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BLAZAR MONITORING WITH THE WATCHER ROBOTIC TELESCOPE

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RESUMEN

Presentamos información sobre una intensa campaña de observaciones de blazars de rayos gamma en el óptico que estamos llevando a cabo capaz de observar variabilidad óptica de corta y larga duración para fuentes del hemisferio sur. Diez fuentes están siendo observadas dentro de este programa con énfasis en PKS 2155-304 y PKS 2005-489 durante el invierno austral de 2013. Ambas fuentes fueron observadas con 3 filtros (V, R e I) obteniendo alrededor de 20,000 imágenes durante un periodo de 5 meses. Un análisis preliminar parcial de los datos indica que no hubo episodios de gran actividad en la banda óptica.

ABSTRACT

We report on a gamma-ray blazar optical monitoring programme that is underway that can provide both short-term and long-term optical variability data for key southern hemisphere sources. Ten sources are being monitored in this programme, with a focus on PKS 2155-304 and PKS 2005-489 during the austral winter of 2013. Both sources were monitored with 3 filters (V, R and I) and over 20,000 images were taken over a period of 5 months. Preliminary analysis of some of this data indicates no major flaring episodes in the optical band.

Key Words: galaxies: active — BL Lacertae

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1. INTRODUCTION

The Watcher robotic telescope is located at Boyden Observatory, South Africa. It was built primarily to observe gamma-ray burst afterglows and to provide supporting optical observations for a range of telescopes and observatories that operate in the gamma-ray (MeV to TeV) and X-ray regions of the spectrum (French et al. 2004). These include Fermi, INTEGRAL, Swift, XMM-Newton and NuSTAR. A highlight result from Watcher to date includes detailed early-time observations of GRB120711A (Martin-Carrillo et al. 2014). Watcher is a 40 cm Classical Cassegrain reflecting telescope and is equipped with standard B, V, R, I filters and an Andor iXon electron-multiplying CCD (EMCCD), and is controlled by the RTS2 software package (Kubánek 2010). For most of Watcher's monitoring programmes, the EM mode is not active, as the targets are typically known, relatively bright, sources (Table 1).

Since its installation in April 2006, Watcher has been used to monitor many other sources when no GRB is being actively observed, including variable stars and Active Galactic Nuclei (AGN). The subset of AGN known as blazars has recently become the focus of a monitoring campaign designed to probe the variability timescales in these AGN by providing both short-term and long-term optical variability data for key southern hemisphere sources.

2. MOTIVATION

Optical studies of blazars are a vital part of the study of these objects due to the fact that the synchrotron peak of the broad spectral energy distribution is often located within this band. Additionally, the relationship between high-energy and optical variability in blazars is complex. The Synchrotron Self Compton (SSC) mechanism can pump up the optical synchrotron photons in the Thomson limit to Fermi-LAT energies. By constraining the optical synchrotron spectrum through multi-wavelength observations, the gamma-ray production capabilities of these sources can be constrained. Dedicated multiband observations are required to understand (i) the nature of the optical variability, which is a defining characteristic of blazars; (ii) the occurrence (or otherwise) of lags between optical and gamma/X-ray flares and (iii) colour changes as a function of intensity. Furthermore, high cadence observations over successive nights, combined with long-term archival data taken over timescales from weeks to years, can be used to construct the power density spectrum (PDS) of the source. A characteristic break timescale in the PDS appears to scale with black hole mass over many orders of magnitude (Ryle et al. 2008). The goal of this programme is to gain

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a better understanding of the blazar central engine and the processes occurring in the relativistic jet.

3. H.E.S.S. SUPPORTING OBSERVATIONS

Given its similar geographical position to the H.E.S.S. gamma-ray telescope in Namibia, Watcher's monitoring capability acquires additional relevance since, in blazar sources, changing optical emission has been linked to changes in GeV gamma-ray emission (Ackermann et al. 2011; Chatterjee et al. 2012; Bonning et al. 2012). Watcher supports contemporaneous optical/VHE gamma-ray observations to be undertaken to further explore the nature of correlated optical-VHE variability. Furthermore, long term monitoring of specific sources can be used to trigger H.E.S.S. observations if evidence of flaring is identified in real-time data. As part of a multi-wavelength campaign, including NuSTAR and H.E.S.S., of the TeV blazar 1ES 0229+200, Watcher conducted an intense monitoring programme in October 2013. This target would not meet the selection criteria for inclusion in the regular blazar monitoring programme as it is relatively faint and northerly and does not appear in the 2nd Fermi Point Source catalogue (Nolan et al. 2012).

Certain VHE gamma-ray binaries are also being monitored. Due to the close interaction between the components in gamma-ray binaries, changes in the optical emission may give rise to gamma-ray variability. Variations in optical emission can also be used to search for orbital periods.

4. TARGET SELECTION

TABLE 1

SELECTED FERMI BLAZARS

Source	Class	SED Class	z	V Mag.
PKS 2005-489	BL Lac	HSP	0.071	11.29
PMN J2022-4513	BL Lac	-	-	13.91
PKS 2155-304	BL Lac	HSP	0.116	12.54
AP Librae	BL Lac	LSP	0.048	11.06
PMN J0617-1715	BL Lac	LSP	0.098	13.15
PMN J0152+0146	BL Lac	HSP	0.08	11.82
3C 273	FSRQ	LSP	0.158	13.94
4C +04.77	BL Lac	ISP	0.027	9.98
BZB J0912+1555	BL Lac	HSP	0.212	13.46
S3 1741+19	BL Lac	HSP	0.083	11.4

There are more than 800 blazars (i.e. BL Lacs or FSRQs) in the 2nd Fermi catalogue (Ackermann et al. 2011; Nolan et al. 2012). A declination constraint of $\leq 20°$ cuts the sample roughly by half. A further cut to include only sources brighter than 14$^{\text{th}}$ magnitude (USNO B1 catalogue) is then applied to ensure good photometric accuracy for intra-night variability studies. The details of the remaining 10 sources are given in Table 1.

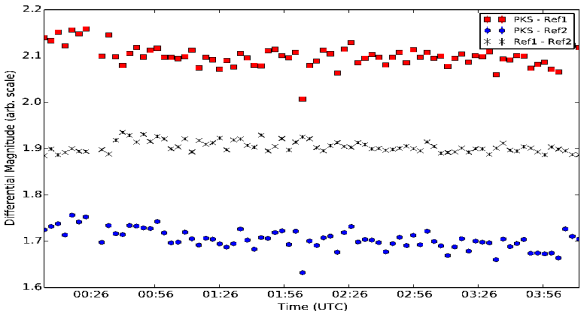

Fig. 1. R-Band lightcurve of PKS 2155-304 for the night of 23/07/2013. PKS, Ref1, Ref2 refer to the magnitudes of the Bl Lac, and the two reference stars, respectively.

5. PRELIMINARY RESULTS

The blazar monitoring campaign during the austral winter of 2013 focused on the blazars PKS 2155-304 and PKS 2005-489, with 8,832 and 11,194 images taken of the sources respectively. A sample lightcurve of PKS 2155-304 is shown in Figure 1, to give an indication of the data quality. Preliminary analysis of a selection of the data indicates that the austral winter of 2013 was a relatively quiet period for both sources in the optical band. However, variation was observed in the higher energy bands (300MeV - 300GeV) by the Fermi satellite during this time period[4].

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