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MULTI-WAVELENGTH OBSERVATIONS OF PKS 2142–75 DURING ACTIVE AND QUIESCENT GAMMA-RAY STATES

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ABSTRACT

PKS 2142–75 (a.k.a. 2FGL J2147.4–7534) is a flat-spectrum radio quasar that was observed quasi-simultaneously by a suite of instruments across the electromagnetic spectrum during two flaring states in 2010 April and 2011 August as well as a quiescent state from 2011 December through 2012 January. The results of these campaigns and model spectral energy distributions (SEDs) from the active and quiescent states are presented. The SED model parameters of PKS 2142–75 indicate that the two flares of the source are created by unique physical conditions. SED studies of flat-spectrum radio quasars are beginning to indicate that there might be two types of flares, those that can be described purely by changes in the electron distribution and those that require changes in other parameters, such as the magnetic field strength or the size of the emitting region.

Key words: galaxies: active – gamma rays: galaxies – quasars: individual (PKS 2142–75) – radio continuum: galaxies – ultraviolet: galaxies – X-rays: individual (PKS 2142–75)

Online-only material: color figures

1. INTRODUCTION

Active galactic nuclei (AGNs) are the brightest persistent sources of electromagnetic radiation in the universe. They radiate intensely from low-energy radio waves to very-high-energy γ -rays and are known to be highly variable at all frequencies. Blazars are the most luminous and violently variable subclass of AGN. High and highly variable polarization have been detected in the radio and optical emission of blazars, and they are the most common type of AGN detected at GeV energies (Abdo et al. 2010b). Blazars have extended plasma jets, which can be detected at radio and, in a growing number of cases, at optical and X-ray frequencies as well.¹⁷ Observational data suggest that blazars are those radio-loud AGN whose jets are aligned at small angles with respect to the line of sight. In this scenario, the bulk relativistic motion of the emitting material results in “relativistic beaming,” i.e., both the luminosity and the variability of emission appear to be enhanced compared to what would be measured in the rest frame of the blazar (e.g., Urry & Padovani 1995). The jets can show apparent superluminal motion in high

resolution, very long baseline interferometric (VLBI) radio images, a consequence of the jets pointing at a small angle to the line of sight. Blazars can be subdivided, based on their spectral features, into BL Lacertae (BL Lac) objects, and flat-spectrum radio quasars (FSRQs). BL Lac objects exhibit weak or no emission lines, while FSRQs show strong, broad emission lines (Urry & Padovani 1995).

The spectral energy distributions (SEDs) of blazars show a characteristic “double-bumped” structure, with the lower-frequency bump almost certainly originating from beamed electron synchrotron emission from the jet (Urry & Padovani 1995). Aside from their classification based on their optical spectra, blazars are also classified based on their frequencies of peak synchrotron emission in a νF_ν representation. Low-synchrotron peaked (LSP) blazars have $\nu_{\text{peak}}^{\text{sync}} < 10^{14}$ Hz; high-synchrotron peaked blazars have $\nu_{\text{peak}}^{\text{sync}} > 10^{15}$ Hz; and intermediate-synchrotron peaked blazars have $\nu_{\text{peak}}^{\text{sync}}$ between 10^{14} and 10^{15} Hz (Abdo et al. 2010a). BL Lac objects can be any of the three classes; however almost all FSRQs are LSP blazars.

The origin of the higher-frequency bump, peaking in γ rays, is less well understood. Two families of models attempt to describe them: leptonic and hadronic models (Böttcher 2007). Leptonic models invoke a source of soft seed photons being Compton up-scattered to higher energies by relativistic electrons

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¹⁷ Lists of X-ray detected and optically detected jets can be found at <http://hea-www.harvard.edu/XJET/> and <http://astro.fit.edu/jets/>, respectively.

within the jet. The seed photon source could be synchrotron emission from the same electrons that scatter them (known as synchrotron self-Compton or SSC) or could be external to the jet (external Compton or EC). The accretion disk (Dermer et al. 1992), the broad-line region (BLR; e.g., Sikora et al. 1994), the dust torus (Błażejowski et al. 2000), or even the cosmic microwave background (Böttcher et al. 2008) have all been considered as seed photon sources for EC processes. Hadronic models assume that a significant fraction of the jet power is converted into the acceleration of protons, so that the protons reach the threshold for pion production. The pions and their secondaries can thus create the γ -ray emission (Mannheim & Biermann 1992). Protons at these high energies can also emit γ rays through synchrotron emission (e.g., Mücke et al. 2003).

Simultaneous flux density measurements of blazars at multiple wavelengths across the electromagnetic spectrum can allow us to distinguish among the many different high-energy emission models proposed (Böttcher 2007). The launch of the *Fermi* Gamma Ray Space Telescope (Atwood et al. 2009) has created new opportunities for studying blazars at high energies. The *Fermi*/LAT is more sensitive and has better energy and spatial resolution than any previous telescope in the MeV–GeV energy range (Atwood et al. 2009). The Large Area Telescope (LAT) has put better constraints on blazar variability within its observing window and has shown that it is not unusual for blazars to exhibit fast variability on timescales of days or even hours at GeV energies (e.g., Saito et al. 2013). The LAT observes the entire sky every 3 hr, which makes it an ideal instrument on which to support multi-instrument observing campaigns on sources in response to their changing γ -ray state.

PKS 2142–75 is an FSRQ at a redshift of $z = 1.139^{18}$ (Jauncey et al. 1978). It is in the Second *Fermi* LAT Catalog as 2FGL J 2147.4–7534 (Nolan et al. 2012) with a flux of $3.6 \pm 0.2 \times 10^{-9}$ photon $\text{cm}^{-2} \text{s}^{-1}$ in the 100 MeV to 100 GeV range, although it is not found in the First *Fermi* LAT Catalog (Abdo et al. 2010b).

