Accretion mode and γ-ray emission: A comparison between 3C111 and 3C371

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Introduction

Despite their low abundance in the γ-ray sky, Misaligned AGN (MAGN) i.e. AGN with a jet viewing angle $> 8-10°$, are an excellent laboratory to study the internal structure of relativistic jets and the radio-γ connection. Based on the efficiency of the accretion onto the SMBH, AGN can be divided into two classes: High Excitation Galaxies (HEG), with a radiatively efficient accretion, and Low Excitation Galaxies (LEG) with an inefficient one [1]. In this work, we investigate the differences between these two types of objects in the γ-ray domain, with the help of VLBI and multi-wavelength observations. As case studies, we select one HEG (3C111) and one LEG (3C371) with similar M_{BH}, redshifts, jet powers, and viewing angles. We analyze $\sim$ 200 VLBI maps, spanning over 4 years at 3 frequencies (15 GHz, 22 GHz, and 43 GHz), to investigate the relation between the structural changes in the radio jet and the emission at higher energies. We find substantial differences between the two sources both in the jet kinematics and in the γ-ray activity.

Kinematics 3C111

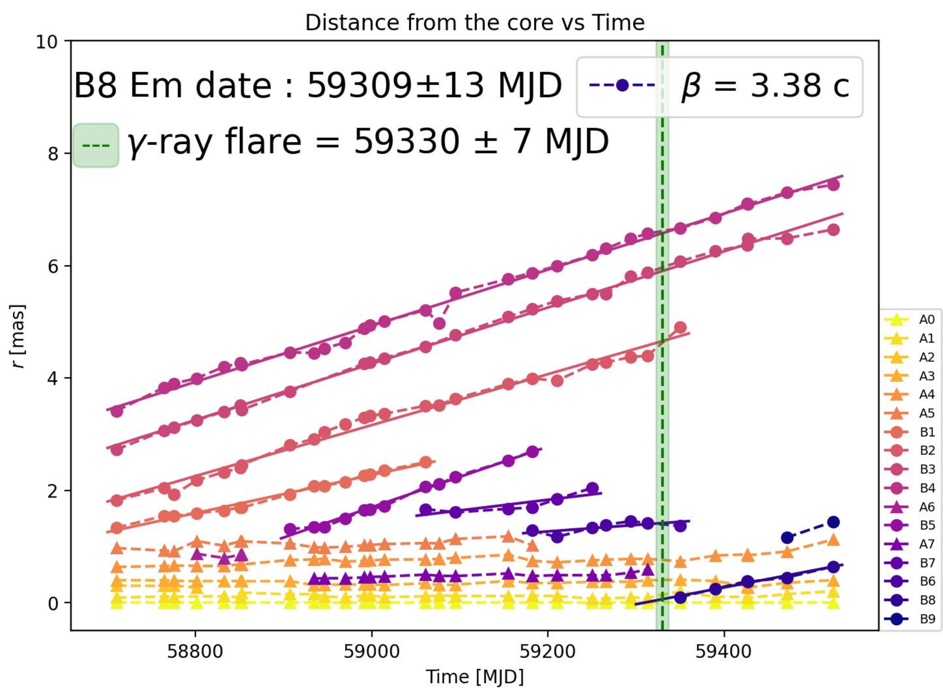


Fig. 1: Proper motion of the VLBI jet components of 3C111 at 43 GHz. The green dotted line is the date of the γ-ray flare, the value of β and the ejection time refer to the B8 component, the one associated with the flare.

3C111 shows stationary features in the innermost part of the jet and moving components also close to the core.

