THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

STEWARD OBSERVATORY

12 april '83

Dear Alan,

After 3 months still no referee's report. I have been bugging Abt, who bugged his secretary, who bugged the referee, who was travelling all the time (!?). I think it's Margaret, Arp or maybe Geoff himself. Anyway the Ap. J. office said it would be in 2 weeks from now.

I will send you a paper on 4C26.42 (A1795) in may and maybe a draft on 3C 277.3 in june. Meanwhile I will be at ① the VLA 12 - 24 april
20 - 25 june
② Bologna 26 june - 1 july
③ Dwingeloo 10 july - 15 aug.

Because Imke accepted a position as assistent professor in Berkeley I will move to Berkeley by the end of the year (to work in Jack Welch's group).

See you somewhere, sometime

Wil.

NATIONAL RADIO ASTRONOMY OBSERVATORY
EDGEMONT ROAD CHARLOTTESVILLE, VIRGINIA 22901
TELEPHONE 804 296 0211 TWX 510 587 5482

21 January 1983

Dear Martin,

I am enclosing a preprint of some VLA, WSRT and Kitt Peak observations which cast severe doubt on the credentials of the $\Delta v \sim 3400$ km/s system in DA240 as a "jet". As the velocity difference is sometimes quoted as evidence for a jet velocity of order 3400 km/s, I would urge caution in interpretation of this system at present.

With best regards,

Alan

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THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

STEWARD OBSERVATORY

17 jan. '83

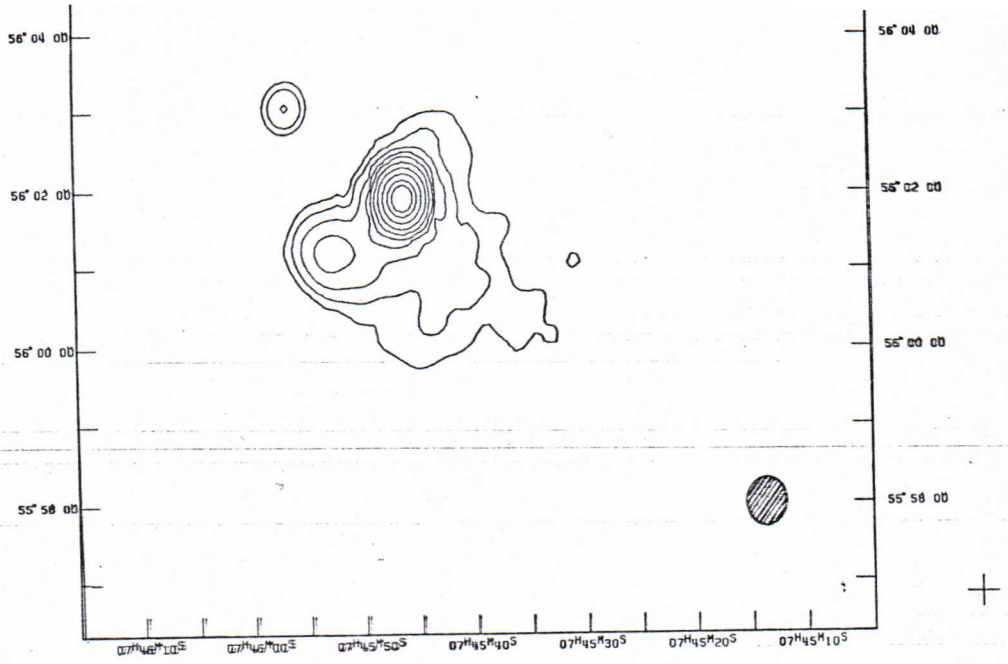
Dear Alan,

Enclosed the DA 240 paper, which I submitted to the Ap. J. last week friday. Also enclosed my paper on 3C 293 (submitted the same day) which may interest you. In fact, I expect you might be the referee! In any case your comments are welcom. Note that I have used two of your figures of the core of 3C 293. I hope you don't mind.

I am leaving for the VLA on jan. 19th & will stay there for ~3 weeks. In Feb/March I will be back in Tucson & working on our Coma A data.

