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MULTIWAVELENGTH STUDY OF QUIESCENT STATES OF MRK 421 WITH UNPRECEDENTED HARD X-RAY COVERAGE PROVIDED BY NuSTAR IN 2013

Baloković M., Paneque D., Madejski G., Furniss A., Chiang J., Ajello M., Alexander D., Barret D., Blandford R., Boggs S., Christensen F., Craig W., Forster K., Giommi P., Grefenstette B., Hailey C., Harrison F., Hornstrup A., Kitaguchi T., Koglin J., Madsen K., Mao P., Miyasaka H., Mori K., Perri M., Pivovaroff M., Puccetti S., Rana V., Stern D., Tagliaferri G., Urry C., Westergaard N., Zhang W., Zoglauer A., Archambault S., Archer A., Barnacka A., Benbow W., Bird R., Buckley J., Bugaev V., Cerruti M., Chen X., Ciupik L., Connolly M., Cui W., Dickinson H., Dumm J., Eisch J., Falcone A., Feng Q., Finley J., Fleischhack H., Fortson L., Griffin S., Griffiths S., Grube J., Gyuk G., Huetten M., Håkansson N., Holder J., Humensky T., Johnson C., Kaaret P., Kertzman M., Khassen Y., Kieda D., Krause M., Krennrich F., Lang M., Maier G., McArthur S., Meagher K., Moriarty P., Nelson T., Nieto D., Ong R., Park N., Pohl M., Popkow A., Pueschel E., Reynolds P., Richards G., Roache E., Santander M., Sembroski G., Shahinyan K., Smith A., Staszak D., Telezhinsky I., Todd N.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2016. The American Astronomical Society. All rights reserved.We present coordinated multiwavelength observations of the bright, nearby BL Lacertae object Mrk 421 taken in 2013 January-March, involving GASP-WEBT, Swift, NuSTAR, Fermi-LAT, MAGIC, VERITAS, and other collaborations and instruments, providing data from radio to very high energy (VHE) γ-ray bands. NuSTAR yielded previously unattainable sensitivity in the 3-79 keV range, revealing that the spectrum softens when the source is dimmer until the X-ray spectral shape saturates into a steep $\Gamma \approx 3$ power law, with no evidence for an exponential cutoff or additional hard components up to ~80 keV. For the first time, we observed both the synchrotron and the inverse-Compton peaks of the spectral energy distribution (SED) simultaneously shifted to frequencies below the typical quiescent state by an order of magnitude. The fractional variability as a function of photon energy shows a double-bump structure that relates to the two bumps of the broadband SED. In each bump, the variability increases with energy, which, in the framework of the synchrotron self-Compton model, implies that the electrons with higher energies are more variable. The measured multi band variability, the significant X-ray-to-VHE correlation down to some of the lowest fluxes ever observed in both bands, the lack of correlation between optical/UV and X-ray flux, the low degree of polarization and its significant (random) variations, the short estimated electron cooling time, and the significantly longer variability timescale observed in the NuSTAR light curves point toward in situ electron acceleration and suggest that there are multiple compact regions contributing to the broadband emission of Mrk 421 during low-activity states.

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Keywords

BL Lacertae objects: individual (Markarian 421), galaxies: active, gamma rays: general, radiation mechanisms: nonthermal, X-rays: galaxies