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# Variability of the Radio Nucleus of the Galaxy M81

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**Abstract.** We report on VLA and VLBI observations of the nucleus of the nearby spiral galaxy M81. The VLA observations show the flux density of the nucleus to be variable by 50%. The VLBI observations indicate that the structure of the nucleus of M81 is somewhat variable on timescales of weeks.

## 1. Introduction

M81, at a distance of 4 Mpc, is the nearest galaxy with an active galactic nucleus, with the possibly exception of Cen A. The nucleus is exceptionally compact: 700 AU $\times$ 300 AU at 22 GHz, with the size being proportional to $\nu^{-0.8}$ (Bietenholz et al. 1996; Bartel et al. 1995; Bartel et al. 1982; see also Kellermann et al. 1976). Here we present further results from new VLA and VLBI observations of the nucleus of M81.

## 2. VLA Flux Density Monitoring

The nucleus of M81 was used as a reference source for the continuing program of VLBI monitoring of SN 1993J (Rupen et al., these Proceedings, p. 355). VLA data were taken simultaneously with the VLBI runs. Flux densities were derived from images, and the results are shown in Figure 1. The systematic uncertainty in the flux calibration (5%) dominates internal uncertainties. The flux density of M81 varies by over a factor of 2 at 8.4 GHz (Van Dyk & Ho, these Proceedings, p. 205). At this frequency, the mean observed flux density was 120 mJy with a standard deviation of 22 mJy or 19%. The flux densities at 5 and 8.4 GHz seem well correlated, although the radio spectral index ($\alpha$, where $S \propto \nu^{\alpha}$) is not constant within our errors: $\alpha$ varies by up to $3.2\sigma$.

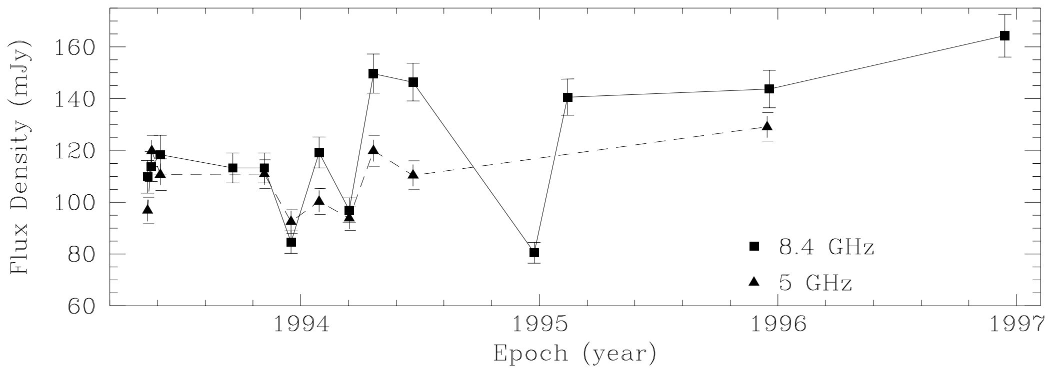


**Figure 1.** VLA flux density measurements

**Table 1.** Summary of the VLBI Model-Fitting Results at 8.4 GHz

| | | One Component Fit Elliptical Gaussian | | | Two Component Fit Elliptical Gaussian | | | Point Source | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | $S$ | Axes Maj. | Axes Min. | P.A. | Axes Maj. | Axes Min. | P.A. | % of $S$ | $r$ | $\theta$ |
| dd/mm/yy | mJy | mas | mas | ° | mas | mas | ° | | mas | ° |
| 16/05/93 | 114 | 0.44 | 0.17 | 58 | 0.40 | 0.18 | 57 | 5 | 0.57 | 74 |
| 16/12/93 | 85 | 0.44 | 0.21 | 50 | 0.42 | 0.17 | 46 | 5 | 0.61 | 81 |
| 21/06/94 | 146 | 0.61 | 0.18 | 45 | 0.48 | 0.17 | 41 | 14 | 0.58 | 51 |
| 12/02/95 | 141 | 0.44 | 0.19 | 50 | 0.44 | 0.13 | 50 | 6 | 0.87 | 45 |
| 18/12/95 | 144 | 0.43 | 0.23 | 49 | 0.40 | 0.17 | 61 | 13 | 0.62 | 57 |
| | | approximate standard errors | | | 0.05 | 0.05 | 5 | 2 | 0.10 | 10 |

Notes: $S$ are flux densities from VLA observations at 8.4 GHz; axis sizes are FWHM.

## 3. VLBI Imaging and Modelfitting

In our VLBI observations, the nucleus of M81 is only slightly resolved and somewhat asymmetrical (in agreement with Bietenholz et al. 1996). In Table 1, we give the results of fitting simple geometrical models to fully calibrated $u$-$v$ data.

We used the AIPS program OMFIT to simultaneously fit model parameters and determine the complex antenna gains. In the simplest case of fitting a single elliptical Gaussian, the size varies by 40%. The data, however, are not well described by such a model: in all cases, the fit is significantly improved if we fit, in addition to the central elliptical Gaussian source, a weaker point source at relative position $(r, \theta)$. Though our resolution is inadequate to determine the detailed source structure, the data clearly demand structure more complicated than a single elliptical Gaussian. Note that our conservative estimates of the uncertainties take into account any contribution from the fit time-variable antenna gains (a more complete description will be published elsewhere).

In summary, we find that there is structure on scales of $\sim 0.5$ mas in the nucleus of M81. It can be described as an elongated core, with a north-east south-west orientation, and a component of lower flux density to the north-east thereof. This latter component, in particular, appears to be variable on timescales of weeks.

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