Cheers,

Wil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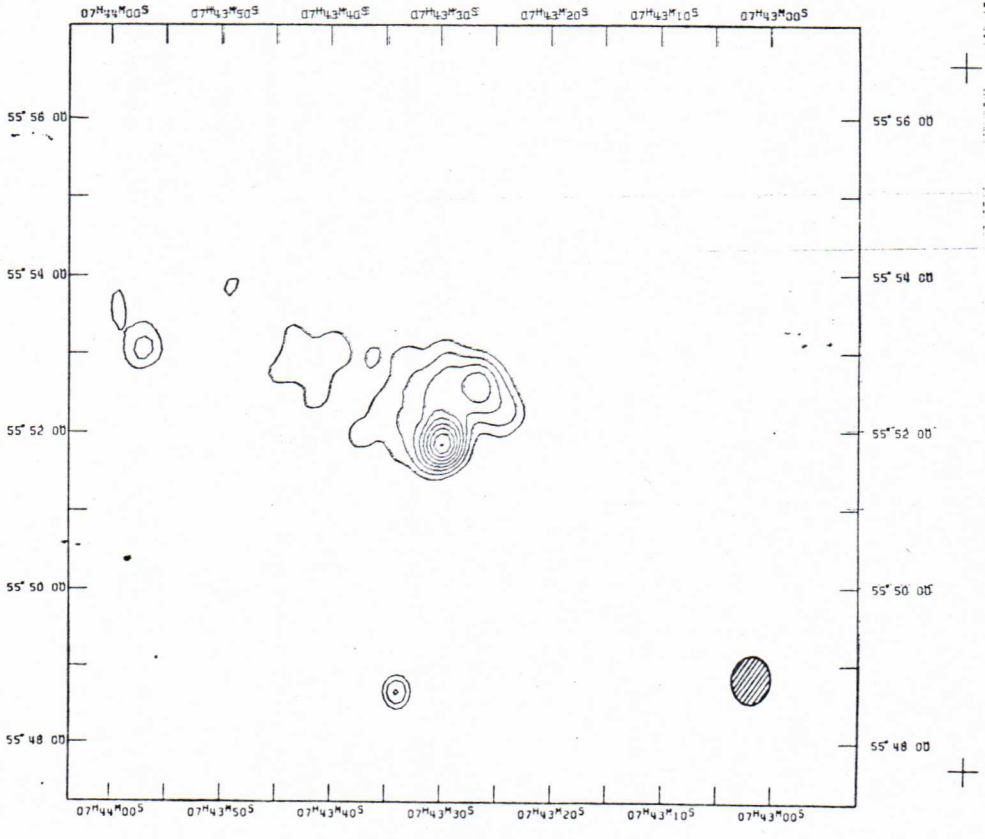
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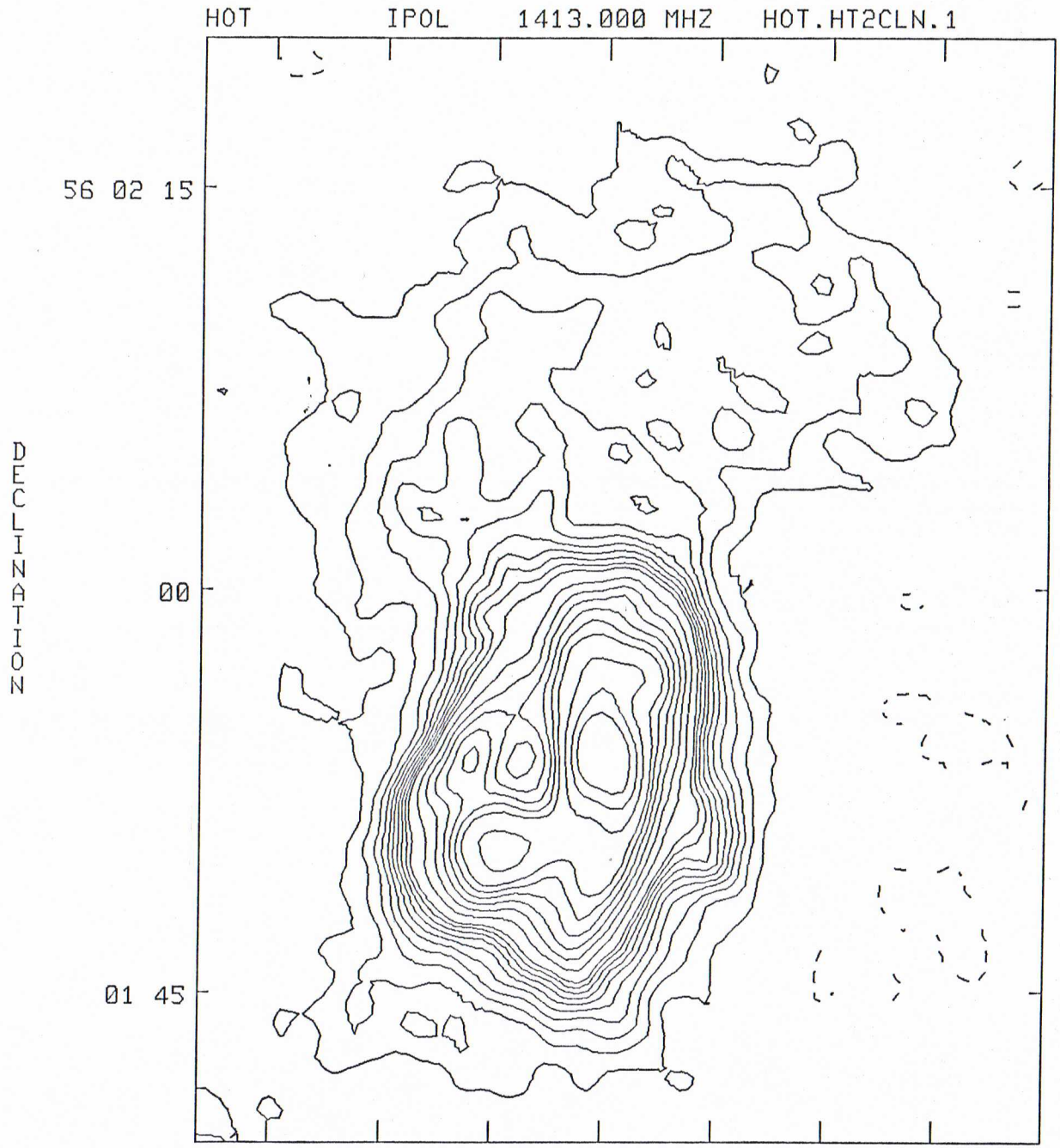

