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OPTICAL POLARIZATION IN THE NUCLEUS OF M87

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ABSTRACT

Heeschen's discovery of significant linear polarization in the ultraviolet radiation of the nucleus of M87 (NGC 4486) is confirmed. There is evidence that this polarization is variable.

Subject headings: galactic nuclei — galaxies, individual — polarization

Heeschen (1972) searched the nuclei of selected radio galaxies for linear polarization at optical wavelengths. He found a significant amount in the ultraviolet in M87 (NGC 4486). More observations seemed desirable not only for confirmation but also because Graham (1971) reported that the very compact radio source in the nucleus of M87 is variable at 5 GHz.

The same sky-compensated polarimeter (Dyck and Sandford 1971) used by Heeschen with the Kitt Peak 2.1-m telescope was used again for observations in 1972. However, an I.T.T. FW129 type photomultiplier with S-11 response replaced the FW130 type with S-20 response used earlier, and the copper sulfate filter needed to suppress the red response of the S-20 tube was omitted. In 1972 the nucleus was centered in the diaphragm using a Westinghouse SEC vidicon television camera, whereas in 1971 the centering was done visually. Observations were restricted to within 1 hour of the meridian to minimize the effects of atmospheric dispersion.

Mean values of the percentage polarization (p) and position angle (θ) were obtained from the mean values of the Stokes parameters and are given as a function of the diaphragm diameter (d) for 1971 and 1972 in table 1. As Heeschen found, the observed degree of polarization increases with decreasing diaphragm size, as would be expected if the nucleus contains a compact source of polarized light and the light from the galaxy (presumably starlight and $\lambda 3727$ emission in the U passband) is unpolarized. We would not expect this result if the observed polarization were simply caused by light scattered into the diaphragm from the highly polarized jet. A measure (with the U filter) of the star BD$+13°$ 2545 which is 6′ north of M87 gave $p = 0.63 \pm 0.16$ percent and $\theta = 70° \pm 7°$; the contribution of interstellar polarization in our own Galaxy to the observed value of p is therefore quite small.

The normalized Stokes parameters ($Q/I = p \cos 2\theta$, $U/I = p \sin 2\theta$) are shown for the individual observations made with the smallest diaphragm in figure 1. Here the line joining a point to the origin equals the percentage polarization (p), and the azimuth of this line measured clockwise from the positive Q/I axis equals 2θ. Observations 1, 2, 3, 5, 6, and 7 all have comparable values of p, but observations 4, 8, and 9 (all in 1972) have distinctly lower values. The counting rates for these latter three observations were also lower than for the other 1972 observations, and this was probably caused by either poorer seeing or inferior guiding. The difference in mean p between the 1971 and 1972 observations is therefore likely to have resulted from seeing or guiding errors. The measured position angle should be little influenced by such errors, however, and this suggests that the difference in mean position angle of

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TABLE 1

MEAN VALUES OF THE POLARIZATION ELEMENTS IN 1971 AND 1972 AS A FUNCTION OF THE DIAPHRAGM (d) IN SECONDS OF ARC

	1971			1972		
d	p (%)	θ (degrees)	n*	p (%)	θ (degrees)	n*
3″2	5.5	137	3	3.1	113	6
6″4	2.4	140	4	1.1	109	2
10″2	0.9	126	2	0.7	116	1

* Number of observations.

over 20° between the 1971 and 1972 observations was caused by a variation in the source.

The jet of M87 was shown to be polarized by Baade (1956), and later Hiltner (1959) mapped the polarization of the jet photoelectrically using an unfiltered RCA 1P21 photomultiplier. He found that the inner and outer of the bright jet condensations were polarized with position angles (113°8 and 125°8) roughly parallel to the jet while the position angle of the central condensation (37°1) was perpendicular to this. The position angle of the jet is about 290° or 110°. Hiltner found 1.6 percent polarization at position angle 123°, but he did not regard this observation as statistically significant. He noted that with his unfiltered S-4 photocathode, a correction for the effect of the stellar background radiation from M87 would approximately double the observed polarization of the jet condensations of 10 percent to give a true

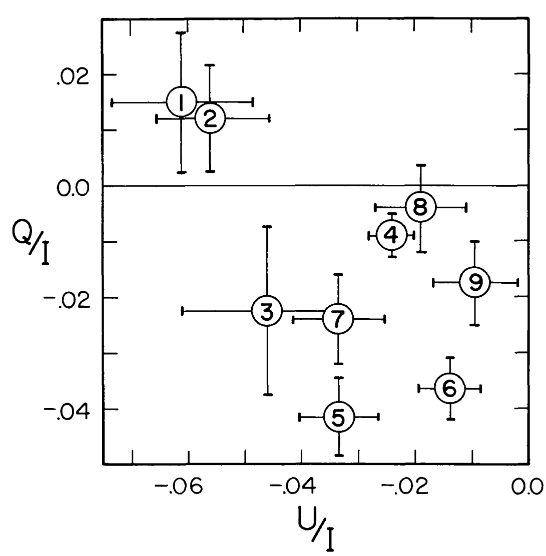

FIG. 1.—Normalized Stokes parameters (*ordinate, Q/I; abscissa, U/I*) for observations of the nucleus of M87 made through a 3″2 diameter diaphragm. The error bars give the nominal rms errors. The numbers refer to the following UT dates and observers and photocathodes: (1) Heeschen, 1971 March 25 (S-20); (2) Heeschen, 1971 March 27 (S-20); (3) Kinman, 1971 April 23 (S-20); (4) Kinman, 1972 March 9 (S-11); (5) Kinman, 1972 March 10 (S-11); (6) Kinman, 1972 March 10 (S-11); (7) Kinman, 1972 March 11 (S-11); (8) Kinman, 1972 March 11 (S-11); (9) Kinman, 1972 March 11 (S-11).

value of about 20 percent. In the brighter nucleus, such a correction would be considerably larger.

The U-magnitude of the nucleus of M87 within a 3″.2 diaphragm is roughly 16.0. If, like the jet condensations, the compact source in the nucleus is actually 20 percent polarized (which is also comparable to the largest values of p found in QSOs), then this nonthermal source will have a U-magnitude of about 17.5 and have roughly one-tenth of the optical brightness of the rest of the jet system. The coincidence of the position angles of the polarized radiation in both jet condensations and nucleus and the similarity to the general orientation of the jet suggests that a single ordering phenomenon is common to the whole system.

More optical data are needed to confirm the variability of this nuclear source. Hogg (1972) reported that the nuclear component has no polarization greater than 0.5 percent at 11.1 cm, but data at shorter wavelengths would be valuable. Meaningful comparisons between observations at different wavelengths become possible when, as here, the radiation at both wavelengths can be shown to come from the same small volume of space.

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