

VLBI OBSERVATIONS OF M87

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On 1980 February 20 we conducted an 8-station intercontinental VLBI experiment in order to study the nucleus and jet of M87 at 1666.6 MHz in right circular polarization. Our array was sensitive to structures from 0.001 to 0.1 arcsec. We made a hybrid map of the nucleus of M87, and also searched for compact structures within the knots of the jet. The map (Figure 1) shows that the nucleus of M87 contains a one-sided jet. This morphology is similar to that observed in many compact extragalactic sources. The position angle of the nuclear jet is $290.5(\pm 1)$ degrees, which precisely matches that of the 20 arcsec jet. No bending of the jet through an angle greater than about 2 degrees is observed. The nucleus also contains a large component (>0.1 arcsec) which is elongated along the same position angle as the jet and has a flux density of roughly 1 Jy. This component is fully resolved by the vast majority of our (u,v) points, and we could not map it with standard techniques.

Assuming that the absence of a detectable counter-jet is due to the effects of relativistic beaming, one can place limits on the flow velocity of the jet, β , in units of the speed of light and the angle, θ , the jet makes to our line of sight. The ratio, R, of the observed intensity of the jet and counter-jet is given by $(1 + \beta \cos \theta) / (1 - \beta \cos \theta)$. Adopting $R=25$, appropriate for components 15 mas down the jet, requires both β and $\cos \theta$ to exceed 0.67. Other possible explanations for the absence of an observed counter-jet are that jets are intrinsically one-sided or that the observed emission from the

counter-jet is delayed (or advanced) by light travel times which exceed the lifetime of the jet emission. One crucial observation for the relativistic beaming model would be the detection proper motion within the nuclear jet. If observed components move with the jet flow, then a proper motion of 10 mas/yr would be expected and easily detected with a second epoch map.

In addition to the nucleus of M87, we mapped portions of the larger jet encompassing knots D and A which are 3.2 and 12.6 arcsec, respectively, from the nucleus. Neither knot was detected. We place upper limits of 25 mJy for any component less than 4 mas in size and of 0.2 Jy for a component less than 0.1 arcsec in size. Combining our results with recent VLA results suggests that the size of knot D is 0.2 ± 0.1 arcsec. Some theories suggests the existence of compact structures in the knots due to effects of shocks or limb brightening, whereas our observations indicate that the knot emission is fairly smooth.

Finally, we wish to point out the possibility of small wiggles in the nuclear jet. Data from our longer baselines are modeled slightly better by a jet that has a peak-to-peak oscillation of several mas perpendicular to its extent and a wavelength on the order of 10 to 20 mas than by a straight jet. Although a structure of this sort exists in the map (Figure 1), it is masked by the 8 mas restoring beam. Further observations are needed to confirm the reality of such wiggles in M87. It is interesting to note that there are published VLBI maps of extragalactic sources which also suggest wiggling jet structures (eg. 3C286 and 3C380).

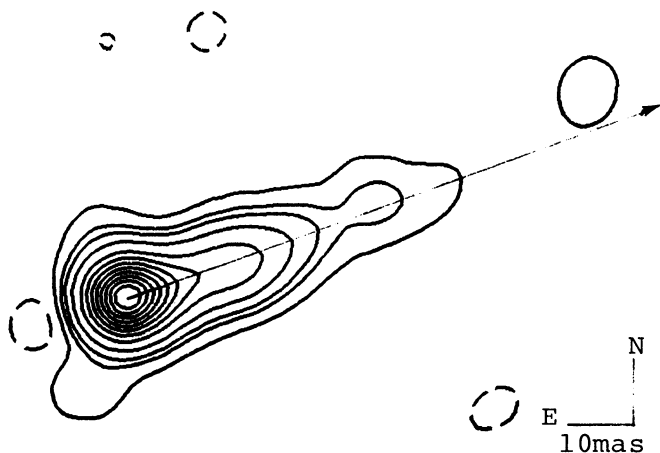


Fig. 1. Nucleus of M87 at 18 cm with an 8 mas beam. Line is $290^{\circ}5$ E of N. Contours are -1, +1, 3, 5, 10, 20, 30, ... , 90% of the peak temperature of 9.9×10^9 K.