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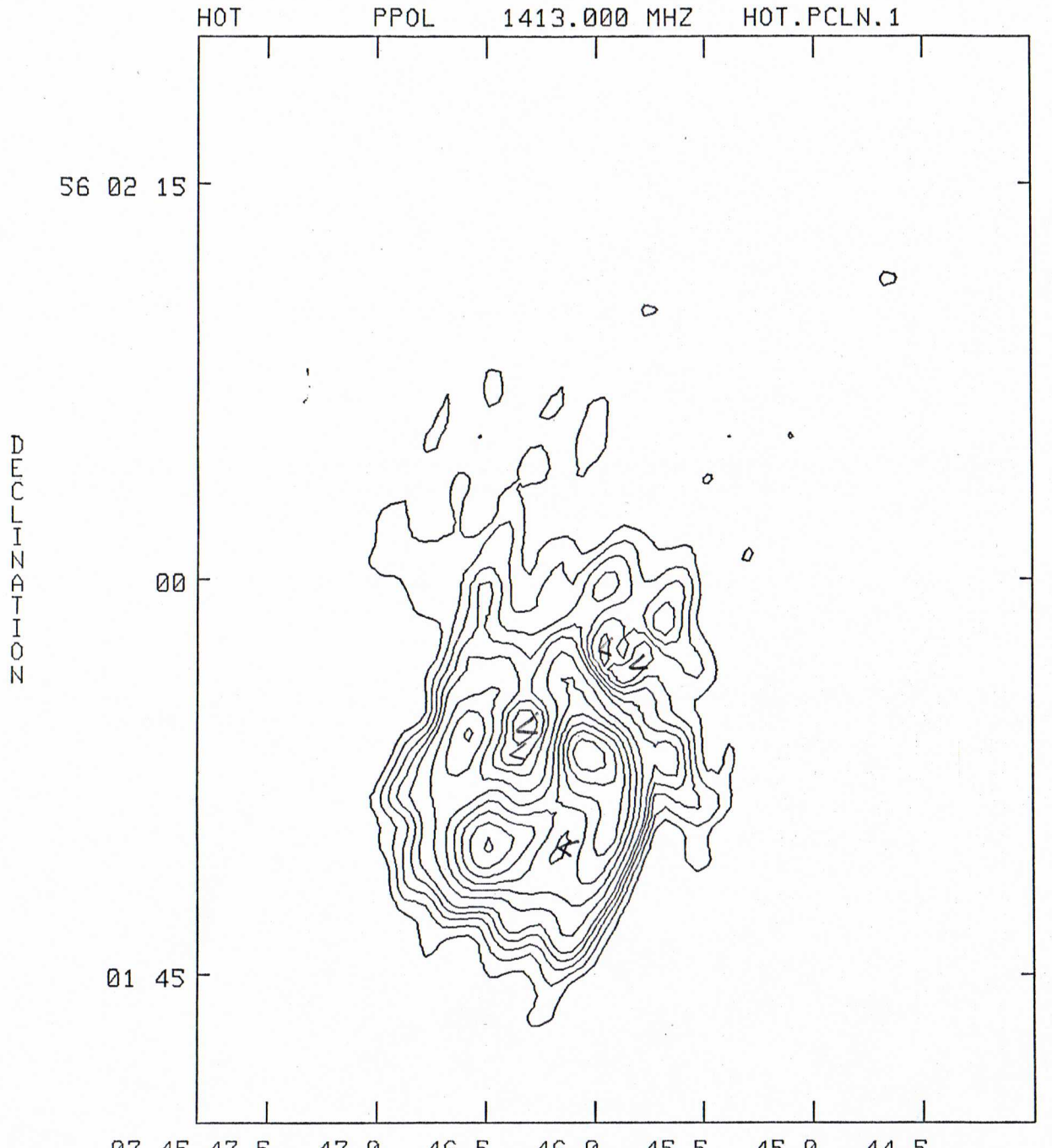

