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Time-dependent modelling and spectral analysis of the extraordinary outburst of Mrk421 during April 2013

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During April 2013, the archetypal TeV blazar Mrk421 underwent a very bright outburst. The flare was observed over nine consecutive days from radio to very-high-energy (VHE; E>100GeV). In particular, MAGIC, VERITAS and NuSTAR exposures provided the most extensive simultaneous X-ray/VHE coverage to date during a blazar flare. The flux reached 15 times that of the Crab Nebula at VHE, and the emission varied down to a 15-minute timescale.

In this talk I will present the X-ray and VHE spectral evolution of the flare on sub-hour timescale making use of the MAGIC and NuSTAR dataset. The spectral behaviour is complex, and reveals patterns that go beyond the usual "harder-when-brighter" trend usually reported for blazars. Notably, we find the first evidence of simultaneous spectral hysteresis at X-ray and VHE energies.

I will also present results of a broadband modelling of the entire flare using a time-dependent leptonic radiation code. The model is applied to about 300 simultaneous SEDs, binned in 15 minutes, throughout the flare. This effort constitutes a significant improvement with regard to previous works that usually adopt stationary models to describe blazar SEDs. It allows us to constrain the particle evolution within the radiation zone of the jet down to the shortest timescales, while keeping track of the particle distribution history. In the vast majority of cases, the flux and spectral variability on sub-hour timescale in the X-ray and VHE bands can be well described by only evolving the electron density in the radiation zone, as well as the hardness of the injected electron distribution. To properly reproduce the VHE spectra at the highest energies, a Doppler factor of at least ~100 is needed, implying relativistic motion of the emitting plasma in the jet frame. While this could be realized in plasmoid chains formed in current sheets during magnetic reconnection, the particle hardness evolution would require significant changes in the plasma magnetization during the flare.

Primary author: ARBET-ENGELS, Axel (Max Planck Institute for Physics)

Co-authors: PANEQUE, David (Max Planck Institute for Physics); Prof. PETROPOULOU, Maria (National & Kapodistrian University of Athens, Greece); POLKAS, Markos (Donostia International Physics Center, Donosti-a-San Sebastián, Spain)

Presenter: ARBET-ENGELS, Axel (Max Planck Institute for Physics)

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