Welcome to the Whole Earth Blazar Telescope (WEBT)

Highlights

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Article

Rapid quasi-periodic oscillations in the relativistic jet of BL Lacertae

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Blazars are active galactic nuclei (AGN) with relativistic jets whose non-thermal radiation is extremely variable on various timescales[1–3]. This variability seems mostly random, although some quasi-periodic oscillations (QPOs), implying systematic processes, have been reported in blazars and other AGN. QPOs with timescales of days or hours are especially rare[4] in AGN and their nature is highly debated, explained by emitting plasma moving helically inside the jet[5], plasma instabilities[6,7] or orbital motion in an accretion disc[7,8]. Here we report results of intense optical and γ-ray flux monitoring of BL Lacertae (BL Lac) during a dramatic outburst in 2020 (ref. [9]). BL Lac, the prototype of a subclass of blazars[10], is powered by a $1.7\times10^{8}\,M_{Sun}$ (ref. [11]) black hole in an elliptical galaxy (distance = 313 megaparsecs (ref. [12])). Our observations show QPOs of optical flux and linear polarization, and γ-ray flux, with cycles as short as approximately 13 h during the highest state of the outburst. The QPO properties match the expectations of current-driven kink instabilities[6] near a recollimation shock about 5 parsecs (pc) from the black hole in the wake of an apparent superluminal feature moving down the jet. Such a kink is apparent in a microwave Very Long Baseline Array (VLBA) image.

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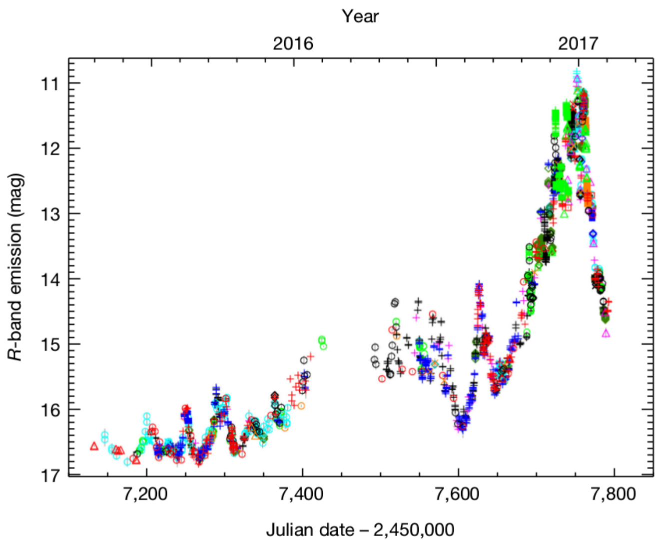


Figure 1 | Observed optical light curve of CTA 102 in the last two observing seasons of the WEBT campaign. *R*-band magnitudes are shown as a function of the Julian date (JD). Different colours and symbols correspond to the various telescopes contributing to the WEBT campaign. Error bars represent 1 s.d. measurement errors. The peak of the 2016–2017 outburst was observed on 28 December 2016 and indicates a brightness increase of about 6 mag with respect to the faintest state.

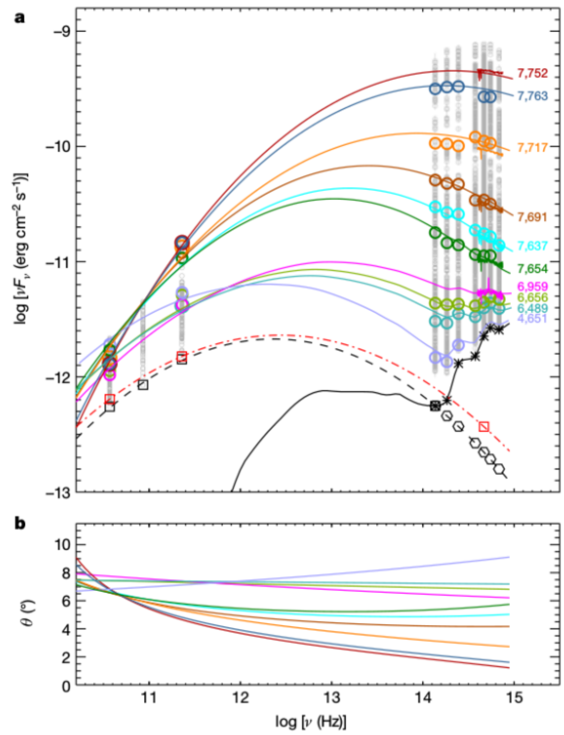
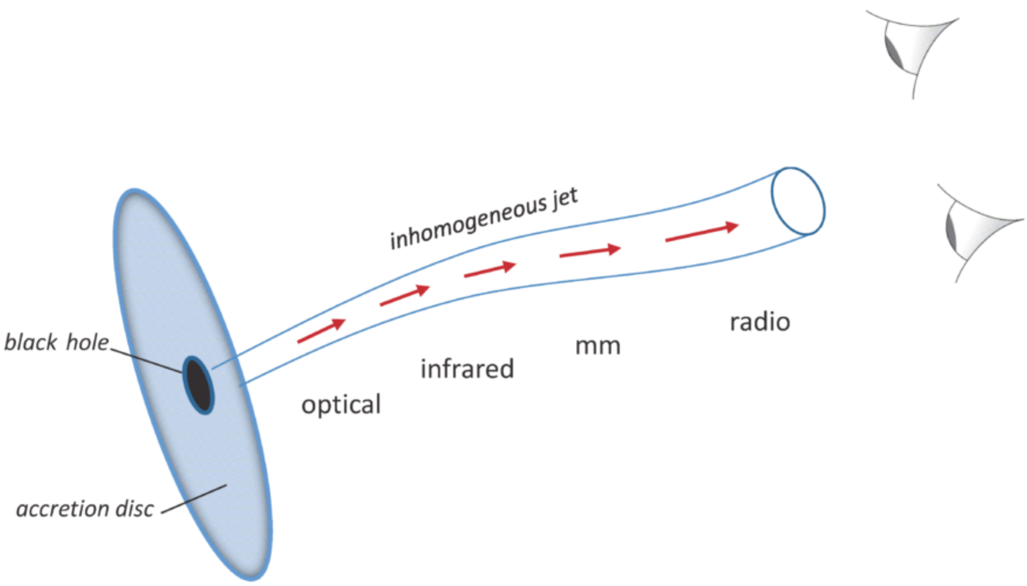


Figure 2 | Spectral energy distributions of CTA 102 and orientation of the emitting regions of the jet. a, Small grey circles highlight the observed variability ranges. The black dashed line represents the minimum-brightness synchrotron SED and the black squares (hexagons) the fitted (derived) minimum synchrotron flux densities. The black solid line and asterisks show the thermal emission model and its contributions to the near-infrared and optical bands. The red dot-dashed line represents the base-level synchrotron SED used for the geometric interpretation. Large coloured circles and coloured lines display observed data and spectra and model predictions, respectively, for selected epochs (expressed in JD − 2,450,000). Measurement errors (1 s.d.) are smaller than the symbol size. **b,** Viewing angles of the emitting region producing the (bulk of the) radiation at frequency ν at the epochs shown in **a**.



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