Multifrequency simultaneous VLBA view of 3C111

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1) Introduction

Nearby radio galaxies are ideal targets for investigating the physical phenomena of relativistic jets. 3C111 contains one of the brightest cores at the cm/mm wavelengths among radio galaxies and exhibits variable emission spanning several Jy. Given its proximity (z = 0.049), 3C111, is an excellent source to explore the jet physics with mm-VLBI observations. We perform a study using multi-frequency (5 GHz, 8 GHz, 15 GHz, 21 GHz, 43 GHz, 86 GHz) VLBA observations. We present various results such as the core shift, the spectral index between 8 GHz and 15 GHz, the brightness temperature and equipartion magnetic field relation for the modelfit components at different frequencies and the Rotation Measure map between 5-8-15 GHz.

2) Core shift and Spectral index

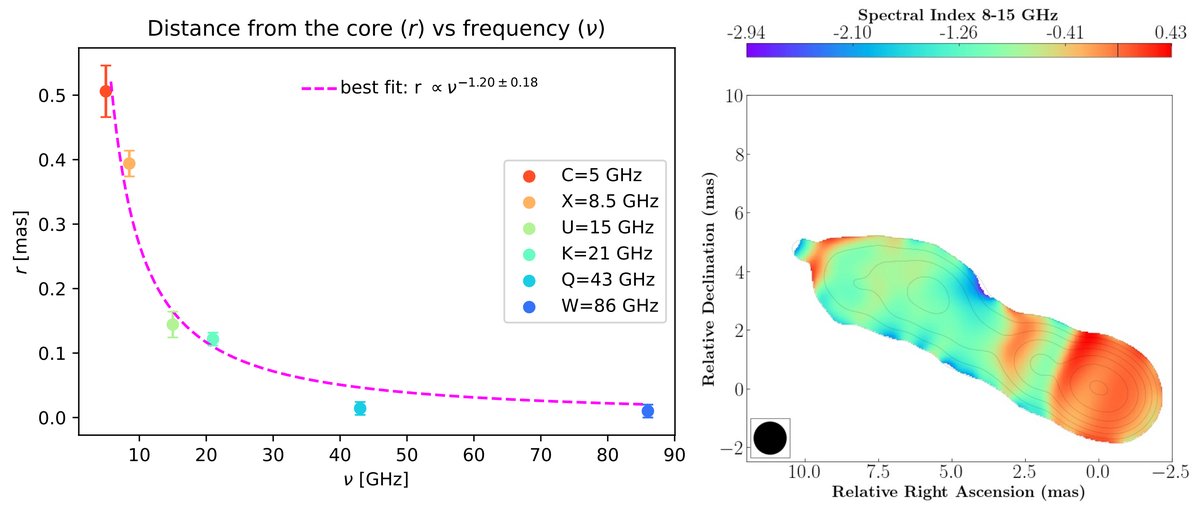

Fig. 1: *Left panel*: The core shift effect [1] on 3C111 computed as $r \propto \nu^k$. The best fit line is plotted in magenta. The index $k = -1.20 \pm 0.18$ is in agreement with the literature [2]. *Right panel*: Spectral index map ($S_\nu \propto \nu^\alpha$) between 8 and 15 GHz. The contours describe the 15 GHz emission. The spectral index distribution spans from $\alpha \approx 0.4$ in the central region, to $\alpha \approx -2$ in the extended region in agreement with a self-absorbed synchrotron spectrum.

