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High-resolution radio observations of TeV candidate sources

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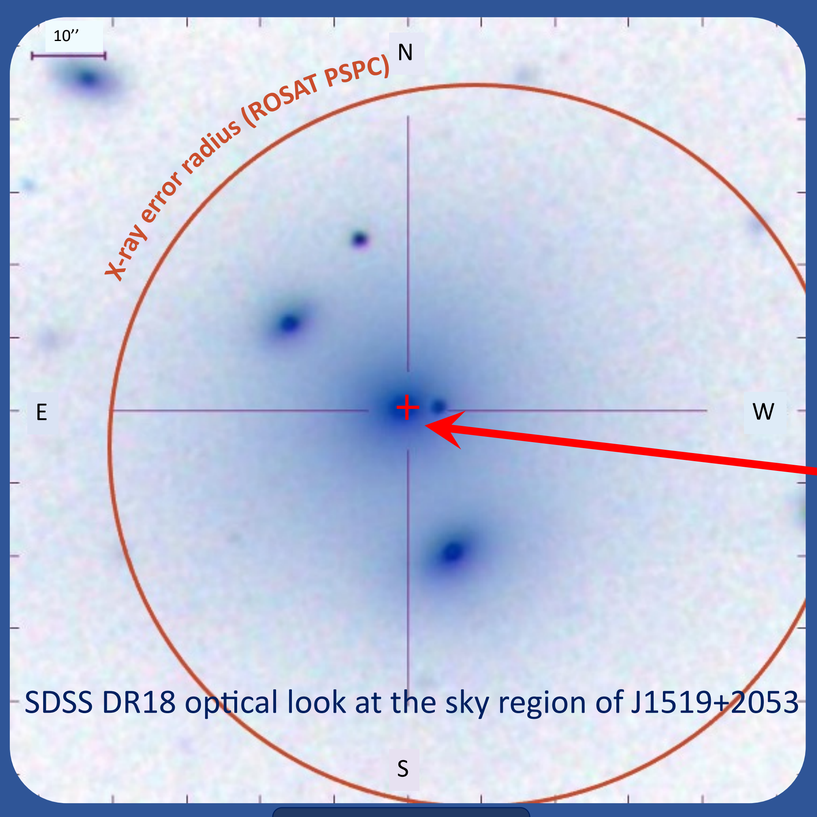
INTRODUCTION