Kinematics 3C371

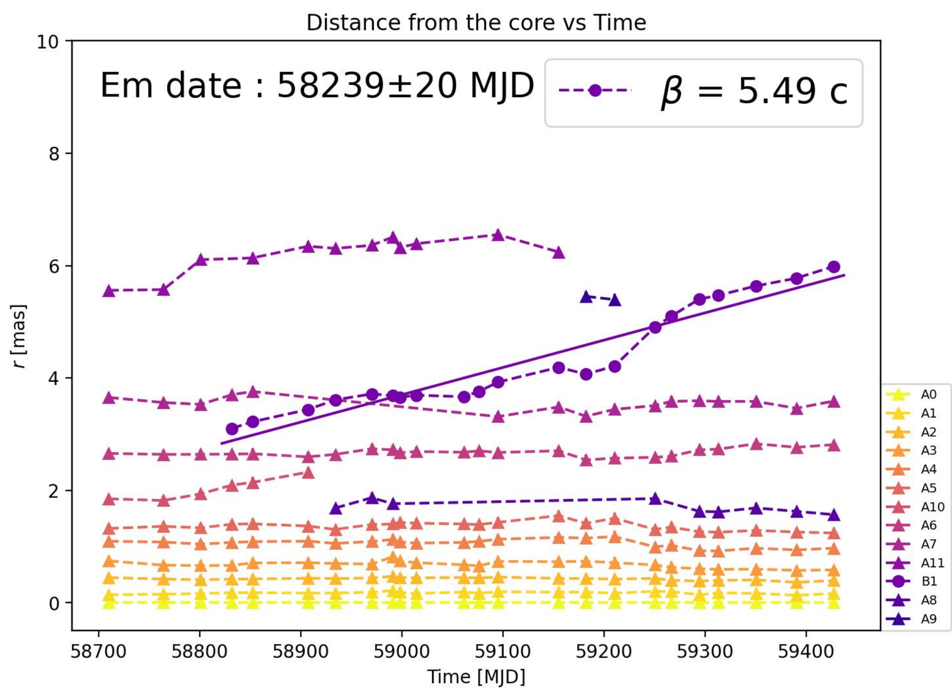
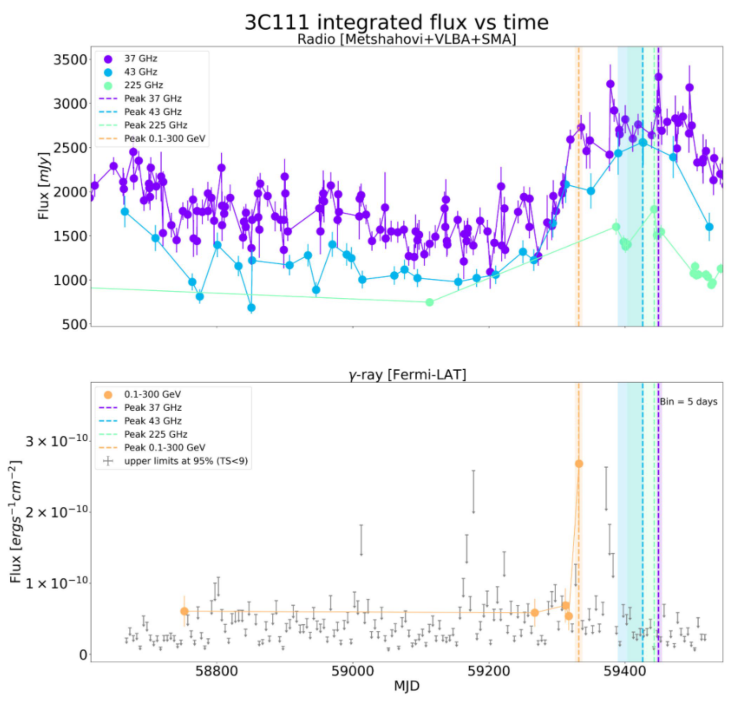


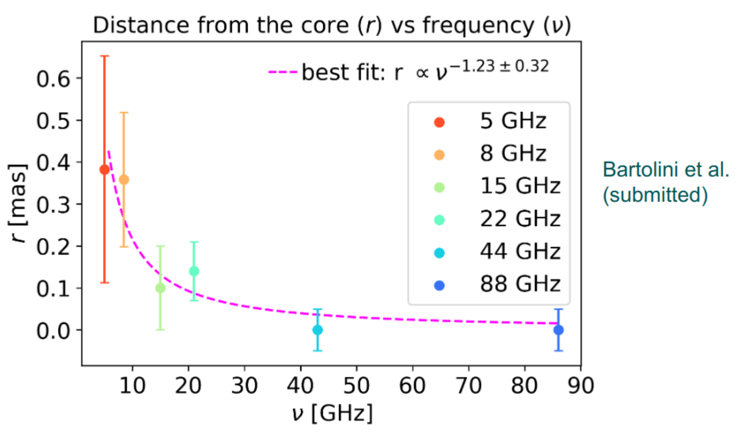
Fig. 2: Proper motion of the VLBI jet components of 3C371 at 22 GHz. The estimated value of β and the ejection time refer to the B1 component.

3C371 shows stationary features in the whole jet except for B1, the first moving component found for this source.

MW Emission 3C111



$$\Delta r_{43-\gamma} = \frac{\beta_{app} c \Delta t}{\sin\theta(1+z)} = 0.19 \pm 0.09 \text{ pc}$$



$$r_C \approx \frac{\Omega}{\nu \sin\theta} = 0.16 \pm 0.14 \text{ pc}$$

Fig. 3: **(a):** 3C111 light curves. Top: radio LC at 225 GHz, 43 GHz, and 37 GHz; Bottom: γ-ray LC with 5 days binning. **(b):** Core shift effect from [2].

The γ-ray flare is followed by a radio flare, with a delay that can be attributed to opacity effects and from which we derive $\Delta r_{43-\gamma}$. The estimated distance between the 43 GHz core and the jet apex (r_C) is consistent with $\Delta r_{43-\gamma}$, thus implying that the flare happened in the proximity of the SMBH.