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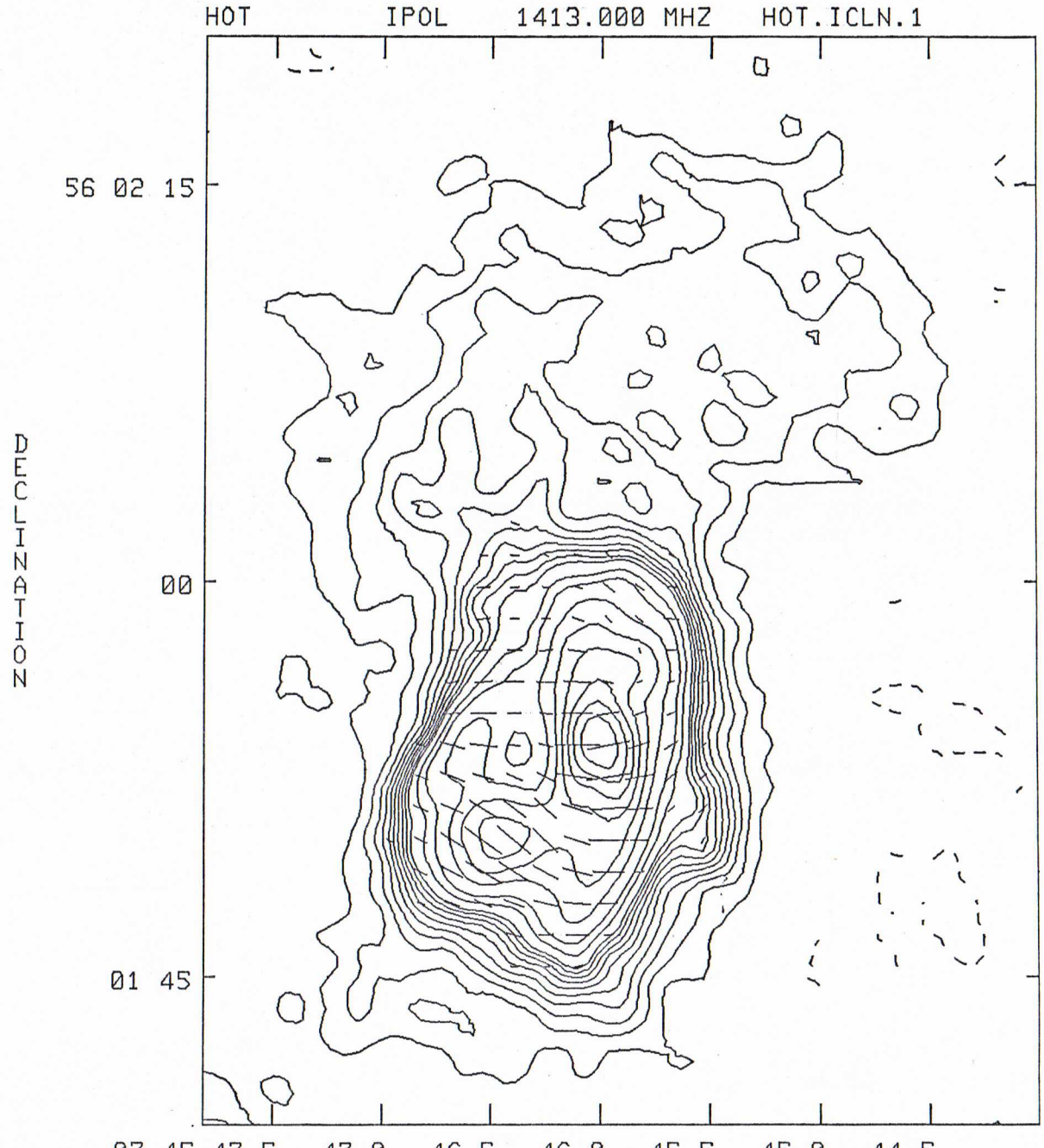

