Webb, J. R., et al. 1990, AJ, 100, 1452

Webb, J. R., et al. 1998, AJ, 115, 2244

White, R. L., Becker, R. H., Helfand, D. J., & Gregg, M. D. 1997, ApJ, 475, 479
Fig. 1.— A $3' \times 3'$ section of a 900-s $R$-band image obtained with the Tek CCD camera mounted on the Wise Observatory 1-m telescope. SDSS J124602.54+011318.8 and comparison objects are marked. Note that SDSS J124602.54+011318.8 is marginally resolved.
Fig. 2.— $R$-band light curve of SDSS J124602.54+011318.8 spanning 45 years of data. The combination of archival digital POSS plates (circles), multi-epoch SDSS data from VB01 (triangles), archival LONEOS data (diamonds), our new Wise data (open squares), and spectral flux measurements (filled squares; see § 3) shows unambiguously that the source is strongly variable. (Note that the error bars on the spectral measurements are not formal 1σ values, but rather are estimates based on the perceived stability of the night.) The object appears to have been quiescent ($R \approx 19.3$) on the 1956 POSS-I plate and during the SDSS spectroscopy and imaging runs in 2000–2001. During March-May 1999, SDSS and LONEOS observations apparently caught the object in a high state, while the 1991 POSS-II data and our Wise observations are intermediate, but still significantly higher than the low-state baseline. The inset shows a detailed view of the recent Wise photometry, along with the spectral flux measurements.
Fig. 3.— **Upper panel:** The unfiltered magnitudes of SDSS J124602.54+011318.8 from NEAT images, as a function of time, relative to the median. Each data point was normalized by the measured flux of a nearby bright star (marked as Star 1 in Fig. 1), assumed to be stable. **Lower panel:** The same as the top panel, but for a star with flux similar to that of SDSS J124602.54+011318.8 (Star 2 in Fig. 1; *open squares*) and a nearby galaxy (Galaxy 1 in Fig. 1; *open triangles*). For both objects the measurements are constant within the errors. The data show that SDSS J124602.54+011318.8 varies on time scales of years, months, and weeks.
Fig. 4.— A spectrum of SDSS J124602.54+011318.8 obtained on 14.5 January 2002 with the 3-m Shane reflector at Lick Observatory. Note the blue, featureless continuum and the probable weak, broad Hα emission line. The redshift measured from the narrow [O III] λ5007 line is 0.385.
Fig. 5.— A spectrum of SDSS J124602.54+011318.8 obtained on 17.7 January 2002 with the Keck-I 10-m telescope. Note the broad Hα emission line and the emergence of the stellar absorption lines.