

The Blazar Times

A Research Newsletter Dedicated to the BL Lac and Blazar Phenomena

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Journal Abstracts

Variations of the TeV energy spectrum at different flux levels of Mkn 421 observed with the HEGRA system of Cherenkov telescopes

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The nearby BL Lacertae (BL Lac) object Markarian 421 (Mkn 421) at a red shift $z = 0.031$ was observed to undergo strong TeV γ -ray outbursts in the observational periods from December 1999 until May 2001. The time averaged flux level $F(E > 1 \text{ TeV})$ in the 1999/2000 season was $(1.43 \pm 0.04) \cdot 10^{-11} \text{ ph cm}^{-2} \text{ s}^{-1}$, whereas in the 2000/2001 season the average integral flux increased to $(4.19 \pm 0.04) \cdot 10^{-11} \text{ ph cm}^{-2} \text{ s}^{-1}$. Both energy spectra are curved and well fit by a power law with an exponential cut-off energy at $3.6(+0.4 - 0.3)_{\text{stat}}(+0.9 - 0.8)_{\text{sys}} \text{ TeV}$. The respective energy spectra averaged over each of the two time periods indicate a spectral hardening for the 2000/2001 spectrum. The photon index changes from $2.39 \pm 0.09_{\text{stat}}$ for 1999/2000 to $2.19 \pm 0.02_{\text{stat}}$ in 2000/2001. The energy spectra derived for different average flux levels ranging from 0.5 to $10 \cdot 10^{-11} \text{ ph cm}^{-2} \text{ s}^{-1}$ follow a clear correlation of photon index and flux level. Generally, the energy spectra are harder for high flux levels. From January to April 2001 Mkn 421 showed rapid variability (doubling time as short as 20 minutes), accompanied with a spectral hardening with increasing flux

level within individual nights. For two successive nights (MJD 51989-51991, March 21-23,2001), this correlation of spectral hardness and change in flux has been observed within a few hours. The cut-off energy for the Mkn 421 TeV spectrum remains within the errors constant for the different flux levels and differs by $\Delta E = 2.6 \pm 0.6_{\text{stat}} \pm 0.6_{\text{sys}}$ TeV from the value determined for Mkn 501. This indicates that the observed exponential cut-off in the energy spectrum of Mkn 421 is not solely caused by absorption of multi-TeV photons by pair-production processes with photons of the extragalactic near/mid infrared background radiation.

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Particle acceleration in rotating and shearing jets from AGN

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We model the acceleration of energetic particles due to shear and centrifugal effects in rotating astrophysical jets. The appropriate equation describing the diffusive transport of energetic particles in a collisionless, rotating background flow is derived and analytical steady state solutions are discussed. In particular, by considering velocity profiles from rigid, over flat to Keplerian rotation, the effects of centrifugal and shear acceleration of particles scattered by magnetic inhomogeneities are distinguished. In the case where shear acceleration dominates, it is confirmed that power law particle momentum solutions $f(p) \propto p^{-(3+\alpha)}$ exist, if the mean scattering time $\tau_c \propto p^\alpha$ is an increasing function of momentum. We show that for a more complex interplay between shear and centrifugal acceleration, the recovered power law momentum spectra might be significantly steeper but flatten with increasing azimuthal velocity due to the increasing centrifugal effects. The possible relevance of shear and centrifugal acceleration for the observed extended emission in AGN is demonstrated for the case of the jet in the quasar 3C273.

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On the central black hole mass in Mkn 501

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We analyse the apparent disagreement between the mass estimates of the central black hole(s) in Mkn 501 based on (i) the observations of the host galaxy, (ii) the high energy (HE) emission mechanism, and (iii) the modulation of the beamed radiation by a black hole (BH) binary system. While method (i) seems to imply a central mass $\gtrsim 5 \times 10^8 M_\odot$, method (ii) suggests a BH mass less than $\simeq 6 \times 10^7 M_\odot$. We critically discuss the estimates inferred from (i) showing that current uncertainties may permit a central mass as low as $\simeq (2-3) \times 10^8 M_\odot$. We demonstrate that in this case the estimates (i) and (ii) might be brought into agreement by assuming a binary BH system where the jet dominating the HE emission originates from the less massive (secondary) BH as suggested by method (iii). On the other hand, if Mkn 501 has in fact a high central BH mass of order $10^9 M_\odot$, a change of fundamental assumptions seems to be required in the context of several HE emission models. We show, that in this case a binary scenario following (iii) may be still possible if the jet which dominates the emission emerges from the more massive (primary) BH and if the binary evolution passes through phases of super-Eddington accretion and/or decreased conversion efficiency.