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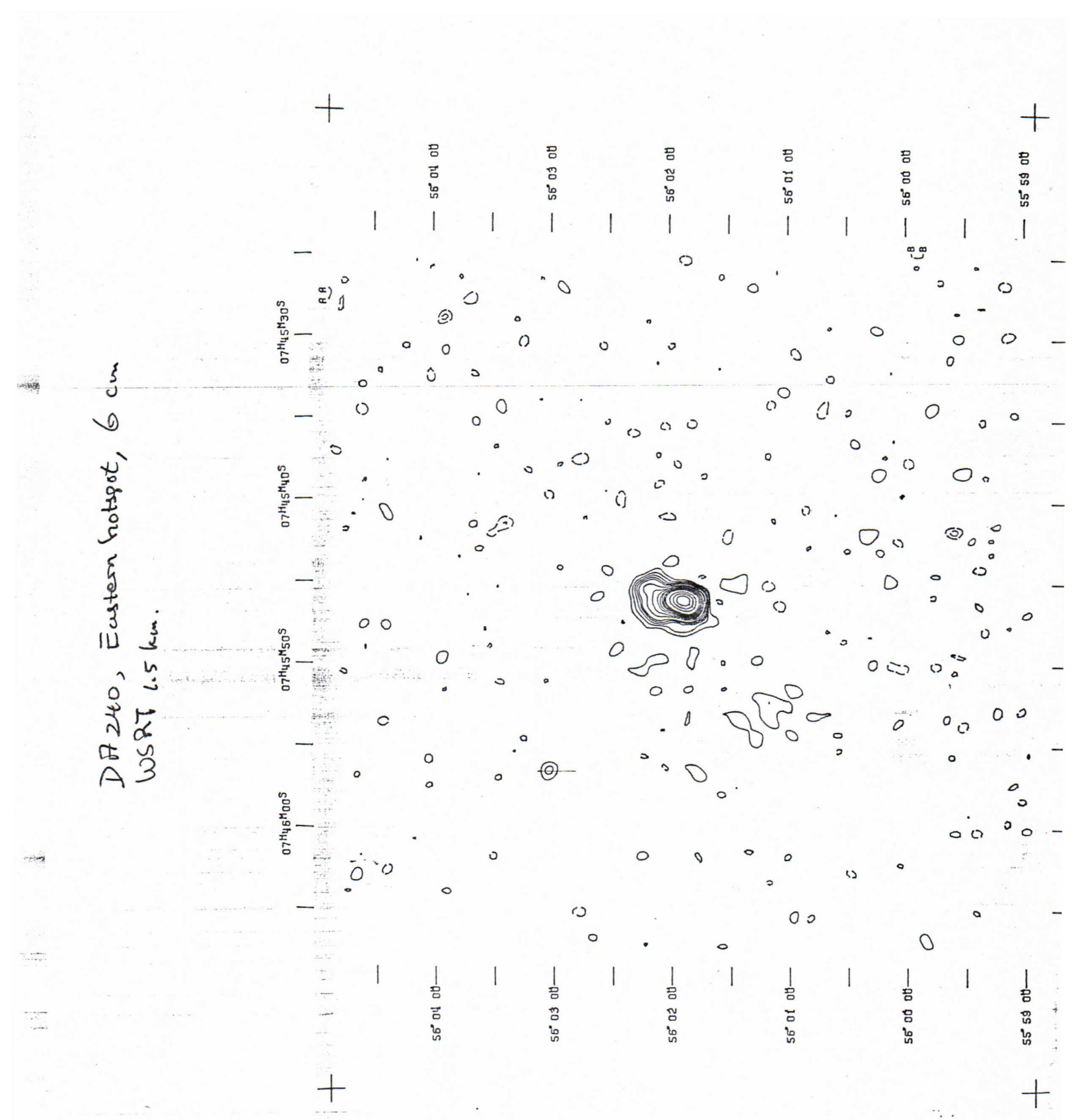
80.0 90.0)