MW Emission 3C371

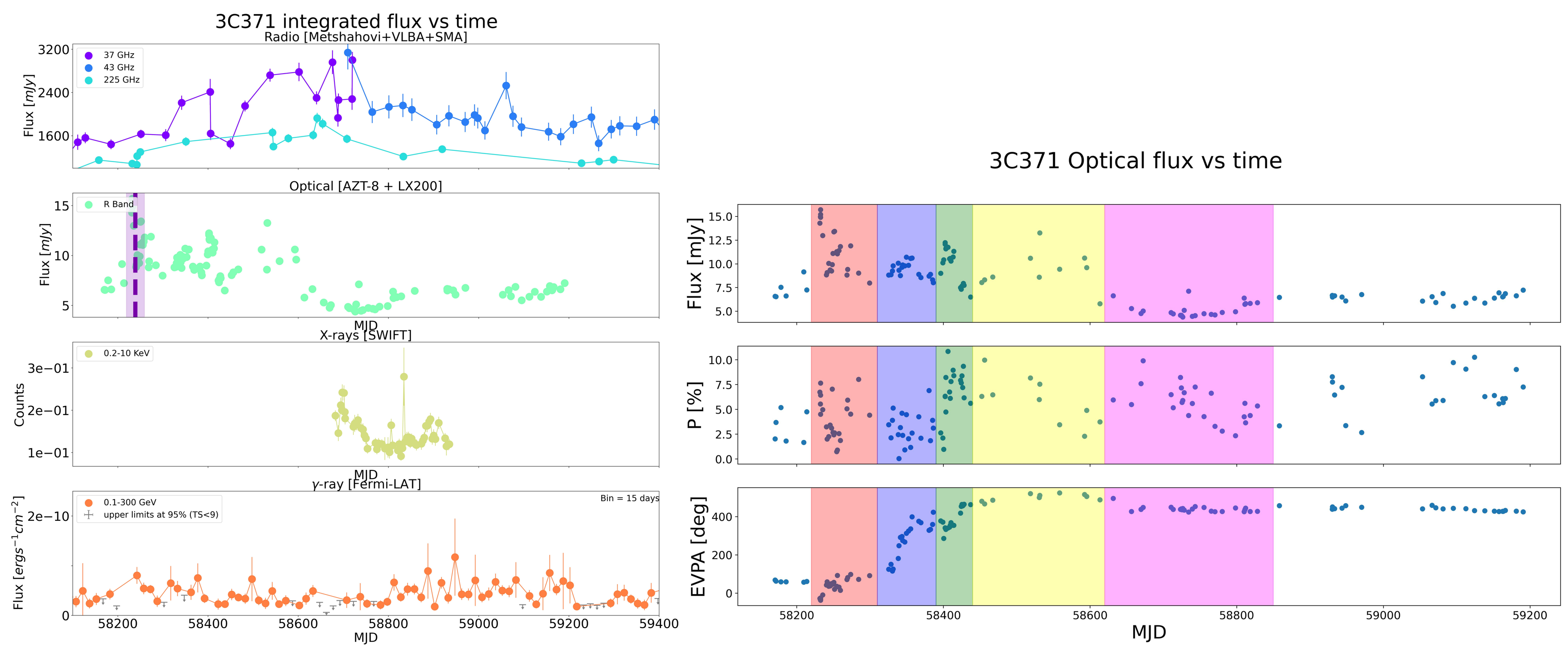


Fig. 4: **(a):** 3C371 light curves. From top to bottom: radio LC at 225 GHz, 43 GHz, and 37 GHz; Optical LC in the R-band; X-ray LC in the 0.2-10 KeV energy range; γ-ray LC with 15 days binning. The purple line indicates the ejection time of B1. **(b):** 3C371 R-band optical LC . From top to bottom, Total flux, fractional polarization and EVPA. The colors defined different phase of the emission.

3C371 experienced a large optical flare followed by increased radio flux and ejection of a moving feature, but no clear counter-part in γ-rays.

3C111 γ-ray flare

3C111 is mostly undetected in the γ-ray domain, except when is in a flaring state [3]. This behaviour has been observed in other HEGs [4], thus suggesting a possible correlation between the accretion mode and the high energy emission.

3C371 Optical flare

By looking at Fig. 4 **b**, we can see a delayed EVPA rotation, possibly coinciding with the onset of the radio flare. This, as well as the observed anti-correlation between P and F [5], is suggestive of a possible contribution of disk emission. Thus, the first moving jet component is perhaps associated with disk activity in this powerful LEG.

HEG vs LEG: The possible scenario

- LEGs have an ADAF-like/hybrid disk that produces a jet with low sheath/spine power ratio. This helps the development of stationary shocks that are efficient sites of particle acceleration that can contribute to a more stable γ-ray activity.
- HEGs have a thin disk that produces a jet with high sheath/spine power ratio that favors the propagation of moving knots but prevents the development of stationary shocks. Therefore they have less sites of efficient particle acceleration, making their γ-ray detection restricted to flaring events.

To test this hypothesis, we will employ 2D RMHD simulations to explore how different spine-sheath configurations affect the jet internal structure and the development of instabilities, following an approach similar to [6].

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