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The Sub-Luminal Parsec-scale Jet of Mkn 501

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We have combined Very Long Baseline Interferometry (VLBI) data from several programs in order to resolve differences in reported parsec-scale jet speeds for the TeV gamma-ray source Mkn 501. Data from the VLBA 2cm survey, and 8 and 15 GHz data from the Radio Reference Frame Image Database, have been combined with data from a 5 GHz VSOP Space VLBI observation to determine the apparent motions of jet components in this source. The combined data set consists of 12 observations between April 1995 and July 1999. Four jet components are detected at most epochs, all of which are clearly sub-luminal (i.e. with apparent speeds $< c$), and two of which appear stationary. The established TeV gamma-ray sources Mkn 501 and Mkn 421 thus both have sub-luminal parsec-scale jets, in contrast to the apparently super-luminal jets of the majority of >100 MeV sources detected by EGRET. No new VLBI component has emerged from the core following the extended TeV high-state in 1997, again in contrast to the general behavior of >100 MeV gamma-ray sources.

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Redshifts of Candidate Gamma-ray Blazars

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We identify 16 optical counterparts of blazars that have been suggested as sources of high-energy gamma-ray emission detected by the EGRET instrument on *CGRO*. Nine new redshifts are obtained, as well one contradiction and two confirmations of published redshifts, ranging from $z = 0.566$ to $z = 3.00$. The optical spectra of four objects are featureless, including high signal-to-noise spectra of the likely counterparts of 3EG J0433+2908 and GeV J0508+0540, which, if at low redshift, would be attractive targets to search for TeV emission using atmospheric Cerenkov telescopes because they emit above 10 GeV. However, the combination of spectroscopy and CCD imaging of those objects shows no evidence for their underlying host galaxies, which probably means that $z > 0.3$, diminishing their prospects as TeV sources.

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Detection of Optical Synchrotron Emission from the Radio Jet of 3C 279

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We report the detection of optical and ultraviolet emission from the kiloparsec scale jet of the well-known quasar 3C 279. A bright knot, discovered in archival V and U band *Hubble Space Telescope* Faint Object Camera images, is coincident with a peak in the radio jet $\sim 0.6''$ from the nucleus. The detection was also confirmed in Wide Field Planetary Camera-2 images. Archival Very Large Array and MERLIN radio data are also analyzed which help to show that the high-energy optical/UV continuum, and spectrum, are consistent with a synchrotron origin from the

same population of relativistic electrons responsible for the radio emission.

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<http://arXiv.org/abs/astro-ph/0210194>

Abstract Guidelines

Abstracts for “The Blazar Times” are solicited for papers that have been recently accepted for publication by a refereed journal, and for recent Ph.D. theses. Please do not submit an abstract before it has been accepted, nor after it is published. Abstracts from papers which are not refereed (e.g., conference proceedings) are not accepted.

The subject matter should pertain directly to the BL Lac and/or blazar phenomenon in general. Both observational and theoretical abstracts are appropriate. Abstracts from papers dealing with other classes of AGN will generally not be included unless they explicitly discuss their relevance to the blazar phenomenon; however exceptions to this rule will be considered.

A monthly call for abstracts will be issued and abstracts received by the last day of the month will usually appear in the following month’s newsletter. Announcements of general interest to the BL Lac and blazar communities may also be submitted for posting in the newsletter. These might include (but are not restricted to) the following: (i) *Job Openings* directed toward blazar researchers, (ii) announcements of *Upcoming Meetings*, (iii) announcements of *Upcoming Observing Campaigns* for which participation is solicited from the community at large, (iv) reviews of *New Books*, and (v) *General Announcements* that provide or request research-related information.

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