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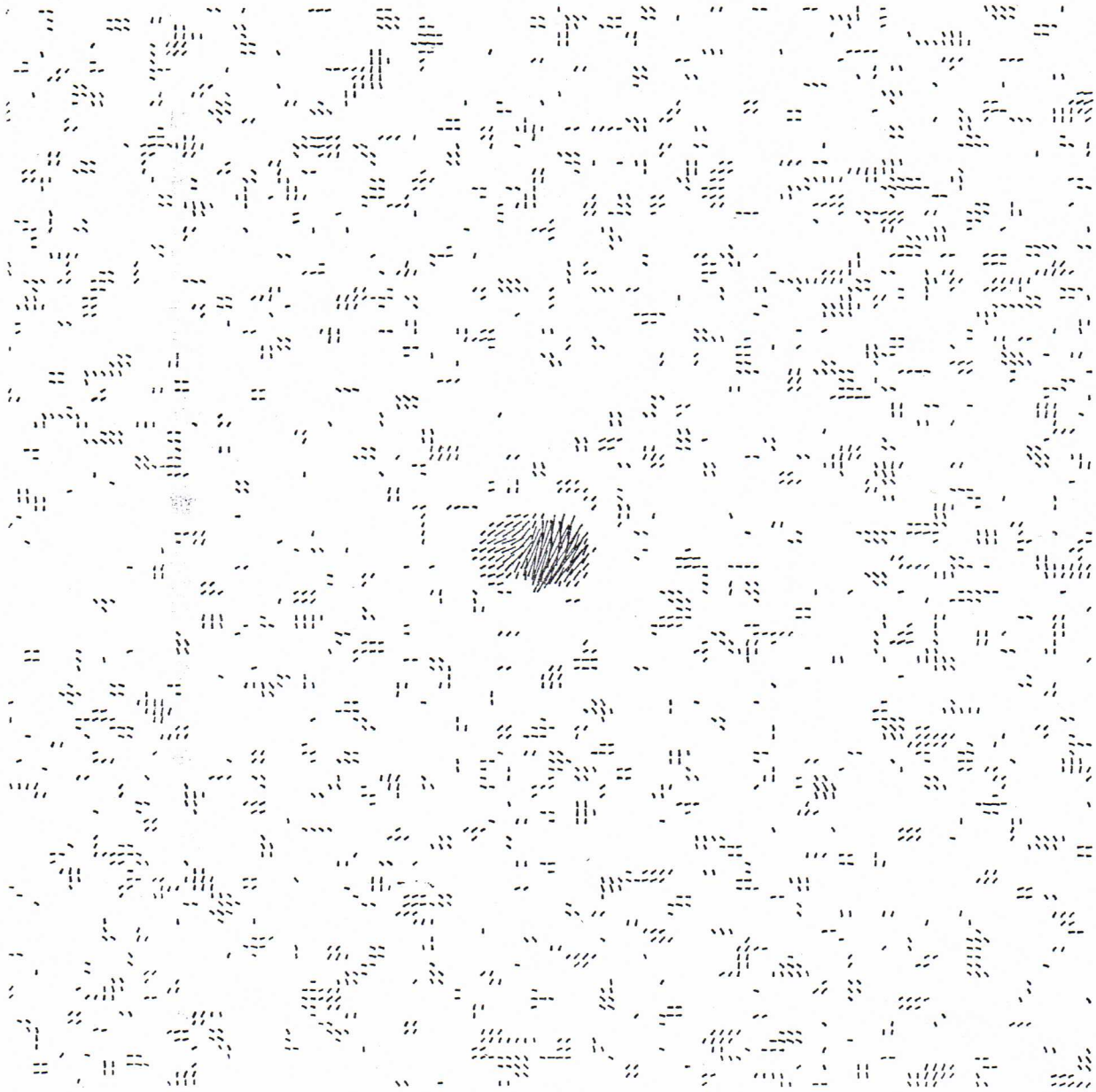

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THE ASTROPHYSICAL JOURNAL, 199:L137–L138, 1975 August 1

A JET IN THE GALAXY IDENTIFIED WITH THE RADIO SOURCE DA 240

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Received 1975 March 28

ABSTRACT

The galaxy MCG 9-13-66 associated with the large radio source DA 240 has been shown to contain a large jet with a featureless spectrum somewhat bluer in color than the galaxy, oriented at 62° to the axis of radio emission. Observations made at Kitt Peak National Observatory and Lick Observatory are described.

Subject headings: galaxies, individual — radio sources

I. INTRODUCTION AND OBSERVATIONS

It has recently been shown that the radio sources 3C 236 and DA 240 are exceedingly large, with dimensions of about 5.7 Mpc and 2.1 Mpc, respectively (Willis, Strom, and Wilson 1974). While it is known that many optical galaxies identified as the sources of powerful radio emission show no morphological peculiarities, we decided that it was worthwhile to obtain direct photographs of the galaxies identified with 3C 236 and DA 240.

Three plates of each galaxy were obtained by one of us at the prime focus of the 4-m reflector at the Kitt Peak National Observatory. While the galaxy identified with 3C 236 appears to be a normal elliptical, the galaxy identified with DA 240, no. 9-13-66 in the *Morphological Catalog of Galaxies* of Vorontsov-Velyaminov and Arhipova (1964), shows a large knotty jet extending S, together with a weaker, more extended asymmetric halo of nebulosity on the S side, around the jet. An indication of the existence of this jet can be seen on the *National Geographic Sky Survey–Palomar* prints, particularly on the O print. The long axis of the radio emission is in position angle 63° ± 1°.