The LAT first detected a flare from PKS 2142–75 on 2010 April 4 (MJD 55,290), when the source reached a daily averaged flux of $(1.1 \pm 0.3) \times 10^{-6}$ photon $\text{cm}^{-2} \text{s}^{-1}$ (Wallace 2010) in the 100 MeV to 300 GeV range. This flux represented an almost three order of magnitude increase over the average flux reported in the 2FGL catalog (Nolan et al. 2012). After the initial flare, this source was detected in a flaring state by the LAT in 2010 October to November and again in 2011 July to August.

During the latest flaring period in 2011, a multiwavelength observing campaign was carried out using the Ceduna Radio Telescope, the Australia Telescope Compact Array (ATCA), *Swift*, the Rapid Eye Mount (REM) Telescope, and LAT. These quasi-simultaneous data were complemented with simultaneous data from the ongoing Small and Moderate Aperture Research Telescope System (SMARTS) blazar monitoring program (Bonnin et al. 2012). The data were used to construct a broadband SED of this object in its active state. We organized another quasi-simultaneous multiwavelength campaign using the same instruments (except for the REM) during a quiescent γ -ray state from 2011 December to 2012 January. This is a particular strength of this work, as quiescent SEDs are often constructed with nonsimultaneous data, which can compromise their utility. The simultaneous quiescent SED allowed us to determine which components of the SED were at elevated levels during

the active state and provided insight into the dominant physical processes occurring at different wavelengths. We present these observations and the resulting SEDs from the active and quiescent states supplemented by a broadband SED constructed using archival data coincident with an earlier flare in 2010 April. All three SEDs were fit with physical models, and the results and their implications for high-energy blazar emission are discussed. Throughout this article we will refer to the 2010 April flare as flare A and the 2011 July to August flare as flare B. The luminosity of this source during flare A is 3.2×10^{49} erg s^{-1} in the 100 MeV to 300 GeV energy range, which is comparable to the luminosity of some of the brightest flares detected by *Fermi* (Nalewajko 2013). During the quiescent period the 100 MeV to 300 GeV luminosity is 4.4×10^{48} erg s^{-1} , which places PKS 2142–75 among the most luminous 2FGL FSRQs (Nolan et al. 2012).

2. LAT OBSERVATIONS

The LAT on the *Fermi* spacecraft is a high-energy γ -ray detector with a wide field of view ($\sim 20\%$ of the sky) covering the energy band from 20 MeV to greater than 300 GeV. It primarily operates in an all-sky scanning mode, observing the entire sky every 3 hr. All LAT results presented here were obtained using the *Fermi* science tools (version 09-27-00) and the P7SOURCE_V6 instrument response functions.

The light curve in the top panel of Figure 1 shows the γ -ray flux of PKS 2142–75 in the 100 MeV to 300 GeV energy range averaged into weekly time bins; it was created as follows. A circular region of interest (ROI) of radius 10° and “source” class events were selected for event reconstruction. Events above a zenith angle of 100° were removed in order to minimize the contamination from photons produced by cosmic rays interacting with the Earth’s atmosphere. A rocking angle cut of 52° was applied. The spectral index of the source was fixed to 2.52 ± 0.04 , the value computed in the 2FGL catalog (Nolan et al. 2012). Fitting of the spectral index with the low photon statistics present in one week of data proved to be unreliable. Sources within the 10° ROI in the XML model had fixed indices and free normalizations, and sources that were outside the ROI had all spectral parameters fixed. Sources in the 2FGL catalog were used to define the model. The background model includes a Galactic diffuse emission component and an isotropic component, which are provided by the publicly available files `gll_iem_v02_P7SOURCE.fit` and `isotropic_iem_v02_P7SOURCE.txt`.¹⁹ The isotropic component accounts for the extragalactic diffuse emission and the residual charged-particle background. A power-law correction to the Galactic diffuse background was not applied, and the normalizations of the isotropic and Galactic diffuse backgrounds were fixed to one. This method yielded reasonable residuals for the fits in each individual time bin. The light curve begins on 2008 June 26 (MJD 54,643) and ends on 2012 February 14 (MJD 55,971). Upper limits on the source’s flux were calculated when the test statistic (TS; Mattox et al. 1996) for a given week was found to be less than 10. The light curve in Figure 2 was made using the same cuts on the data and the same model for the sources in and near the ROI, although the binning was changed to 2 weeks. The upper-limit threshold is the same and the time range plotted is from 2011 July 19 (MJD 55,761) to 2012 March 13 (MJD 55,999).

¹⁸ At this redshift, using a cosmology with $H_0 = 71 \text{ km s}^{-1} \text{Mpc}^{-3}$, $\Omega_m = 0.27$, and $\Omega_\Lambda = 0.73$, PKS 2142–75 has a luminosity distance of $d_L = 7.7 \text{ Gpc}$. We use this d_L for the source in this article.

