Multiwavelength monitoring of gravitationally lensed blazar QSO B0218+357 between 2016 and 2020

F. Longo1, J. Sitarek2, V. Fallah Ramazani3,4, A. Lamastra5, E. Lindfors3, M. Manganaro6, K. Nilsson3, for the MAGIC Collaboration, F. de Palma1, F. D’Ammando6 for the Fermi-LAT Collaboration and A. Barnacka9,10, K. Hada11,12, D. K. Sahu13

Abstract:
QSO B0218+357 is currently the only gravitationally lensed source from which both high-energy (HE, >~100 MeV) and very-high-energy (VHE, >~100 GeV) gamma-ray emission has been detected. We report the Fermi-LAT and multiwavelength monitoring observations of this source in radio interferometry, optical and X-rays performed between 2016 and 2020. During the monitoring individual flares in optical, X-ray and HE bands have been observed. We analysed the MAGIC telescopes data during the flaring states to search for the associated VHE emission, constraining the VHE gamma-ray duty cycle of the source.

Search for VHE gamma rays:
- No VHE gamma ray emission has been seen in individual nights of monitoring with MAGIC
- Fermi/LAT data used to evaluate the GeV state of the source during the monitoring
- Large data sample of 72 hr collected for constraining the low state emission of the source

Enhanced states of the source:
- Three periods of enhanced state of the source were observed during the monitoring
- o F1: a ~three months long period within a high GeV state during which optical variability by an order of magnitude was observed
- o F2: moderately enhanced optical flux of the source (a factor 2 with respect to low state in optical)
- o F3: X-ray flare with simultaneous marginal UV flux increase (+70 ~ -41%)%.
- Periods F1 and F3 have simultaneous MAGIC data, however no VHE gamma-ray emission was detected

KaVA radio interferometry view of QSO B0218+357

Fig 1. MWL light curve of QSO B0218+357 between January 2016 and January 2020. From top to bottom: MAGIC flux >100 GeV, Fermi/LAT flux >0.1 GeV, Fermi/LAT spectral index, Swift/XRT and XMM-Newton X-ray flux in 0.3 – 10 keV range (corrected for Galactic absorption), Swift-UVOT and XMM-OM observations in U-band, NOT observations in B-band, optical observations in R-band with KVA and NOT. OVO monitoring results at 15 GHz. KaVA/VLBI observations at 22 GHz (filled symbols show A image, empty ones B image) and 86 GHz (sum of A and B images shown with stars). Flux upper limits are shown with downward triangles. Optical data are corrected for the host/lens galaxy contribution and Galactic absorption. The points in red are contemporaneous (within 24 hr stick) with MAGIC observations. The grey filled regions mark the enhanced emission periods (F1, F2, F3).

Fig 2. Selected KaVA images at 43 GHz spanning 2-year period. Top panel and bottom panels are images A and B of the source. Blue and red dots represent the average position of the core and jet components. Two cyan points in image A represent the average positions of the sideway components. Gray circle represents the smoothing kernel of the image.

- KaVA images show clear core and jet component in both images. The projected distance of the jet component from the core (corrected for the lensing distortion) is about 10 pc
- The brighter image A allows us to disentangle sideways features in the jet
- No significant movement of the jet features is visible

Summary:
- Long-term MWL monitoring campaign of gravitationally-lensed blazar QSO B0218+357
- No VHE gamma-ray emission observed during the campaign, but a few interesting enhanced MWL states were identified from optical to HE gamma rays
- Precise measurements of the radio image of the source at 22-86GHz with KaVA – possibility to improve the lens model

Bibliography: