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ADDITIONAL OCCULTATION STUDIES OF WEAK RADIO SOURCES AT ARECIBO OBSERVATORY: LIST 4

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ABSTRACT

Positions, structures, and optical identifications are derived from the lunar-occultation observations of ten weak radio sources.

I. INTRODUCTION

This paper gives the positions, structures, and optical finding charts for a further ten sources observed in the occultation program of the Arecibo Observatory. The radio and optical data are presented in Tables 1, 2, and 3 with their associated notes. Details of the methods of observation and analysis, together with a discussion of the format used for the presentation of the data, may be found in the first two papers of this series (List I: Hazard, Gulkis, and Bray 1967; List II: Hazard, Gulkis, and Sutton 1968). Positions, structures, and suggested identifications for other sources studied in the occultation program are given in List III (Gulkis, Sutton, and Hazard 1969).

II. NOTES ON THE SUGGESTED IDENTIFICATIONS

Finding charts for region of sky around each source are given in Figure 1 (Plate 3). Where an identification is suggested, its position is indicated by the solid lines; where no identification is proposed, the solid lines indicate the position of the radio source.

a) AO 0036+03

The identification of this source with a bright elliptical galaxy has already been suggested by Clarke, Bolton, and Shimmins (1966). At the time of occultation, the limb of the Moon was found to pass through the center of the galaxy within the limits of error of the position measurements ($\pm 10''$). Since the size of the main body of the optical galaxy perpendicular to the limb is about $45''$, this suggests that the radio source is coincident with the galaxy. The estimated width of the radio source between half-brightness points is $\approx 12''$, and its overall extent is about $22''$, which further shows that the radio emission is contained within the optical perimeter of the galaxy and is more highly concentrated at the center than the optical emission. The possibility that there is structure within the radio source, however, cannot be excluded.

* Operated by Associated Universities, Inc., under contract with the National Science Foundation.