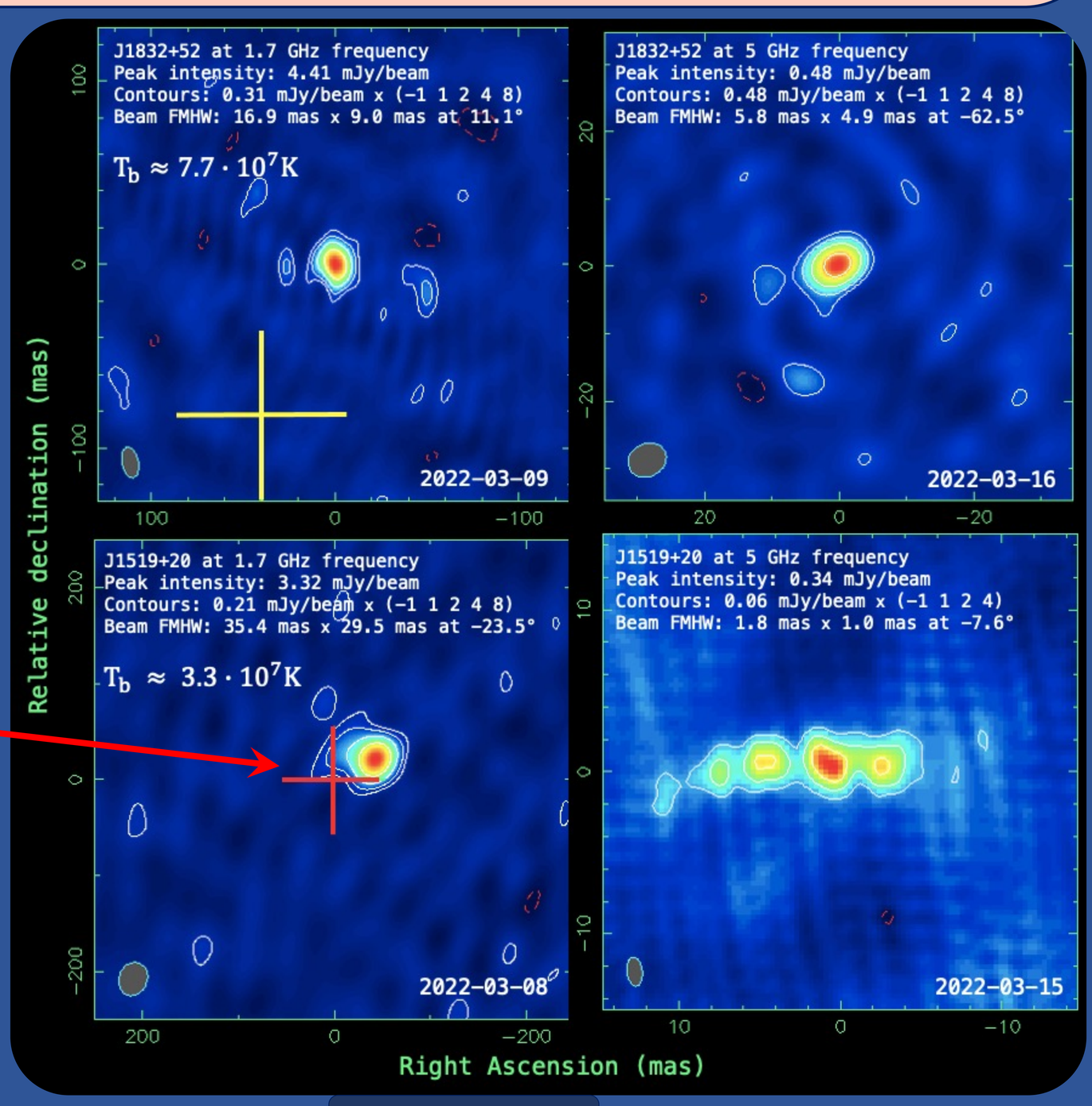
Radio-loud active galactic nuclei (AGNs) with their jets pointed close to our line of sight significantly contribute to the radiation observed in the very high energy (VHE) gamma-ray regime. The upcoming Cherenkov Telescope Array (CTA) is expected to detect fainter TeV objects, increasing the proportion of non-blazar extragalactic high-energy sources. Balmaverde et al. [1] compiled a list of 14 radio- and X-ray-detected objects (based on the NVSS (NRAO VLA Sky Survey) [2] and the ROSAT (ROentgen SATellite) catalog [3]) that are good TeV-emitting candidates (Te-REXes). Depending on whether the presence of an AGN could be ascertained using the optical spectra or not, the sample was further divided into two groups, BL Lacs and Passive Elliptical Galaxies (PEGs). These are theorized to be detected with the CTA based on empirical relations between radio/X-ray and gamma-ray properties, that were observed in brighter high-energy-peaked BL Lacs. We used the mas-scale resolution radio data to identify the origin of the radio emission as it can help constrain the expected number of TeV sources to be detected by CTA.

OBSERVATIONS

Here we present the results of our dual-frequency (1.7 and 5 GHz) EVN + e-MERLIN phase-referenced observations of two PEGs from the Te-REX sample. A total of 21 antennas participated in the observations. Both sources were categorized as PEGs: J1519+2053 ($z = 0.04$) and J1832+5202 ($z = 0.05$).



SDSS DR18 optical look at the sky region of J1519+2053



ASTROMETRY

We compared the peak of the 5 GHz radio images with the optical positions of corresponding sources. Yellow cross in the intensity map of J1832+5202 indicates the nearest Gaia DR3 [4] object's position. The source J1519+2053 coincides with an optical galaxy (red cross in the radio and optical image) detected in the Sloan Digital Sky Survey (SDSS). This SDSS spectrum was used to classify the source as a PEG. For this galaxy, no Gaia counterpart exists. The closest Gaia-detected object (also seen in SDSS) lies within the ROSAT X-ray detection's error radius.

RADIO PROPERTIES

We found that both PEG cores have brightness temperatures (see figure above) higher than the theoretical limit for galaxies without active nuclei at 1.7 GHz frequency ($T_b = 10^5$ K) [5]. The 1.7-GHz radio powers of the two sources are in the order of $10^{22} \frac{W}{Hz}$, thus they are an order of magnitude higher than the limiting value for non-thermal radio emission originating from starburst-related activity ($\sim 2 \cdot 10^{21} \frac{W}{Hz}$ [6,7]). Given the two observing frequencies (ν), we estimated the spectral indices (α), using the convention $S_{\mathrm{core}} \propto \nu^{\alpha}$, where S_{core} denotes the flux density of the core. These values are $\alpha_{\mathrm{J1832}} = -0.21 \pm 0.07$ and $\alpha_{\mathrm{J1519}} = -0.45 \pm 0.13$ indicating flat spectra [8].

We conclude that both observed faint radio targets show signs of a jetted active galactic nucleus which makes it a good candidate to be detected by the future CTA. Three BL Lacs in the Te-REX sample already have 5-GHz VLBI measurements. We will analyze those and compare them with our PEG sources.

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