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Variability study of Mrk-421 in near IR bands from Mt. Abu Observatory.

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Abstract. Mrk421 is the nearest, and brightest blazar detected in almost all the spectral windows, including high energy γ-rays. It exhibits short and long timescale variations at all frequency bands. Though it has been observed extensively at various wavebands, a lot more observations, preferrably simultaneous, are required to help understand the physical mechanism of energy generation and structure of the relativistic jet by looking for correlations between the emissions at different wavelengths. Here we report observations in near infrared made during April 23 - 27, 2001, using the Mt Abu IR Telescope (MIRT). We find the source to be in its quiescent phase during this observation period.

Key words: Mkn-421 , γ-ray emission, Infra-red bands.

1. Introduction

Mrk 421 was first noted as a blue excess object which turned out to be an elliptical galaxy with a bright, point like nucleus at red shift z = 0.03 (Ulrich et al. 1975). The spectrum of the nucleus was featureless and optical flux showed polarization. The variability in optical flux was detected long back (Miller 1975, Liu et al., 1997). This source is also found to be very active at high energies, and it was the first extragalactic source discovered by the Whipple observatory to emit TeV,γ-rays (Punch et al., 1992). Also among the GeV-emitting blazars, Mrk 421 is the first - and so far the brightest, member where the γ-ray emission extends up to the TeV energies at a level allowing detailed spectral and flux variability studies in the broadest range of wavelength (Maraschi et al. 1999; Brinkmann et al. 2001; Zweerink et al. 1997; Macomb et al. 1995). At TeV energies, flares with variability time scale as short as 15 minutes have been observed (Gaidos et al. 1996). The SED of Mrk421 shows a double-peaked feature, like most of the blazars, with two maxima (see e.g. Buckley et al. 1996; Sambruna, Maraschi & Urry 1996; Ulrich, Maraschi & Urry 1997; Fossati et al. 1998a). The first hump has a maximum around UV-soft X frequencies and the second one peaks at γ-ray frequencies at around 100 GeV, a typical blue blazar. Mkn 421 has been extensively observed at high energies. However, for a meaningful interpretation of high energy observations (flaring activity) a lot more data in optical and near IR region is required.

Due to the highly interesting chracteristics, Mrk 421 is one of the most extensively observed BL Lacertae object at all wavelengths. It is characterized by a strong variability in the whole spectral region and more so in higher energy bands. Makino et al. (1987) coordinated a campaign of simultaneous multi-frequency observations covering radio through X-ray frequencies on two occasions separated by 5 weeks in 1984 January and March and each observation carried out for one week. The SED show the gradual steepening towards high frequencies. The UV and optical- infrared fluxes decreased by 20% in 5 weeks while radio flux remained stable. The X-ray flux decreased by a factor of about 2, the change being more pronounced in hard X-rays (Makino et al. 1987). The degree of polarization in the optical band rose to about 15% on the time scale of a few days while position angle remained unchanged (Tosti et al. 1998). Similar high increase in optical polarization to the extent of 10% in B band was also noticed during December 1996 by Baliyan et al. (2001). Another campaign was conducted in high energy region in April 1998 (Takahashi et al. 2000). A pronounced high- amplitude flare recorded by Beppo SAX and Whipple. In X-ray multiple flares were detected, occuring on times scales of about 1 day, in ASCA data. Comparison of data from ASCA, EUVE, RXTE indicates that variability amplitudes in the low energy synchrotron component are larger at higher energy bands. Large intraday variations, correlated with the X-ray flux, were observed (Takahashi et al. 2000). Xie et al. (1998) have reported observation of a dramatic outburst in the optical B-band, the brightness increasing by 1.34 mag in 26 minutes. Microvariability in optical polarization was reported by Joshi & Deshpande (1991). However, not much data is avilable in near IR band. We monitored this source for a few nights in April 2001 and the results are reported here.

2. Observation and Data Analysis

The photometric observations during the period from April 23 to April 27, 2001 were carried out from the 1.2 m telescope at Gurushikhar, Mt.Abu Observatory (MIRO) using the NICMOS-3 infrared array. The characteristics of the camera are discussed elsewhere (Joshi et al. 2001). The 4'× 4' field of view of the 256× 256 pixel HgCdTe detector array was used during good photometric conditions. Due to the high sky background in infrared bands, the single exposure time was kept limited to 30 sec in the J and H bands while K' exposure time was taken to be 3 seconds. The 30 second exposure time in J & H bands was found to be the most suitable for a single frame to ensure that signal from the background plus source lies in the linear range of the detector response(Joshi et al. 2001). Several frames were taken at one location to improve the signal to noise ratio. Several such sets were taken by changing the location of the source on the detector. A set of two standard stars were also observed alongwith the source with source-standard star-source sequence. Median filtered master sky frames were constructed using all the frames. The frames of individual sets were average combined. All the frames were corrected for the sky background by subtracting the master sky frames. This gives us the first order sky corrected frames. The residual sky is taken care while performing the photometry. The master sky frame was corrected for the dark (instrumental signature) and was used to construct the flats. Several such frames were median filtered to construct the normalized master flats. The sky subtracted source frames were corrected for flat field response of

the detector by dividing the source frame by master flats. Final images were corrected for bad pixels.