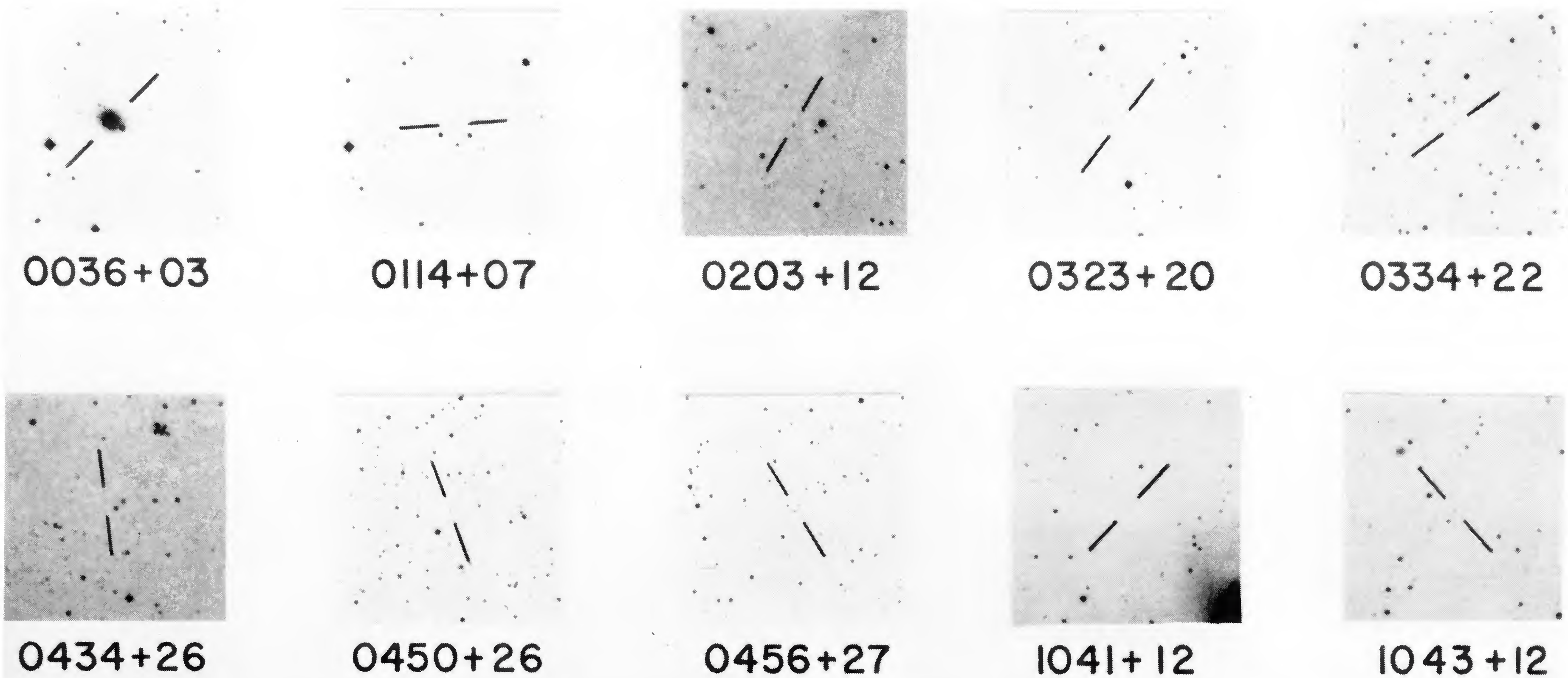

FIG. 1.—Regions of the sky around ten occulted radio sources. Photographs are enlargements of the *Palomar Sky Survey* plates and are approximately 9′ square. Each optical identification is marked by the solid lines on a plate whose color is the same as that of the proposed identification (Table 3).

LANG *et al.* (*see* page 17)

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TABLE 1

POSITIONS OF TEN WEAK RADIO SOURCES DERIVED FROM OCCULTATION OBSERVATIONS AT 430 MHz

Source	Number of Occultation Curves	Radio Position (1950.0) Right Ascension	Error (±)	Declination	Error (±)	Notes
AO 0036+03, 4C 03.1, PKS	1	00ʰ36ᵐ43ˢ.8	1ˢ.1	03°03′41″.0	2″	Positional accuracy: ±2″ in P.A. 2°. R.A. is taken from Shimmins (1968).
AO 0114+07 (A), 4C 07.4, PKS	2	01 14 50.41	0.05	07 25 57.0	1	
AO 0203+12	2	02 03 36.2	0.3	12 57 53	5	Double source; position quoted is that of the centroid of emission.
AO 0323+20	2	03 23 30.5	0.2	20 53 07.5	3	
AO 0334+22, 4C 21.12	1	03 34 30.2	...	22 00 25.6	...	Positional accuracy: ±1″ in P.A. 225°. R.A. is taken from Pilkington and Scott (1965).
AO 0434+26	2	04 34 52.01	0.1	26 21 34.3	2	
AO 0450+26, 4C 26.17	2	04 50 45.36	0.6	26 30 04.7	10	Position at 195 MHz.
AO 0456+27, 4C 27.14	1	04 56 49.4	...	27 01 22.3	...	Positional accuracy: ±1″ in P.A. 271°. ±24″ in P.A. 181°. Position obtained by using scaling technique.
AO 1041+12	1	10 41 40.0	...	12 02 00	...	Positional accuracy: ±1″ in P.A. 327°. R.A. is Arecibo pencil-beam position.
AO 1043+12	2	10 43 48.3	0.3	12 27 02.0	3	

TABLE 2

STRUCTURAL DATA AT 430 MHz FOR TEN RADIO SOURCES DERIVED FROM OCCULTATION OBSERVATIONS

Source	Approximate Flux Density at 430 MHz ($\times 10^{-26}$ W m^{-2} MHz^{-1})	Spectral Index n ($S \propto f^{-n}$)	Angular Size*	Notes on Structure†
AO 0036+03	3.8	0.7	≈12″ in P.A. 2°	Weak or nonscintillator.
AO 0114+07 (A)	2.9	0.7	70 percent of flux in component A, ≤0″.8 in P.A. 34°, ≤2″ in P.A. 234°	Component B of ≈30 percent of flux is ≈15″ from A along P.A. 110°. 20 percent flux ≤2″.‡ Scintillator: ≈60 percent of flux ≈0″.15 in P.A. 247°.
AO 0203+12	0.9	...	≈29″ in P.A. 65°, ≈24″ in P.A. 210°	There are two components of ≈7″ in angular size and of equal flux, separated by ≈15″ at both position angles. Weak or nonscintillator.
AO 0323+20	0.7	0.7	≈2″.5 in P.A. 253°	Possible double with a component separation of ≈2″.
AO 0334+22	1.3	0.7	≈2″ in P.A. 224°	Weak or nonscintillator.
AO 0434+26	2.0	...	≈2″.5 in P.A. 49°, ≈2″.3 in P.A. 267°	Weak or nonscintillator.
AO 0450+26	1.2	0.7	≈9″ in P.A. 72°, ≈9″ in P.A. 77°	This observation taken at 195 MHz.
AO 0456+27	1.7	0.9	≤0″.4 in P.A. 271°	Scintillator: ≈50 percent of flux ≤0″.16 at P.A. 291°.
AO 1041+12	0.6	0.3	≈1″ in P.A. 297°	
AO 1043+12	0.7	0.7	≤2″ in P.A. 91°, ≤2″ in P.A. 351°	

* Minimum restoring beam in this analysis was 0″.8. The resolved sources have a majority of their flux in a component whose full width at half-maximum is the angular size. For complex sources the quoted angular size refers to the overall extent and not to the small-scale structure, unless these are specifically given.

