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Sub-milliarcsec Structure of 3C 111 at 0.7 and 3.6 cm

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Abstract. VLBA+Effelsberg observations of the radio galaxy 3C 111 at 7 mm show remarkable rapid changes in structure which cannot be described in terms of simple component motions or changes in the structure of fixed components.

1. Introduction

3C 111 (0415+379) is a classical double-lobed radio source with a well pronounced FR type II morphology (Linfield & Perley 1984) associated with an N-type galaxy. The object displays several small-scale features characteristic of a highly active nucleus and is regarded typical for a 'beamed object' oriented towards us: it has a prominent superluminally variable parsec-scale radio source with a one-sided jet pointing in the same direction as the one-sided highly collimated 'VLA-jet', and a broad line emission region embedded in a starlike nucleus. 3C 111 is an excellent object for studying the 'young' (subparsec scale) jet in a FR II radio galaxy.

1) It has the strongest compact core at cm/mm wavelengths ($S \gtrsim 1.5$ Jy) of all FR II radio galaxies. The spectrum between 4 cm and 3 mm is flat or inverted (Bloom et al. 1994). At times 3C 111 displays superluminal structural changes and/or strong mm outbursts. A large outburst, with flux values > 10 Jy at 90 GHz, was discovered with the IRAM interferometer at Plateau de Bure (J. Wink, private communication) in January 1996.

2) 3C 111 is also the nearest (z=0.0485) of all FR II–type objects with relatively strong compact central components. The spatial resolution achievable with the VLBA + Effelsberg is $\sim$2.5 light months at 43 GHz (corresponding to 0.65 pc/mas; $H_0 = 100$ km/s/Mpc, $q_0 = 0.5$).

Our 6 cm VLBI monitoring observations in 1978/80/85/86/87/89 showed dramatic changes in the parsec-scale structure (Götz et al. 1987; Preuss, Alef, & Kellermann 1988; Preuss, Alef, & Kellermann 1990).

2. New Observations and Results

Following the large mm-outburst of 3C 111 we observed the object twice (see Fig. 1) in the standard polarization mode at 3.6 cm and 7 mm, in July and September 1996.

Preliminary total intensity maps at 7 mm (Fig. 1) show an elongated, curved multiple component structure of about 1.1 mas extent, roughly aligned with the large-scale jet. The structure is complex, has no pronounced asymmetry, and is not strongly dominated by a single compact component; the flux of the second brightest feature is $\gtrsim 65\%$ of the dominating component's value at both epochs. Also, there is no very compact (unresolved) component at these epochs. Note the curvature on the inner subparsec scale of this otherwise straight, long and well-collimated jet.

The structure shows significant changes between the two epochs which can not be described just by relative motion or expansion of components. There appears to be a mix of dimming and flaring of stationary and moving emission components. To obtain a clearer picture of the structural changes, in the aftermath of the strong mm outburst, a sequence of further, more densely spaced, observations is in progress.

The 3.6 cm brightness distribution (first epoch; not shown here) shows a similar one-sided 'core-jet' structure as previous 6 cm maps. The polarized intensity map at 3.6 cm (same epoch) shows the brightest jet component, $\sim$4 mas from the core, to be polarized at the 5% level (polarized flux density $\sim$ 90 mJy).

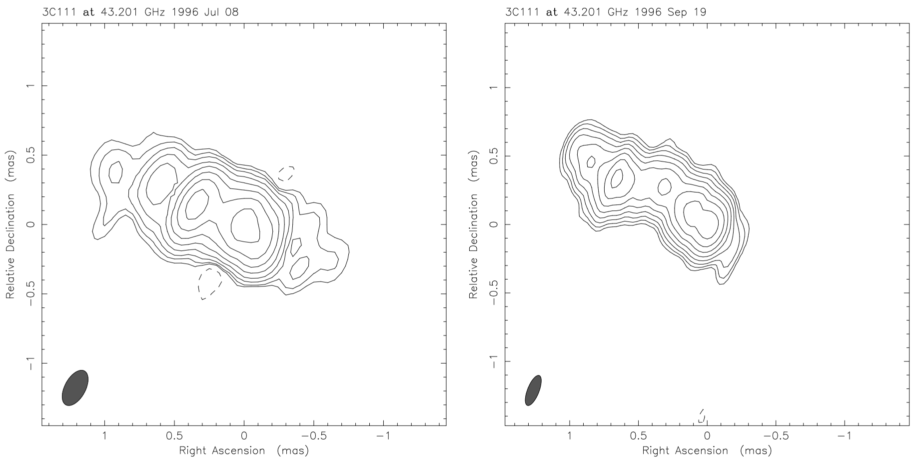

Figure 1. VLBI *clean maps* of 3C 111 at 43 GHz for 2 epochs. The contour levels are -0.5, 0.5, 1, 2, 4, 8, 16, 32, 64 % of peak brightness. Arrays used, model fluxes, map peaks, and Beam FWHM are: VLBA (except Saint Croix), 6.3 Jy, 1.6 Jy/beam, 0.28 x 0.15 (mas) at PA $-28.5°$for the first epoch, and VLBA + Effelsberg, 3.0 Jy, 0.4 Jy/beam, 0.22 x 0.09 (mas) at PA $-19.9°$ for the second epoch.

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