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Magnetic Field and Faraday Rotation Measure Structure in the Jet of 3C 120

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Abstract. We present multi-frequency polarimetric VLBI observation of 3C 120. We investigated RM distribution of central parsecs of the host of the jet. Our analysis revealed the RM feature closely associated with the change of magnetic field (B-field) orientation of the jet. The change of B-field is brought by the some physical mechanism of the synchrotron emitting plasma of the jet. On the other hand the change of RM distribution is brought by the change of electron density and/or B-field strength of the low energy plasma ($\gamma < 20$), since such plasma is responsible for the Faraday rotation. This result leads us to expect the idea that the low energy plasma is surrounding the synchrotron emitting plasma, and both of them are physically associated.

1. Introduction

High angular resolution observations using VLBI have been providing us various aspects for Active Galactic Nuclei (AGN) jets in milli-arcsecond (mas) scale. Especially polarimetric observations give the unique information about the orientation and order of magnetic field (B-field). Recently several observations show a significant Faraday rotation measure (RM) of central parsecs of the hosts of jets (e.g., Zavala & Taylor 2003). Therefore, in order to investigate the B-field intrinsic to the source, the effect of RM should be taken into account. Although Faraday rotation is an obstacle to see the intrinsic B-field, RM distribution allows us to probe the condition of physical property of the low energy plasma ($\gamma < 20$, where γ is Lorentz factor (e.g., Homan & Wardle 1999)) near the jets. However it has not been certain that RM distribution as seen in VLBI scale is originated in the jet or in foreground plasma somewhere in between the jet and us. Here we report the multi-frequency polarimetric observations of 3C 120 to show the RM structure.

2. Observation and Data Reduction

We used an archive data set of 3C 120. The observation was carried out at 5, 8 and 15 GHz using the Very Long Baseline Array (VLBA) on November 2-3, 1996. Each observing band contains two 8-MHz basebands. Both right and left hand circular polarizations were recorded at each observing station. The data reduction was performed with the AIPS software in the usual manner. We note that IF2 of 8 GHz was not used, because the instrumental polarization was not calibrated well for unknown causes.
For imaging we used DIFMAP initially, then imported AIPS to self-calibrate the full datasets using task CALIB before the final DIFMAP image.

3. Results and Discussion

We show the RM distribution and B-field map overlaid on the total intensity map at 4.987 GHz in Figure 1. We labeled the jet components based on the model fitting results using DIFMAP in Figure 2. We note that RM and B-field are calculated using EVPAs at 8 and 15 GHz for the east side of the dashed line, though polarized flux is detected at 5 GHz. This is because the wavelength square (λ^2) law of Faraday rotation can not be applied between optically thick and thin frequencies, indeed C7 component becomes optically thick at 5 GHz. On the other hand, we used EVPAs at 5 and 8 GHz for the west side of the dashed line, since no polarized flux was detected at 15 GHz in this side. The bullets in Figure 1 represent sample points to show how the EVPAs are fitted.
The B-field orientation in the components east of C7 shows roughly parallel to the jet axis, while those west of C6 shows a rotation of 60 – 70 degree with respect to the jet axis. This change of B-field orientation indicates some physical change in the synchrotron emitting plasma, such as shock or some instability. On the other hand RM distribution also changes significantly from C6 to C7. Faraday rotation is a phenomenon caused by the low energy plasma, whose Lorentz factor is $\gamma < 20$. Thus the synchrotron emitting plasma[1] of the jet dose not play an important role for Faraday rotation, because such plasma is, in effect, heavier than the thermal plasma. In spite of that it is essentially different between the synchrotron emitting plasma and the Faraday rotator, the change of RM distribution shows spatially coincidence with the change of B-field orientation. Such a feature leads us an idea that Faraday rotator is surrounding the synchrotron emitting plasma and both of them are physi-

[1] It is difficult to measure the Lorentz factor of synchrotron emitting plasma of the jet directly. However a few cases for which hint the Lorentz factor of electron have been reported include the hot spots of radio lobe. For example, $\gamma \sim 500 - 1000$ have been inferred by Carilli et al. (1991)