¹⁹ <http://fermi.gsfc.nasa.gov/ssc/data/access/lat/BackgroundModels.html>

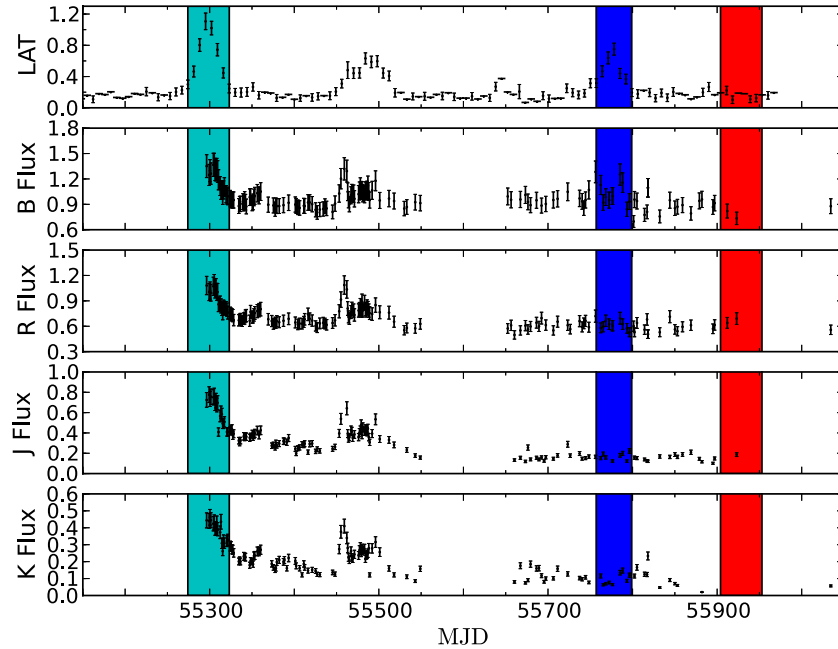


Figure 1. *Fermi*/LAT and SMARTS light curves for PKS 2142–75. The LAT light curve covers the 100 MeV to 300 GeV energy range and was generated using a bin size of 1 week and a TS threshold of 10 for upper limits, with fluxes given in units of $10^{-6} \text{ photon}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$. The optical light curves are from the SMARTS 1.3 m telescope and are in units of $10^{-15} \text{ erg}^{-1} \text{ cm}^{-2} \text{ s}^{-1} \text{ Å}^{-1}$. The periods corresponding to the multiwavelength observations are indicated in cyan (flare A), blue (flare B), and red (quiescent).

(A color version of this figure is available in the online journal.)

During flare A the source was observed by the *Wide Field Infrared Survey Explorer* (WISE) and SMARTS. We organized our first multiwavelength campaign during flare B. Our second set of observations was carried out from 2011 December to 2012 January in order to observe the source in a nonflaring state and obtain the quiescent SED. A LAT spectrum was created for each of these three periods by averaging and using the same cuts on the data and the same initial model parameters used for the light curve. The time ranges extending from 2010 March 10 (MJD 55,265) to 2010 April 30 (MJD 55,316) and 2011 July 21 (MJD 55,763) to 2011 August 18 (MJD 55,791) were chosen to define the flare A and flare B states because the source’s daily TS was above 25. The quiescent state was defined to be 2011 December 08 (MJD 55,903) to 2012 January 26 (MJD 55,952) because the source was not significantly detected in the 100 MeV to 300 GeV energy range on daily timescales, and this time range coincides with our observations at other wavelengths. For all time ranges an initial likelihood analysis was run over the full energy spectrum to evaluate the parameters for a power-law spectral model for the γ -ray emission. For the initial likelihood analysis the spectral index was left free so we could determine whether the spectrum changed during the different γ -ray states. The spectral index of the source in the 100 MeV to 300 GeV energy range was found to be 2.37 ± 0.03 during flare A, 2.37 ± 0.06 during flare B and 2.79 ± 0.14 during the quiescent state. Using the initial power law as a starting point, likelihood analysis was run again within each individual logarithmic energy bin fixing the spectral index to the value determined from the initial fit to the whole energy range. The bin sizes are different in the active state and quiescent state because significantly fewer photons are available during the quiescent state, which also limited the number of energy bins that could be computed. Upper limits on the target source’s flux were calculated when the TS within the energy bin was below 10. The γ -ray spectra are shown in Figure 3.

In order to estimate the variability timescale of PKS 2142–75, a light curve with one-day bins for flare A was generated and can be found in Figure 4. On 2010 April 3–4 (MJD 55,289–55,290) the flux appears to double. Thus a variability timescale of the order of a day is justified. A similar variability timescale for flare B was found on 2011 July 29–30 (MJD 55,771–55,772).

3. SWIFT OBSERVATIONS

Swift is a multiwavelength space-based observatory (Gehrels et al. 2004) that has three instruments: the Burst Alert Telescope (BAT), the UltraViolet and Optical Telescope (UVOT), and the X-Ray Telescope (XRT). *Swift* uses momentum wheels to rapidly change the direction in which it is pointing. The observatory’s primary objective is to observe γ -ray bursts, making its ability to slew rapidly a necessity; however this ability has become extremely useful for studying blazars due to their rapid variability.

Two observing campaigns with the UVOT and XRT instruments on board *Swift* were conducted on this object (which was too faint to be detected by BAT). The first series of observations ran from 2011 August 10 (MJD 55,783) through 2011 August 23 (MJD 55,796; flare B), while the second series ran from 2011 December 8 (MJD 55,903) through 2011 December 21 (MJD 55,916; quiescent state). *Swift* did not observe the source during flare A. The latest versions of the *Swift* data reduction software (07Jun2011_V6.11) and calibration data (caldb.indx20110725) were used in our analysis.