3) Brightness distribution

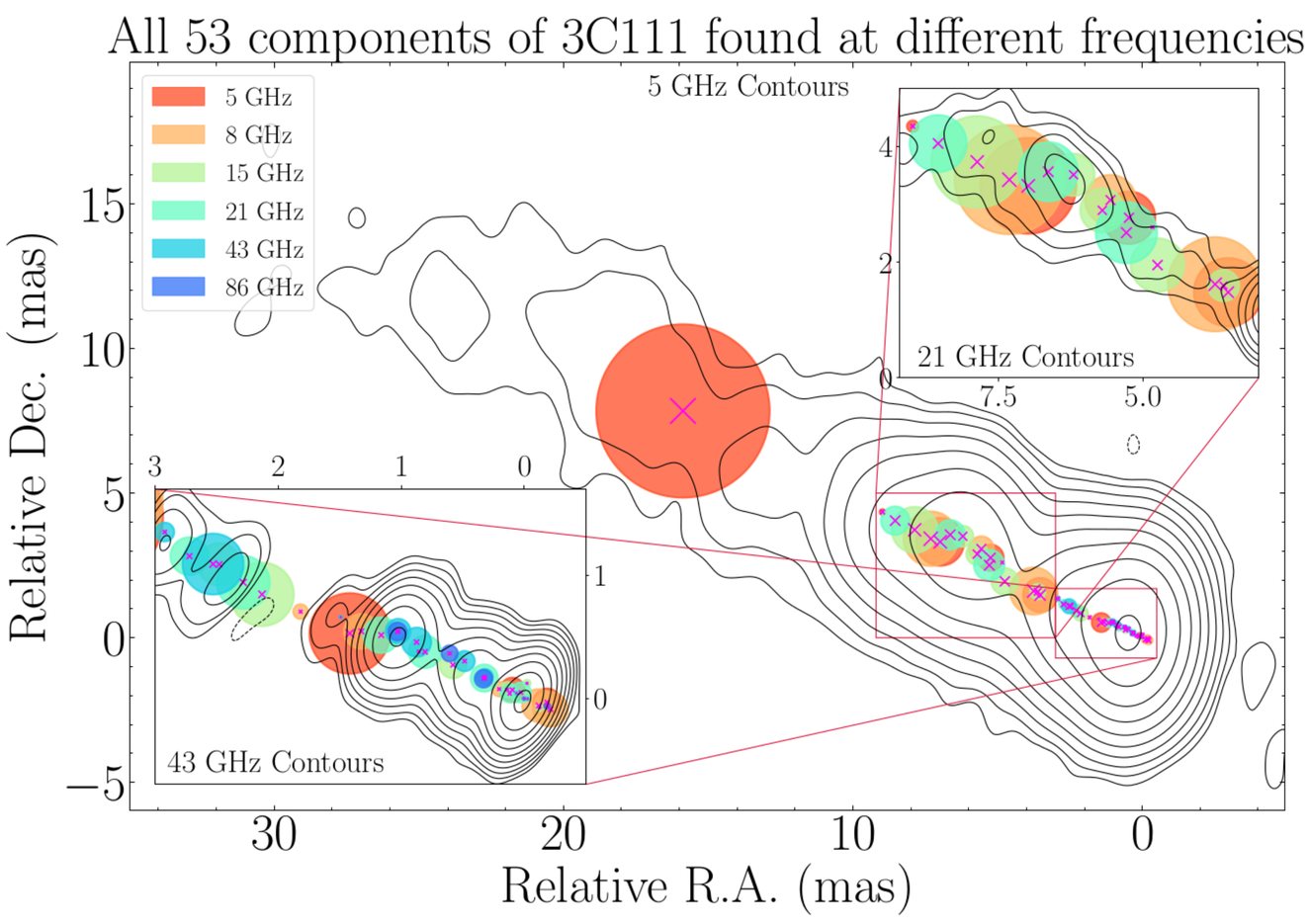

Fig. 2: Modelfit components in 3C111 obtained using `difmap`, plotted over the 5 GHz contours. The two insets show the inner regions, plotted over the 21 GHz and 43 GHz. The components size θ correlates with their distance from the core r: $r \propto \theta^{1.09 \pm 0.12}$. Moreover, the equipartion magnetic field H_{eq} scales as $H_{eq} \propto \theta^{-1.08 \pm 0.04}$, suggesting adiabatic expansion of the components [3].