Reproductions of two plates of MCG 9-13-66 are shown in Figure 1 (Plate L10). The red plate was a 60-min exposure on nitrogen-baked Kodak 127-2 emulsion through a GG 495 filter. The "blue" plate was a 45-min exposure on nitrogen-baked IIIa-J emulsion through a GG 385 filter.

The jet has structure; there are two condensations 9″ and 15″ from the center of the galaxy. The extent of the jet is about 16″ in position angle 181° ± 1°. The extended luminosity farther out around the jet is smooth on the red plate but has a lumpy spiral-arm–like structure on the blue plate. Both plates show what may be a companion galaxy of low surface brightness about 70″ SW of MCG 9-13-66. Several nonstellar images can be seen around the galaxy on the red plate, particularly two about 20″ W of it. These do not show on our single IIIa-J plate but are real since they appear on the second 127-2 plate, and they appear distinguishably nonstellar in comparison with nearby stellar images, despite the fact that the seeing was not of high quality.

The spectra of the jet and of the nucleus of the galaxy over the wavelength range 3400–7100 Å were observed with the image dissector scanner (Robinson and Wampler 1972) at the Cassegrain focus of the Lick Observatory 3-m telescope, on 1974 November 17 and 19. A 2″ × 2.″4 slit was used and the usual 8-min chopping between object and sky. The nuclear spectrum is not unusual compared with other "normal" radio galaxies at low redshift, showing emission lines of [O II] λ3727, [N II] λλ6548, 6584, and Hα in addition to the stellar absorption features of Ca II, the G band, Mg *b* band, and Na I normally seen in the nuclei of elliptical galaxies. [N II] λ6584 is stronger than Hα. We obtained a redshift $z = 0.035$ in good agreement with the value of $z = 0.0356$ obtained by M. Schmidt, quoted by Willis *et al.* (1974).

The spectrum of the jet is continuous, showing no features with equivalent widths $W_\lambda \gtrsim 3$–4 Å, and is somewhat bluer than the spectrum of the nucleus. In the nucleus we derive colors on the scanner system of $U - B = 1.15$, $B - V = 1.19$ through the 2″ × 2.″4 slit, while in the region scanned in the jet, about 8″–9″ from the galaxy center, we derive colors of $U - B = 0.66$, $B - V = 0.86$. No attempt has been made to correct these colors for starlight in the smooth extended luminosity distribution of the galaxy which was also admitted through the aperture. As they stand, these colors, if fitted to a power law $F_\nu \propto \nu^{-\alpha}$ spectrum, correspond to a spectral index $\alpha = 3.0$ over the range 3400–7000 Å.

II. DISCUSSION

It is well known that optical jets associated with radio sources are rare, the best known cases studied previously being the jet in M87 (Curtis 1918; Felten, Arp, and Lynds 1970) and the jet in 3C 273 (Greenstein and Schmidt 1964). The jet in MCG 9-13-66 is much brighter relative to the main body of the object than is the case in either M87 or 3C 273, and extends 17 kpc from the center (for $H = 50$ km s^{-1} Mpc^{-1}).

No spectrum lines have been detected in the other

* Visiting astronomer at Kitt Peak National Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

jets mentioned above (Humason, quoted by Baade and Minkowski 1954; Arp 1967; Greenstein and Schmidt 1964), and it is well known that the high linear polarization measured in the jet in M87 (Baade 1956; Hiltner 1959) led to the conclusion that it is optical synchrotron radiation (Shklovsky 1955; Burbidge 1956). It is desirable that polarization measures be made in the jet of the galaxy identified with DA 240. It would not be surprising if linear polarization were found in this jet. This would suggest that it also is an optical synchrotron source.

One feature of some interest is that the jet is oriented at a large angle of 62° with respect to the major axis of the radio source. It is natural to suppose that the violent event(s) which gave rise to the jet and the radio source are related. The alignment between small-scale and much larger-scale radio and optical structures in some radio sources suggests that the galaxy often continues to eject matter along a well-defined axis in its own rest frame. In this case the optical jet and the major axis of the radio source are not aligned. This might suggest that we are observing the galaxy roughly pole-on and it has rotated by a large angle since the ejection of the matter responsible for the radio source. Alternatively, it is necessary to argue that ejection does not always follow a well-defined path in the galaxy. It might be of interest to look for compact radio sources along the axis defined by the jet, as well as in the lobes of the extended radio sources.