Ultraviolet and optical data were taken in the “filter of the day” mode. During the first series of observations, the source was imaged with the *U*, *W1*, and *W2* filters with central wavelengths of 3465 Å, 2600 Å, and 1928 Å respectively. During the second, the *U*, *W1*, and *M2* (center wavelength: 2246 Å) filters were used. Aperture photometry and coincidence loss corrections were made using the standard UVOT data reduction task

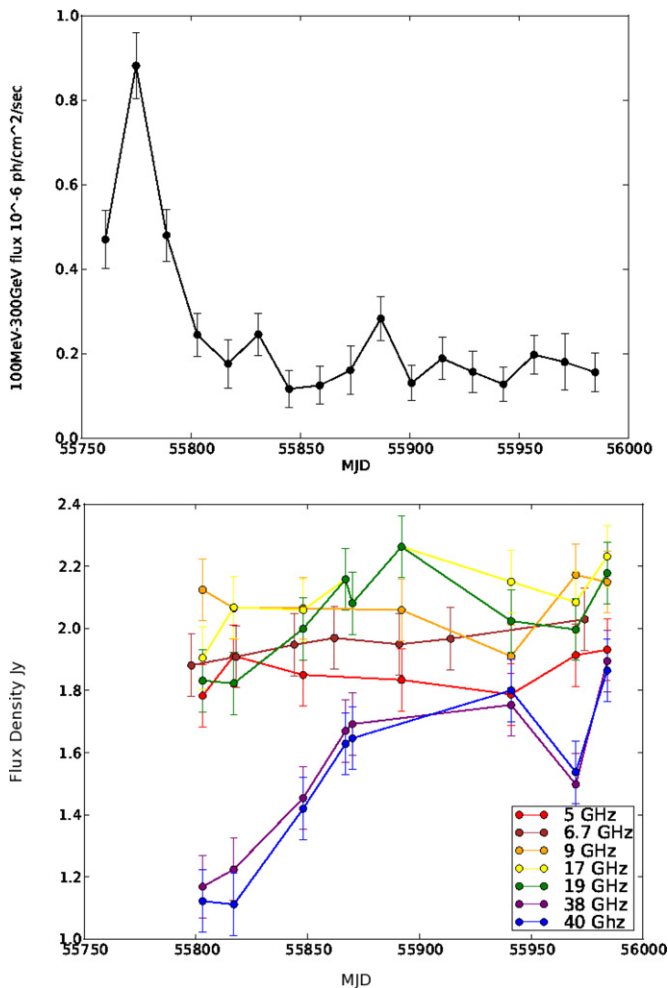


Figure 2. γ -ray (above) and radio (below) light curves of PKS 2142–75 displayed together for comparison purposes. The γ -ray curve is made using 2 week bins starting on MJD 55,761 (2011 July 19), which corresponds to the beginning of flare B and extends until MJD 55,999 (2012 March 13). The flux densities at 6.7 GHz were obtained from the Ceduna Radio Telescope. Those at all other frequencies were observed by the ATCA. 1σ error bars are shown. Note the significant increase in flux at the two highest radio frequencies in 2011 November following the γ -ray flare in 2011 August.

UVOTSOURCE. Circular source and background regions of radius $10''$ were used for the calibration. Magnitudes have been corrected for Galactic extinction using the method described in Fitzpatrick (1999). The extinction parameter $E(B - V)$ was calculated from the N_H column density using the method described in Predehl & Schmitt (1995). Uncertainties in the UV fluxes are predominantly determined by the dereddening correction. For the V , B , and U filters we estimate a fairly conservative uncertainty of 5% in the final calculation of the flux. For the $W1$, $M2$, and $W2$ filters a higher uncertainty of 25% is used because they overlap with a UV “bump” in the extinction curve, which is highly dependent on the line of sight and is therefore difficult to model.

The XRT exposures from each series of observations were binned together resulting in total exposure times of 12 ks during flare B and 5 ks during the quiescent state (Figure 5). Circular source and background extraction regions of radii $60''$ and $119''$ were used for all pointings. For both observations the spectrum was determined using data in the 0.3–10 keV range. The source emission was fit by an absorbed power law during both epochs using an N_H column density of $6.6 \times 10^{20} \text{ cm}^{-2}$ from Galactic H I (Kalberla et al. 2005). We measured an X-ray spectral

index of 1.4 ± 0.1 during flare B and 1.5 ± 0.1 during the quiescent state. The flux in the 0.3–10 keV range during flare B is $(3.0 \pm 0.2) \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$, and during the quiescent state the flux is $(3.4 \pm 0.6) \times 10^{-12} \text{ erg cm}^{-2} \text{ sec}^{-1}$. Therefore the variation observed between the two states is insignificant.

4. SMARTS OBSERVATIONS

The SMARTS carries out regular photometric monitoring of LAT sources of interest at optical and IR frequencies (Bonning et al. 2012).²⁰ PKS 2142–75 was regularly observed by the ANDICAM instrument mounted on the SMARTS 1.3 m telescope from 2010 April 10 (MJD 55,296) to 2012 September 15 (MJD 56,185). The results of the SMARTS monitoring of this source are displayed in Figure 1. ANDICAM is able to take optical and infrared data simultaneously with dichroic filters. A moveable mirror allows dithering in the IR while the optical exposure is in progress. The details of the data reduction are described in Bonning et al. (2012). The magnitudes are corrected for Galactic extinction using the extinction parameters derived from the recalibration (Schlafly & Finkbeiner 2011) of the infrared-based dust maps reported in Schlegel et al. (1998). Magnitudes are converted into fluxes using the photometric zero points found in Frogel et al. (1978), Bessell et al. (1998) and Elias et al. (1982). Simultaneous photometric data points at B , R , J , and K bands observed on 2010 April 13 (MJD 55,299, flare A), 2011 August 12 (MJD 55,785, flare B), and 2011 December 28 (MJD 55,923, quiescent) are used in conjunction with our scheduled multiwavelength observing campaigns for our SED fits.