4) T_B and H_{eq}

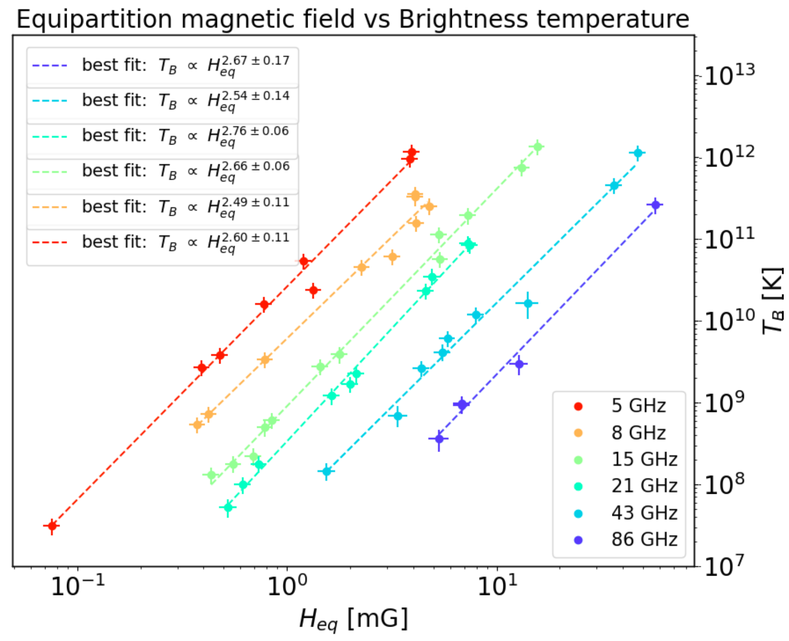

Fig. 3: Brightness temperature T_B (estimated as $T_B \approx 1.22 \times 10^{12} F(\nu)(1+z)/(\theta^2 \nu^2)$ [4]) in [K] vs equipartion magnetic field H_{eq} (estimated as $H_{eq} = (3L/4V)^{2/7} \times 10^4$ [5]) in [mG] in logarithmic scale. The dashed colored lines represent the best fit for the data points of each frequencies. These suggest a strong correlation between these physical quantities for each frequency, with an average trend of $T_B \propto H_{eq}^{2.62 \pm 0.11}$. Such a tight correlation spanning several orders of magnitude, could find a natural origin in the common dependence between T_B and H_{eq}.

5) Rotation Measure

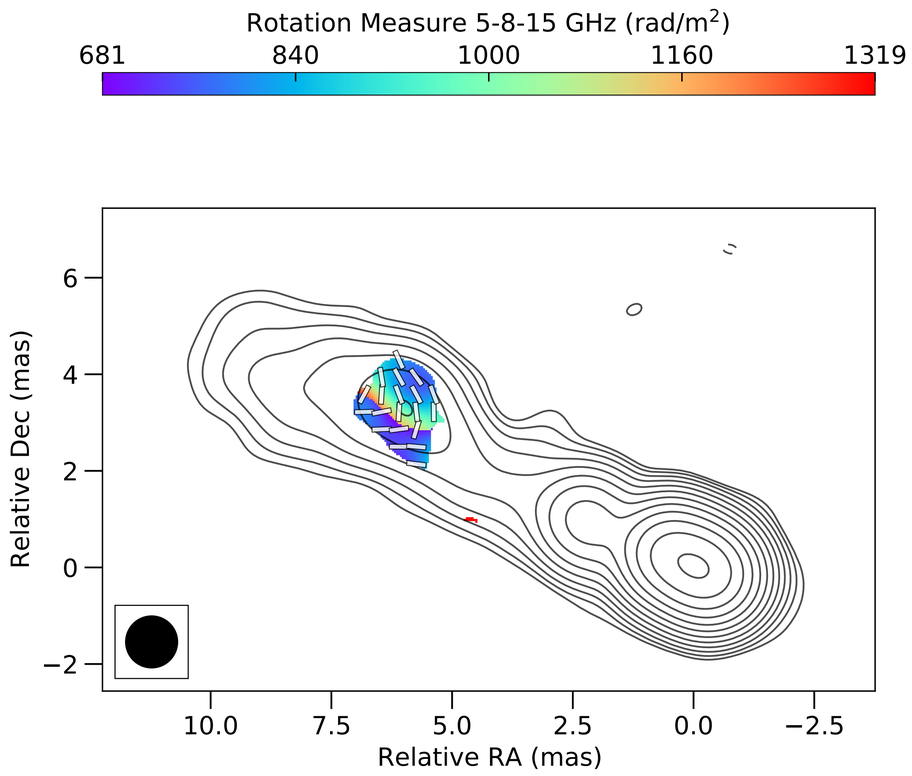

Fig. 4: Rotation measure map between 5,8 and 15 GHz plotted on the 15 GHz contours. The white bars corresponds to the Faraday-corrected EVPAs. The magnetic field orientation has a coherent gradient that spans from being perpendicular to the jet axis to being almost parallel to it, in the same jet region, in agreement with the simulations for a helical structure [6].

6) Summary & future studies

From the wide range of frequencies used, we observe unique features both in total intensity and polarizartion. This work provides interesting insights on the physical properties of 3C111 such as at the T_B-H_{eq} relation or the possible helical structure of the magnetic field in its outflow. We highlight that the analysis carried out, can be used for a concrete comparison with the simulations. Moreover, our observations took place shortly after a γ-ray flare, and so they could be used to explore the behaviour of HERGs during the flaring activity.

References

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