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HST Observations of the Jet of 3C120

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Abstract. The WFPC2 observations made by J. Westphal, in July 1995, allow us to confirm the existence of condensations O', O1 and O2; they are located at intersections between the radio jet and filaments emitting in the continuum and in the lines. The depolarization of the radio jet at the position of knot R1 is related to the interaction of the jet with a strongly ionized region of the galaxy. We also detect additional knots closer than 2.5" from the nucleus. The high angular resolution brings precise measurements in position and flux. The optical and radio positions are in good agreement and the radio/optical spectral indices of the knots are as expected in the case of synchrotron radiation.

1. Introduction

In two cases, observations of extragalactic jets are performed with nearly similar resolutions at both optical and radio wavelengths : 3C 273 and M87. In 1994, Lelièvre et al. detected an optical jet out of the nucleus of 3C 120, using the CFH Telescope and an atmospheric compensation device providing elementary images with a resolution of 0.4" (FWHM) and 0.66" after filtering. They associated several optical features with radio knots in the range 2.5"– 7" from the nucleus. In 1995, Hjorth et al. could not find clear evidence of optical counterparts of radio knots on images with poorer resolution ($> 0.76''$). Nevertheless, they claim detection of a continuous flux between 6" and 15" from the nucleus. There was a clear need to get data with better resolution and to explore the inner part of the jet.

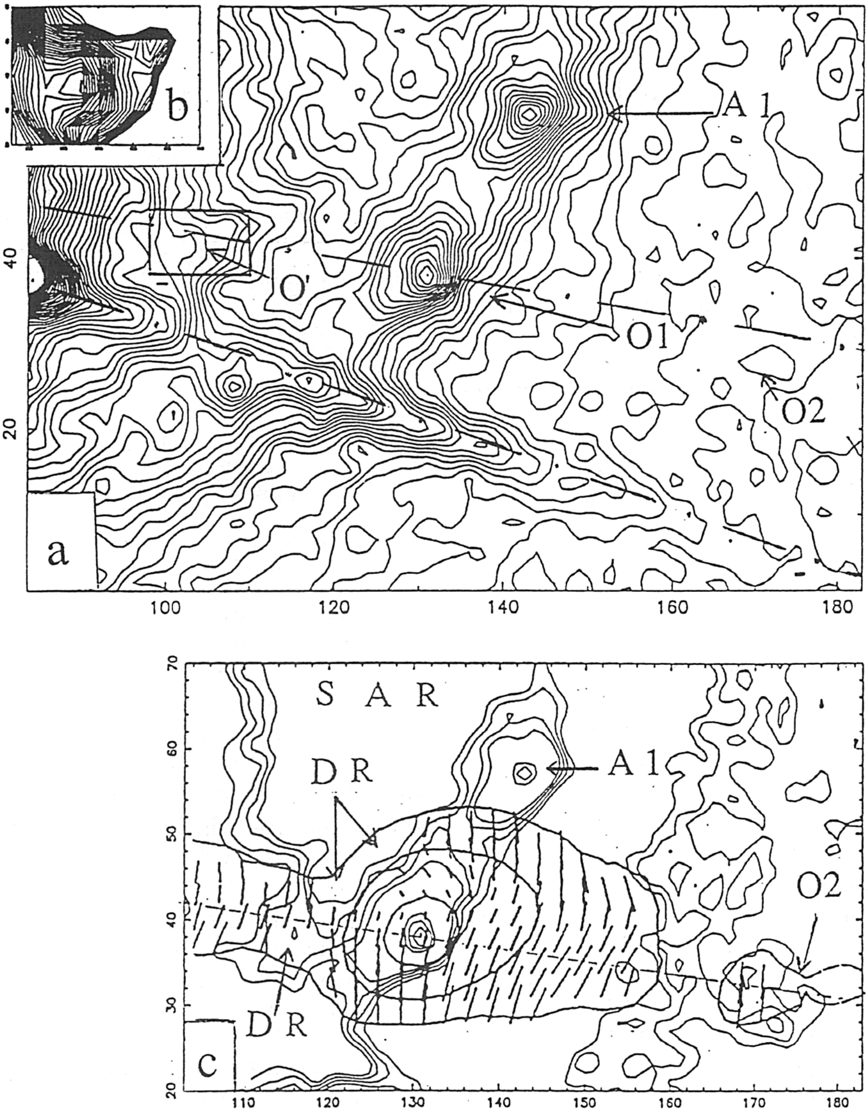

Figure 1. Main condensation O1 of the optical jet. Filter F814W. North is up and east left. Resolution is 0.15". The dotted lines show the direction NR1 of the radio jet and the axis of the diffraction spike. Condensations O'and O2 are also visible. The isophotes increase linearly from 11 to 61 in steps of one DN (data number). b) The detailed map of O' showing two maxima. c) Superposition of the map of figure 2a and the polarization map of the radi ojet (Walker et al. 1987, 5 GHz, resolution 0.37"). Isophotes: 12.5, 13, 13.5, 22, 23, 24, 25, 26, 32, 33 and 34DN. The depolarized regions DR occur in strongly absorbed regions SAR of the optical image.

2. Observations and results

Four sets of data have been obtained by J. Westphal on July 25, 1995, with the WFPC2 of the HST. They consist of 3 exposures (one short and two long) through four filters at wavelengths 555 nm, 547 nm, 675nm and 814 nm. The scale is 0.0455” per pixel and the resolution is close to 0.1” (FWHM). To study the jet in the continuum, we selected data taken through the 814 nm filter that, outside of the nucleus, is only weakly polluted by the presence of one of the SIII lines.The main difficulty resides in the presence of one diffraction spike very close to the jet. For data reduction, we had to adopt different techniques according to the distance to the nucleus.