5. NEAR-INFRARED OBSERVATIONS WITH REM

The REM (Molinari et al. 2010) Telescope is a 60 cm telescope observing in the infrared and optical wavebands. It is designed to react quickly to changes in the sky. It is located on the La Silla premises of the ESO Chilean Observatory, making it ideal for observing highly variable southern sources (e.g., Nesci et al. 2013). Observations of PKS 2142–75, with an exposure time of 150 s, were made on 2011 August 10 (MJD 55,923, flare B) shortly after the flare in γ -ray emission observed by LAT. To calibrate the data, 10 reference stars from the Two Micron All Sky Survey catalog (Skrutskie et al. 2006) were used with J magnitudes ranging from 11.10 to 14.9. The linear fit between instrumental and nominal magnitudes was always good, with a slope of nearly 1, and a dispersion of about 0.07 mag. Two NIR flux measurements of PKS 2142–75 were made, resulting in magnitudes of 15.05 ± 0.16 in the J band and 14.92 ± 0.31 in the H band. The errors reported are computed by IRAF/apphot, and they are based on the Poisson statistics of the net counts and the detector noise: this method generally underestimates the actual error in the source’s magnitude. The source was rather faint for REM, so that the total net counts were rather low and the strongly structured background light leads to an additional error of 25%–30% (0.3 mag) in the flux measurement. Our total error for the source flux is estimated to be 50% at both frequencies.

6. WISE OBSERVATIONS

The WISE (Wright et al. 2010) is a space-based all-sky infrared mapping mission. The cryogen cooled photometric survey occurred between 2009 January and 2010 October at

²⁰ <http://www.astro.yale.edu/smarts/glast/home.php>

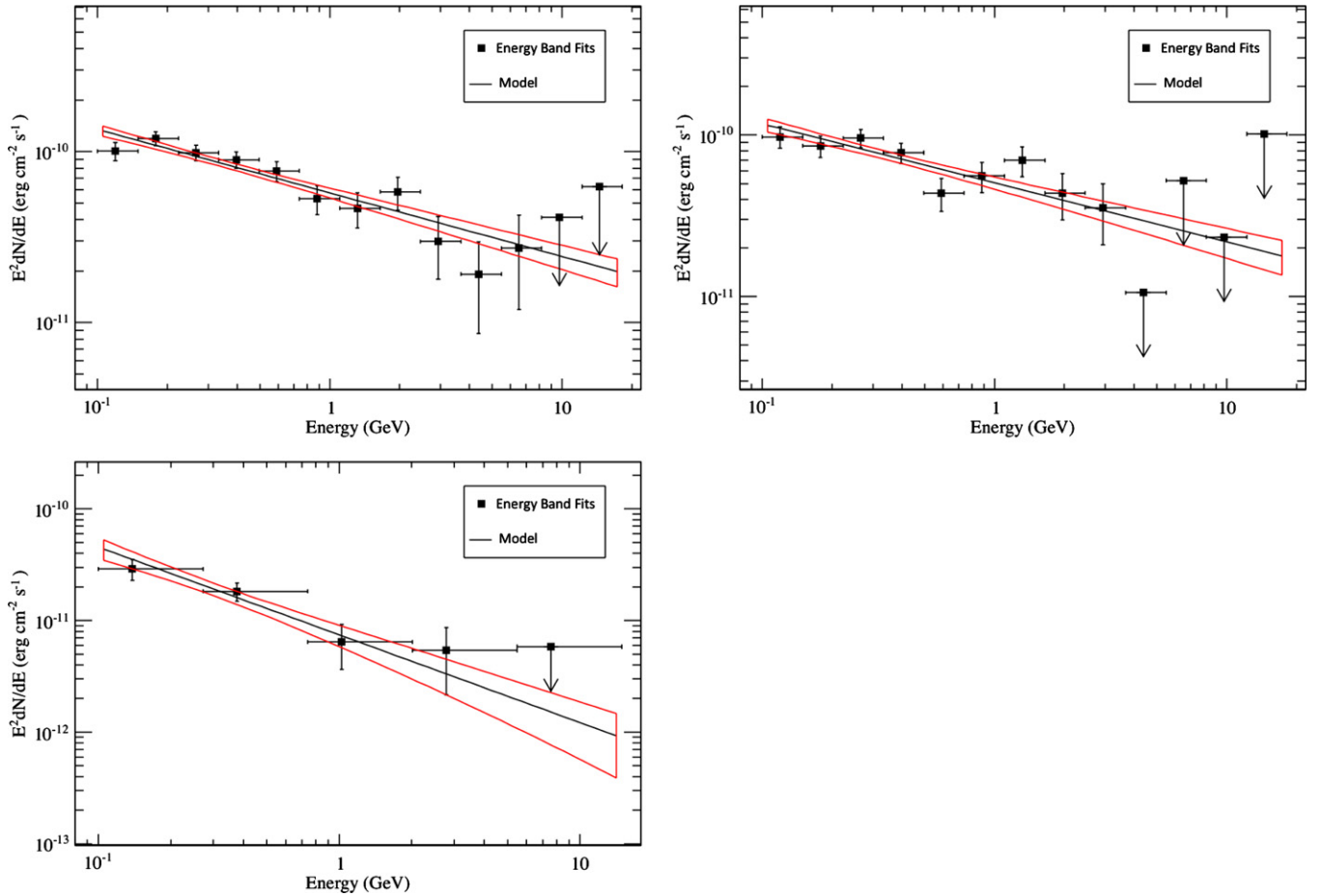


Figure 3. γ -ray spectra for PKS 2142–75, top left flare A, top right flare B, and bottom left quiescent state. The black curve represents the initial power-law fit to the full energy range and the red curve is the butterfly plot derived from the covariance values determined in the initial fit to the full energy range. (A color version of this figure is available in the online journal.)

