Multi-Epoch 8.4 GHz VLBI Observations of the Nucleus of Centaurus A

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Abstract

We present the results of several 8,4 GHz VLBI observations of the nucleus of Centaurus A. We find that the source possesses a classical core-jet structure with the inner portion of the jet expanding at a proper motion of 4.0 mas yr^{-1} or an apparent velocity of 0.26c along the jet.

1. Introduction

At a distance of only 4 Mpc [H84] the radio source Centaurus A in the peculiar elliptical NGC 5128 is the closest active galaxy to the Milky Way. It therefore affords potentially the highest linear imaging resolution (1 mas = 0.019 pc) for such an object and, hence, the best prospects for studying an active nucleus near the central source. On very large scales Centaurus A is an FR I double-lobed source with structure out to 250 kpc at a position angle of 0° [Ju92]. On intermediate (10 kpc) scales, a smaller, apparently younger, double-lobed source lies at a position angle of 51°, roughly perpendicular to the dark dust lane which bisects the elliptical galaxy [B83]. The jet feeding these lobes appears one-sided, in the northeasterly direction, and has been detected at X-ray and infrared wavelengths as well as radio [B83,J091]. The compact nucleus has been studied by us with VLBI at 2,3 GHz on 0.2- 2,0 pc scales and found to possess a jet at the same position angle and with one-sidedness in the same sense [M89]. No significant changes in structure have been detected at 2.3 GHz over an eight year period from 1980 to 1988, although during that time the shortest baseline (with 100 mas fringe spacing) was the only one to be sampled consistently and with sufficient signal-to-noise to detect motion in the jet.

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2. The 8.4 GHz VLBI Observations

Our 8.4 GHz observations of Centaurus A span nearly a decade and include two imaging experiments at epochs 1991.17 and 1991.90, each with a 3 x 7 mas beam. For comparison wealsohave several single-baseline experimentsat epochs 1982.30 . with 30 mas resolution, 1990.05 with 8 mas resolution, and 1991.78 with 7 mas resolution. The 1982 observations, employing the Deep Space Station (then 64m) antenna at Tidbinbilla and the 64m at Parkes, showed an elongated jet structure similar to that seen at 2.3 GHz and the 3 Jy flux at 8,4 GHz implied a spectral index of α = –0.8, typical of optically thin non-thermal synchrotrons sources [M89]. There was also some evidence in 1982 for a weak (0.5 Jy) component 100 mas away from but in line with the jet which was visible at 8.4 GHz but not at 2.3 GHz.

The recent 8.4 GHz observations employed the 70m or 34m at Tidbinbilla, the Parkes antenna, the 26m in Hobart, Tasmania, the 22m at Mopra, and one of the 22m antennas of the Australia Telescope at Narrabrai. Significant changes in both source strength and structure are readily seen in the multi-epoch visibility data, The flux of the Centaurus A nucleus has increased from 3 to $\sim$ 11 Jy over the ten year period. Also, in the early 1990 Tidbinbila-Hobart data, there appeared to be a compact, unresolved component close to the jet which had not been present in 1982, and which became rather resolved by late 1991,

3. Analysis and Discussion

We have calibrated and imaged the two largest datasets (1991.17 and 1991.90) using standard hybrid mapping procedures. The two maps are shown in Figure 1 with contours at $\pm 1, \pm 2, \pm 4$, 8, 16, 32, 50, 60, 70, 80, and 90 percent of the peak flux, which is 2.91 and 2.98 Jy per beam, respectively, The beam size in both is 3 x 7 mas at a position angle of $\sim$ 90°. Note that the linear extent of these images ($\sim$ 1 pc) is comparable to the inferred size of many broad line regions of active galaxies or quasars, and our resolution (0.06 pc) is substantially smaller than that. The change in elongation of the core over the nine month period, which is responsible for the visibility changes discussed above, is a full beam width (3 mas) in extent, yielding a speed of 4.0 $\pm$ 8 mas yr^{-1}, or v = 0.26c. The direction of the motion appears to be along the jet. There is also some indication that outer components in the jet are moving at a similar speed, but this result is less certain due to the lower signal-to-noise there,

Finally, we wish to point out that there is no evidence in our recent 8.4 GHz data for a 0.5 Jy flat-spectrum or self-absorbed component 100 mas away from the brightest portion of the jet, as was indicated in the 1982 data. Also there appears to be no evidence for an accretion disk perpendicular to the jet with a brightness temperature greater than 3×10^7K at distances 0.1 pc or more from the core.

In summary, the Centaurus A nucleus appears to be a subliminal version of the classic core-jet VLBI source – a property consistent with the entire object being a low power FR I source.

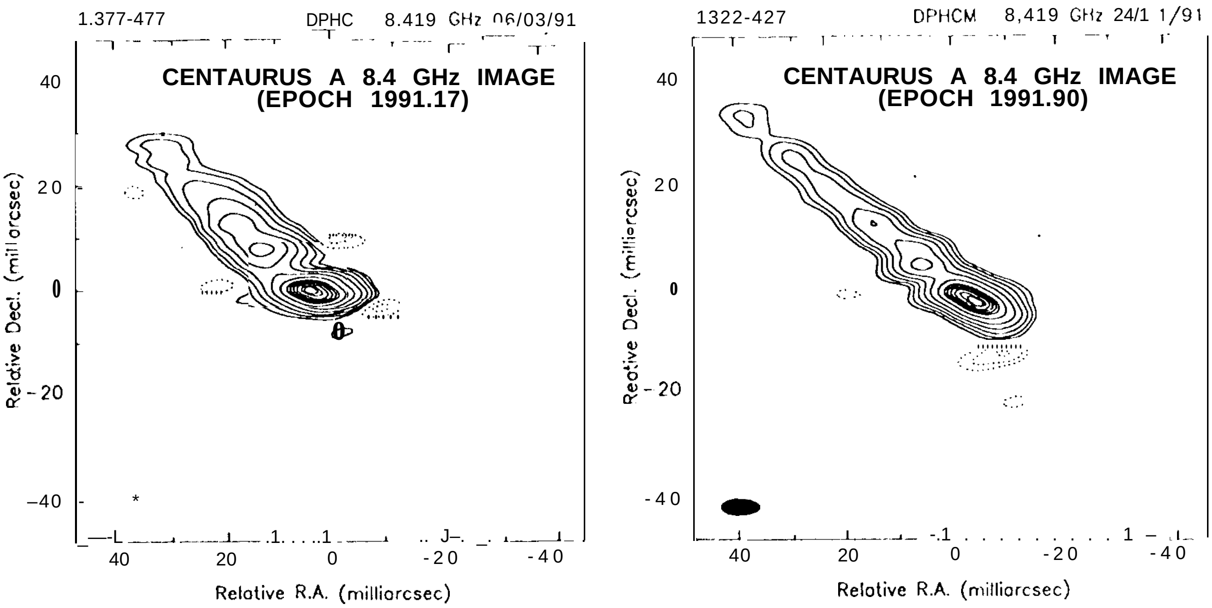

Figure 1. 8.4 GHz VLBI images of Centaurus A

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