We are indebted to S. O'Dell for helpful discussions and to D. Crowne for making the reproductions. Extragalactic research at UCSD is supported in part by grants from the National Science Foundation and by NASA through grant NGL 05-005-004.

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E. Margaret Burbidge, G. R. Burbidge, and Harding E. Smith: Department of Physics, C-011, University of California, San Diego, P.O. Box 109, La Jolla, CA 92037

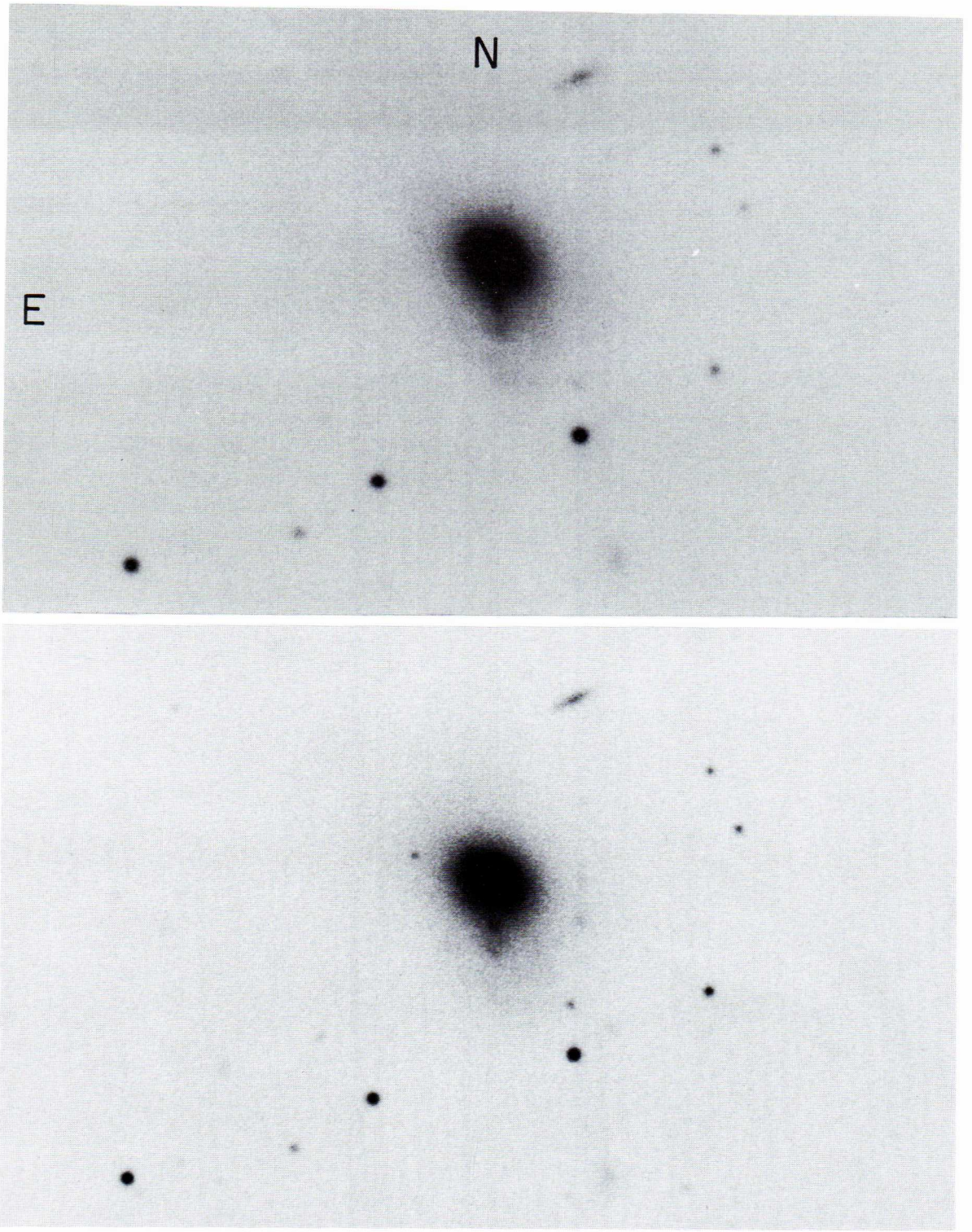

FIG. 1.—Galaxy at center of large radio source DA 240, showing jet. *Upper*, IIIa-J ("blue") plate; lower, 127-2 (red) plate. Upper plate is printed darker to show outer arm–like structure outside jet. Plates obtained at prime focus of the 4-m telescope at Kitt Peak National Observatory. Scale: 1 cm = 13″.25.

BURBIDGE *et al.* (*see* page L137)