3.4–22 μm . *WISE* has a 40 cm diameter mirror that sits inside a solid hydrogen-cooled cryostat. *WISE* only made one observation of our target source on 2010 April 13 (MJD 55,299). By a fortunate coincidence, this observation occurred during a γ -ray flare of this object (flare A). These *WISE* data, at bands W1, W2, W3, and W4, were obtained from the All-Sky Source Catalogue.²¹

7. RADIO OBSERVATIONS

The radio data reported here were obtained from two different monitoring programs, one using the ATCA and the other using the Ceduna Radio Telescope. As part of the TANAMI (Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry) program (Ojha et al. 2010), ATCA has been monitoring TANAMI sources at several radio frequencies (Stevens et al. 2012). ATCA data were reduced with the Miriad software package, following standard practices for continuum data. Flux densities were calibrated against PKS 1934–638 for frequencies below 25 GHz and against Uranus or PKS 1934–638 for higher frequencies. One flux density measurement was made for each 2 GHz band and represents the flux at the center frequency, assuming that the spectral index across the band does not vary. PKS 2142–75 was monitored roughly every 3 weeks by the ATCA since flare B. The results of the monitoring campaign are

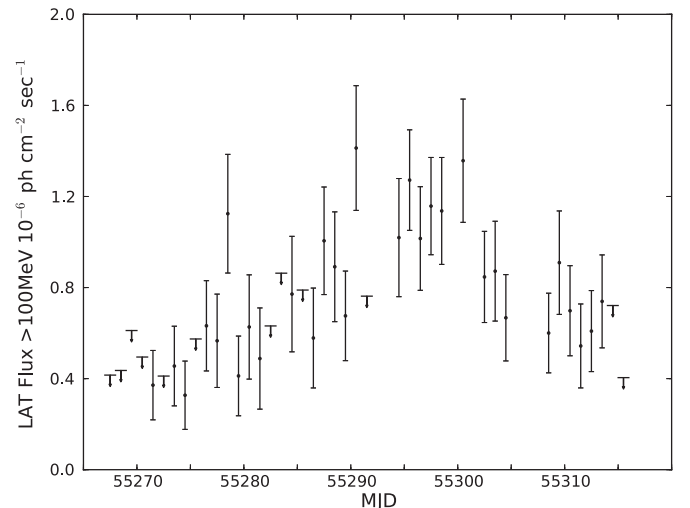


Figure 4. γ -ray light curve in the 100 MeV to 300 GeV energy range with one-day time bins. This light curve starts on 2010 March 10 (MJD 55,265) and ends on 2010 April 30 (MJD 55,316). The same initial cuts on the data, TS threshold for upper limits and initial model parameters as the weekly binned light curve (Figure 1), were applied.

displayed in Figure 2. Note the rise in the flux density at 38 and 40 GHz after flare B. For the SED fits, observations on 2011 August 30 (MJD 55,803) and 2012 January 15 (MJD 55,941) at frequencies of 5.5, 17, 19, 38, and 40 GHz were used for flare B and the quiescent period, respectively.

²¹ <http://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-scan?mission=irsa&submit=Select&projshort=WISE>

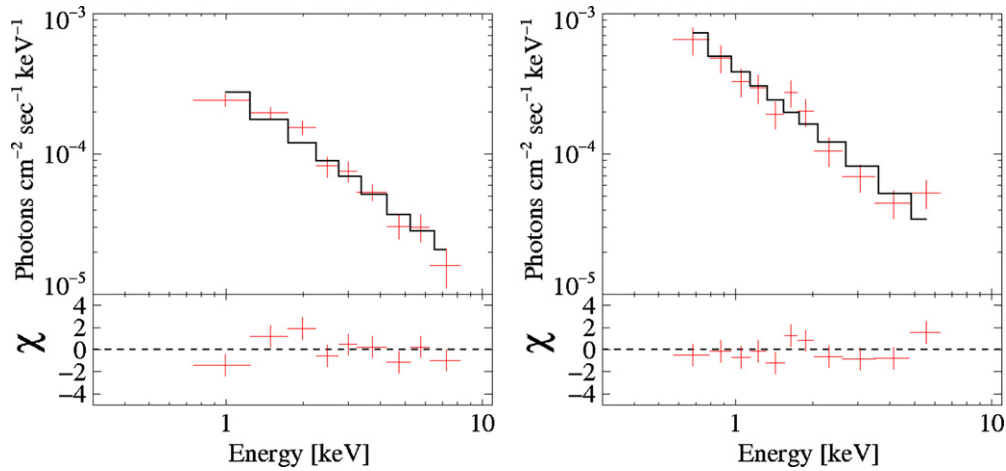


Figure 5. XRT spectra for PKS 2142–75. Left: flare B. Right: quiescent. Both states are fit with an absorbed power law of N_H column density of $6.6 \times 10^{20} \text{ cm}^{-2}$. The red points with error bars represent the data, the black line indicates the fitted model, and the bottom chart shows the residuals in terms of σ , with 1σ error bars.

The University of Tasmania operates a 30 m radio telescope at Ceduna in South Australia (e.g., McCulloch et al. 2005). This telescope has been monitoring TANAMI sources at 6.7 GHz typically once every 2 weeks. The data are collected in four scan blocks, two scans in right ascension and two in declination. A block is rejected if any of its scans fail a Gaussian fit. The data are corrected for gain-elevation effects, and a pointing correction is applied. PKS 1934–638 is used as the primary flux density calibrator. Variation in system temperature due to ambient temperature changes over the course of 24 hr necessitates daily averaging of the data. The data used in the construction of the SEDs for flare B and the quiescent period were obtained on 2011 July 30 (MJD 55,772) and 2011 December 15 (MJD 55,910). No significant variation is observed at 6.7 GHz. Unfortunately we do not have radio data during flare A.