TABLE 1 **3C 120 Relative distance of condensations to the nucleus**

RADIO	R''''	R'''			R''		R'a	R'b	R1	R2a	R2b	R3
Distance (")	0.2" and 0.4"	1" to 1,75"			1.8" to 2.3"		2,46"	2,80"	3,76"	5,60"	6,01"	7,03"
OPTICAL	O''''	O'''a	O'''b	O'''c	O''a	O''b	O'a	O'b	O1	O2ab		
Distance (")	~0.3"	1.18	1.44	1.76	2.15	2.30	2.53"	2.70"	3.76"	5.76"		
	O''''/R''''		O'''/R'''		O''/R''		O'/R'		O1/R1		O2/R2	
Index	0.83		0.78		0.83		0.68		0.72		0.70	
(corrected)									(0.84)			

The optical features O1, O’ and O2 of Lelièvre et al. (1994) are illustrated in figure 1; O1 is clearly separated from condensation A. Figure 2 shows two new condensations O” and O”’ ; Additional sub-structures (O”a, etc) are also detected. Closer to the center, we use the short exposure, which is not saturated, and detect a condensation O”” that can be associated with radio knots R”” between 0.2” and 0.45”.

Table 1 lists radio positions of the knots as measured on the figures of papers (Benson et al. 1988, Muxlow and Wilkinson 1991 and Walker et al. 1987). Precisions are typically 0.05”. Our measured optical positions are also listed in table 1. Precisions are close to 0.1” and even better for O1. The positions of R1 and O1 are the same. Fluxes have been estimated at 5GHz (from figure 15 in Walker et al. 1987) and compared to I magnitudes in order to compute the spectral indices. In the case of the main knot O1, we were able to substract not only the contribution of the galaxy but also the flux contributed by condensation A. The corresponding corrected value is : $\alpha(R/O) = 0.84$.

3. Discussion

There is a good agreement between the positions of optical and radio features. Thus, like the radio knots, the optical condensations from O”” to O2, are not strictly aligned on the direction Nucleus-R1. The structures at 0.1” resolution show sub-structures that are not identical but similar to the radio structures and as pointed out by Walker (1997) for radio knots, condensations O1 and O2 also show a south-north asymmetry with a steep edge towards the south.

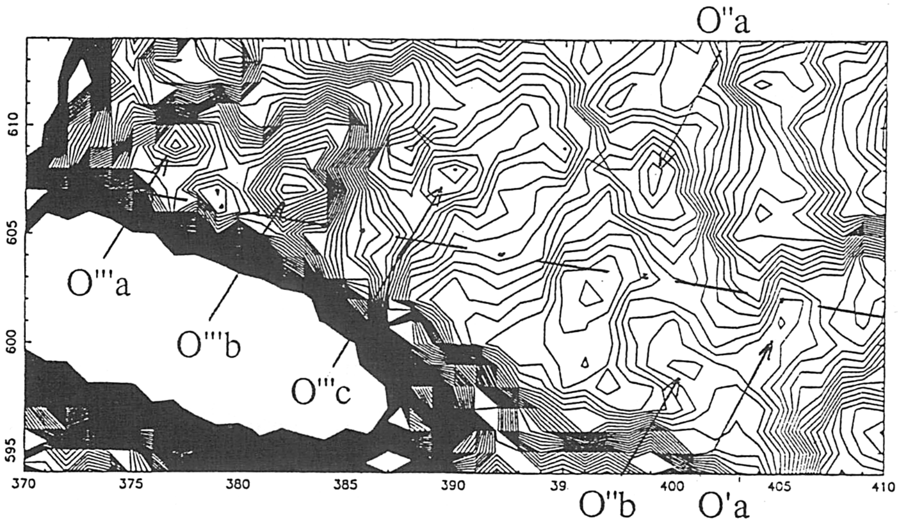

Figure 2. Region of condensations O" and O"'. Distance from the nucleus : 1" to 2.5". The mean radial gradient has been substracted. The optical jet is very close to the diffraction spike. Isophotes increase linearly in step of 0.25 DN starting at 5.

Unlike the radio jet at resolution 0.37", in optics at resolution 0.15", we do not see, between the knots, a continuous structure that can be undoubtedly attributed to the jet.

The HST data do not include polarization but Hjorth et al. (1995) found that condensation A is polarized as the radio jet. This is likely due to the main component O1 of A.

For all these reasons, the optical condensations appear as good counterparts of the synchrotron radio knots.

The galaxy is gas-rich and for O1, there are, at least, three arguments in favor of an interaction between the jet and ionized gas: a) in the region of O1, Baldwin et al. (1980) found a ratio $OIII/H_\beta$ higher than in any other part of the galaxy ; b) on a spectrum taken along filament A, Axon et al. (1989) found a maximum of OIII emission at O1 ; c) on figure 1c, depolarization of the radio jet is divided in two parts : north-east to the center of O1, depolarization is due to a plasma related to the knot itself and towards the east, a total depolarization in two regions reveals the existence of ionized and absorbing zones. Soubeyran et al. (1989) already interpreted this depolarization as due to the jet going through a layer of ionised gas.

The emission by the jet, at optical wavelengths, reinforces the idea of Grandi et al.(1997) that the emission, at 100 KeV, is due to the jet. Between the nucleus and 6", there is no significant variation of the radio/optical index ; this indicates that no important loss of energy of the jet occurs along the path. This case is similar to the one of M87 (Meisenheimer et al. 1996) and different from the behaviour of 3C 273 (see Lelièvre et al. 1984 and Bahcall et al. 1995).

These observations are compatible with the idea that the jet is driven by a precession motion and, as suggested by Soubeyran et al. (1989), their filaments A,B and D could be star formation regions produced by the successive encounters of the jet with regions of ionized gas.

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