3. Results & Discussion

These final images were then used for phtometry of the source and standrad stars using IRAF package. The photometry was performed using aperture photometry, keeping same aperture values for the standard stars and Mrk421. We have J and K' band data on first two nights and J and H values on fourth night. The April 26 night was not very stable and there we have only J band data with larger uncertainty.

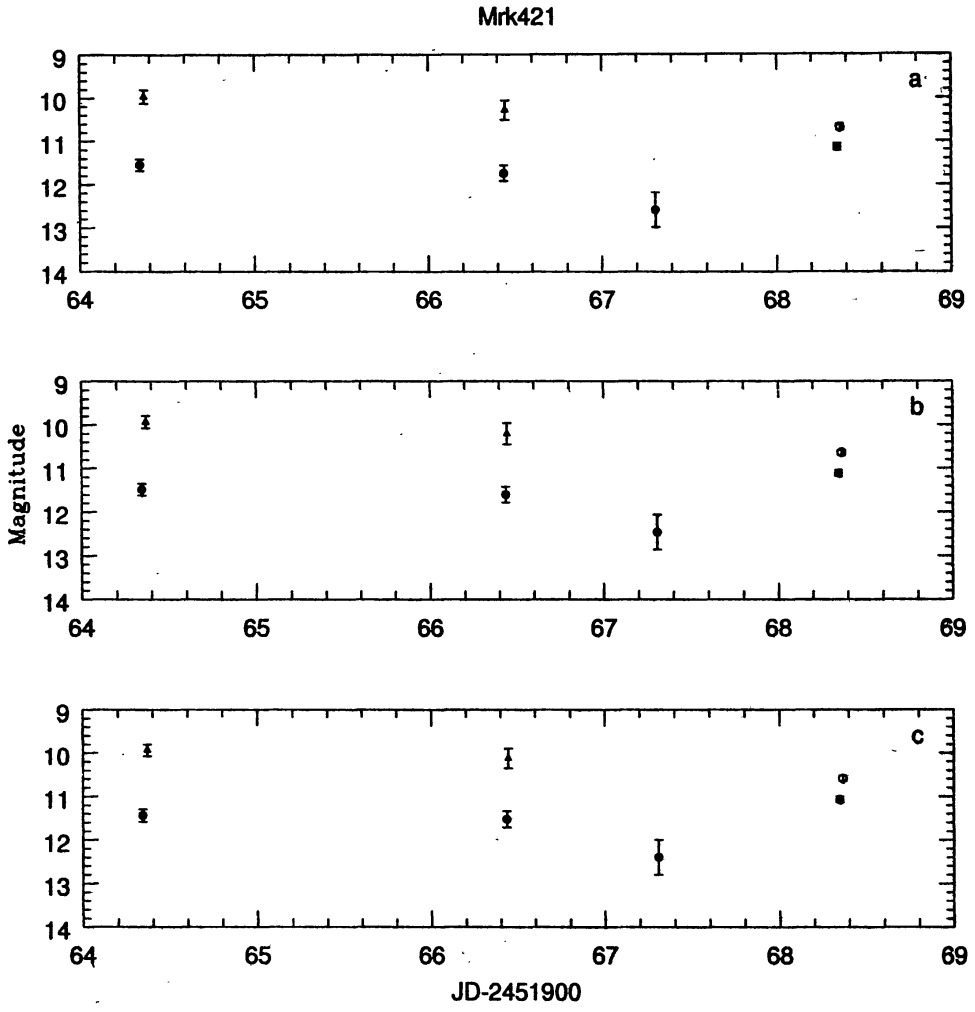

Figure 1. Mrk 421 light curves in near infrared wavebands. The filled circles, open circles and triangles show J, H and K' values respectively. Plots a, b and c represent photometric values obtained using 3, 4 and 5 arcsec apertures.

We did not notice any significant intranight variability so the photometric magnitudes are obtained averaging over individual nights and are plotted in the Figure 1 (a-c) in all

three apertures employed. We do not see any change in the J and K' magnitudes, and hence in color (J-K') during April 23 and 25. The April 27 night was very good and we notice a slight increase in the J magnitude value of Mrk421 compared to values during first two nights. This increase in J brightness is above the error limits which are low. However, Mrk421 appeared rather faint in J on April 26, but then errors are large and in the absence of observations in other bands, any interpretation could be misleading.

We, therefore conclude that Mrk421 appears to be in its quiescent phase with a possible enhancement in the flux on April 27, 2001. Comparison with data from some other set of observations will be helpful to draw some definitive conclusion.

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