8. RESULTS AND DISCUSSION

The results from each of our three data sets are plotted on the SEDs shown in Figure 6. A separate one-zone leptonic model of blazar emission (Dermer et al. 2009) was fit for each distinct γ -ray state, and the values of the model parameters are presented in Table 1. This model assumes that the lower-frequency bump is nonthermal synchrotron radiation emitted by electrons that are isotropically oriented in the comoving frame of the jet, in a tangled, randomly oriented magnetic field in the jet plasma. Radio emission from the core is thought to be a superposition of multiple jet components (Konigl 1981) and is therefore treated as an upper limit for the purposes of our modeling. We consider SSC and EC processes when modeling the SED of PKS 2142–75, and we assume that EC scattering is the primary method by which γ -rays are produced. For PKS 2142–75, the size of the emission region is constrained by an upper limit on the variability timescale of one day derived from the γ -ray light curve displayed in Figure 4.

Correlations between γ -ray and optical flares with radio light curves and the rotation of optical polarization angles observed in other LSP blazars (Marscher et al. 2010) indicate that the γ -ray emitting region may be located outside the BLR where the dust torus would be the dominant source of seed photons for EC scattering. Therefore, for PKS 2142–75 we assumed that inverse Compton scattering of dust torus photons is the primary method by which high-energy photons are produced. The dust torus was assumed to be a one-dimensional annulus oriented

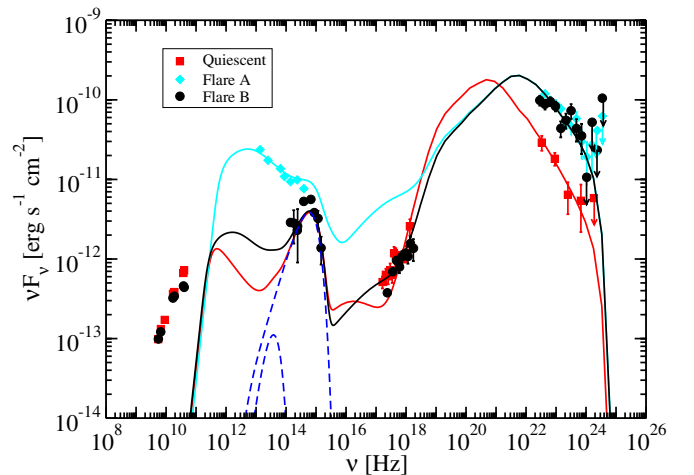


Figure 6. Quasi-simultaneous spectral energy distributions of PKS 2142–75 measured during active γ -ray periods on 2010 April (flare A), 2011 August (flare B), and a quiescent γ -ray period on 2011 December. The data are fit with a leptonic model of blazar emission. The low-energy component is primarily modeled by synchrotron emission and thermal emission from the accretion disk. The smaller dashed blue curve represents emission from the dust torus and the larger dashed blue curve indicates accretion disk emission. The high-energy component is explained by inverse Compton scattering of dust torus photons by electrons within the jet.

orthogonal to the jet directions. Its parameters were chosen to be consistent with the sublimation radius (Nenkova et al. 2008).

The lack of correlated variability between the γ -ray flux and the optical/UV flux in flare B and the quiescent state as well as the shape of the optical components of the SED during those two states is indicative of the accretion disk playing a role at those frequencies. Moreover, a historical optical spectrum, which was used for the determination of the redshift (Jauncey et al. 1978) of this source, shows broad-line emission. We assume that the accretion disk is an optically thick blackbody. The accretion disk parameters and black hole mass (Shakura & Sunyaev 1973) were chosen to be consistent with the optical data in the flaring and quiescent states. The disk’s luminosity is $L_{\text{disk}} = 0.047 L_{\text{Eddington}}$, which is a fairly typical value for FSRQs (Ghisellini et al. 2011).

Flare A does exhibit correlated variability at optical wavelengths. For flare A, the intensity of the magnetic field (B) in the model of the emitting region needs to be changed due to

Table 1
Model Fit Parameters

Parameter	Symbol	Quiescent	Flare A	Flare B
Bulk Lorentz factor	Γ	30	30	30
Doppler factor	δ_D	30	30	30
Magnetic field (G)	B	0.3	1.0	0.3
Variability timescale (s)	t_v	6.0×10^4	6.0×10^4	6.0×10^4
Comoving blob radius (cm)	R'_b	2.5×10^{16}	2.5×10^{16}	2.5×10^{16}
Low-energy electron spectral index	p_1	2.2	2.2	2.2
High-energy electron spectral index	p_2	4.0	3.7	3.7
Minimum electron Lorentz factor	γ'_{\min}	11	11	11
Break electron Lorentz factor	γ'_{brk}	1.0×10^2	3.0×10^2	3.0×10^2
Maximum electron Lorentz factor	γ'_{\max}	7.0×10^3	7.0×10^3	7.0×10^3
Black hole mass (M_\odot)	M_{BH}	5×10^9	5×10^9	5×10^9
Disk luminosity (erg s^{-1})	L_{disk}	2.9×10^{46}	2.9×10^{46}	2.9×10^{46}
Accretion efficiency	η	1/12	1/12	1/12
Jet height (cm)	r	3.1×10^{18}	3.1×10^{18}	3.1×10^{18}
Dust temperature	T_{dust}	1.0×10^3	1.0×10^3	1.0×10^3
Dust luminosity (erg s^{-1})	L_{dust}	1.1×10^{45}	1.1×10^{45}	1.1×10^{45}
Dust radius (cm)	R_{dust}	9.7×10^{18}	9.7×10^{18}	9.7×10^{18}
Jet power in magnetic field (erg s^{-1})	$P_{j,B}$	3.9×10^{44}	4.3×10^{45}	3.9×10^{44}
Jet power in electrons (erg s^{-1})	$P_{j,e}$	2.1×10^{46}	1.2×10^{46}	1.2×10^{46}

the more dramatic response from the synchrotron component of the spectrum. The IR fluxes measured by the SMARTS team are almost an order of magnitude greater than they were in flare B. In order to decrease the ratio of inverse Compton radiation to synchrotron radiation the magnetic field had to be increased from 0.3 G (its modeled value during flare B and the quiescent period) to 1.0 G. The magnetic jet power is an order of magnitude higher than it is during the quiescent state and flare B. This increase in the magnetic field allows the synchrotron flux to increase without having an effect on the inverse Compton spectrum. For flare A, our model predicts a significant X-ray flare from SSC emission. Unfortunately, no X-ray observations are available for that time. If no X-ray flare was observed, or if a smaller X-ray flare than predicted was observed, that would argue for a larger R'_b to reduce the SSC emission observed. The SEDs could be fit with a longer variability timescale, making the emission region less compact. This would decrease the SSC component so that other parameters would need to be changed to fit the SEDs. For example, a combination of lower Doppler factor and higher dust luminosity should also allow a good fit in this scenario. This should also decrease the jet power in electrons, bringing the model closer to equipartition between electron and magnetic field energy density. However, this would contradict the short variability timescale found from the light curve (see Figure 4 and Section 2 above).

The electron distribution within the emitting region is described as a broken power law with indices p_1 below and p_2 above a break at γ'_{brk} and a low- and high-energy cutoff at a minimum and maximum Lorentz factor (γ'_{\min} and γ'_{\max} , respectively). For our source, p_1 is not well constrained, and p_2 is constrained by the γ -ray spectrum. During flares A and B γ'_{brk} increases from 100 (in the quiescent state) to 300, and the spectrum above γ'_{brk} hardens, with p_2 decreasing from 4.0 during quiescence to 3.7 during the active states. Somewhat counterintuitively, the jet power in electrons ($P_{j,e}$) decreases during the active states. This is because γ_{brk} is lower during the quiescent state, and most of the power is below γ_{brk} . The jet power in Poynting flux ($P_{j,B}$) is the same in the quiescent and flare B states, since the magnetic field, B , does not change between

them; however, it increases by more than a factor of 10 in the flare A state due to the increase in B .

For flare B we do not increase the magnetic field compared to the quiescent state. Only changes to the electron distribution function are needed. This is similar to results for PKS 0537–441 (D’Ammando et al. 2013), where it was also found that only changes in the electron distribution were needed to describe three states of that source. That is because for the quiescent and flare B states of PKS 2142–75, the optical emission seems to be dominated by the accretion disk, and we have modeled it as such. This makes the synchrotron emission much less constrained. The results presented here are, therefore, much weaker than those of D’Ammando et al. (2013).

During all three states the magnetic and electron jet power are far from equipartition. This is different from other AGN that have been modeled in a similar manner (D’Ammando et al. 2012a, 2012b, 2013). The jet power in electrons is much greater than the jet power in the magnetic field during all three states. Jet powers are calculated assuming that the jet is two sided (Finke et al. 2008).

9. CONCLUSIONS

During flare A, PKS 2142–75 was observed with SMARTS, *WISE*, and *Fermi*, which together provide strong constraints on the synchrotron component of the SED during that flare. During flare B, PKS 2142–75 was observed with the ATCA, the Ceduna Radio Telescope, REM, SMARTS, *Swift*, and *Fermi*. To provide a baseline, another multiwavelength observing campaign was mounted in 2011 December/2012 January when it was in a quiescent state. By measuring the brightness simultaneously at many wavelengths we have gained insight on some of the intrinsic parameters of this highly variable source.

We have shown that flare B can be explained by changing only the electron distribution relative to the quiescent state, while flare A requires changing an additional parameter, namely the magnetic field strength, B . The two flares in PKS 2142–75 have very different behavior in the synchrotron component of the spectrum while showing similar behavior in the γ -ray

component of the spectrum. Clearly, the same source can exhibit different behaviors for different flares. Referring to FSRQs in general, a picture where there are two types of flares seems to be emerging. One type of flare, like flare B in PKS 2142–75 and the flares in PKS 0537–441 (D’Ammando et al. 2013), involves only a change in the electron distribution from the quiescent state. Another, like flare A in PKS 2142–75 and the flares in PKS 0208–512 (Chatterjee et al. 2013), seems to require changes in other parameters, likely the magnetic field strength and perhaps also the size of the emitting region.

We have modeled the dominant physical process driving the luminosity of this source at different wavelengths. The optical and ultraviolet emission is primarily caused by thermal accretion disk emission during flare B and the quiescent state as evidenced by the shape of the optical SED and the lack of correlated variability at optical and UV frequencies during these two different γ -ray states. Our model suggests the jet power in electrons is much greater than the jet power in the magnetic field. We have also seen that the synchrotron component can play a major role at optical wavelengths as is evidenced by flare A. We assumed that the primary method by which γ -rays are produced in PKS 2142–75 is by inverse Compton scattering of dust torus photons.

It should be noted that a number of the parameters in these three SED models are rather poorly constrained and observations are in progress or planned to refine the parameters and resolve some of the degeneracies in the one-zone leptonic model used in this work. As part of the TANAMI program (Ojha et al. 2010), we are currently gathering VLBI data on the source to potentially resolve the jet structure and track the kinematics of components within the jet. This may allow us to put additional constraints on the Doppler factor and resolve the degeneracy between Doppler factor and the magnetic field. Also, observations in the submillimeter regime (especially at the high frequency end of ALMA’s observing band $\sim 10^{12}$ Hz) will put important constraints on the emission mechanisms in this object.

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