† Scintillation data are taken from Harris and Hardebeck (1969).

‡ Compare Lang (1969).

TABLE 3

POSITIONS OF OPTICAL IDENTIFICATIONS*

Source	Optical Position: Right Ascension	Optical Position: Declination	Approximate m_{pg}	Type of Object	Notes
AO 0036+03	00h36m44s.0	03°03′41″	13	Elliptical galaxy, red	Previously identified by Clarke *et al.* (1966).
AO 0114+07(*a*)	01 14 50.4	07 26 00	18	Galaxy, red	Object *b* is the identification suggested by Clarke *et al.* (1966). Object *a* lies closer to the occultation position. There is a second faint nebulosity close to *a* in P.A. 135°.
(*b*)	01 14 49.535	07 26 30.30	18	Stellar, blue	
AO 0203+12	02 03 36.2	12 58 09	17	Galaxy, red	
AO 0323+20	...	...	...	...	
AO 0334+22	03 34 30.4	22 00 44	18	Galaxy, red	No other object within 1′.
AO 0434+26(*a*)	04 34 52.1	26 21 42	18	Galaxy, red	Object *a* is the probable identification.
(*b*)	04 34 50.4	26 21 36	16	Star? red	
AO 0450+26	04 50 45.0	26 30 10	18	Galaxy, red	
AO 0456+27	04 56 49.4	27 01 42	18	Galaxy, red	The position given is that of object *b* in Fig. 3.
AO 1041+12(*a*)	10 41 37.7	12 01 54	20	Galaxy, red	
(*b*)	10 41 38.4	12 02 26	20	Galaxy, red	
AO 1043+12	10 43 49.4	12 27 03	18	Stellar, blue	The blue object in position angle 136° is probably a plate flaw.

* Except for AO 0114+07 (cf. Lu 1969), the optical positions and photographic magnitudes have estimated peak errors of 10″ and 1 mag, respectively.

b) AO 0114+07

The suggested identification is with the faint red galaxy indicated in Figure 1 (Pl. 3). A blue stellar object about 33″ north of the radio position, preceding the galaxy by about 14″, has been suggested as the identification by Clarke, Bolton, and Shimmins (1966). As the optical and radio positions of identified sources do not always coincide, their suggested identification with the blue stellar object cannot be excluded. However, the close agreement of the occultation position with that of the galaxy makes the galaxy the more probable identification.

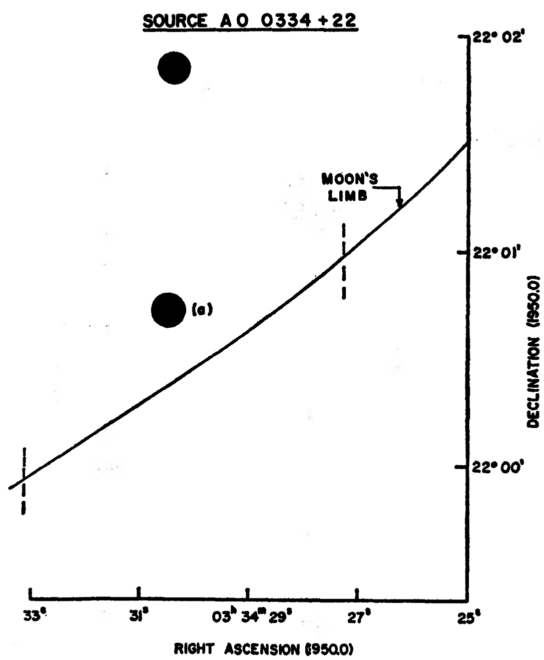

FIG. 2.—Section of the limb of the Moon near the point of occultation of AO 0334+22. Broken lines indicate 3 standard deviations of error about the estimated 4C R.A.

c) AO 0203+12

The only object close to the radio position is the red galaxy indicated on Figure 1. It lies about 20″ from the center of the radio emission, but is possibly coincident with one of the two source components. The low signal-to-noise ratio of the restored distributions prevents an accurate measurement of their positions. In addition to the suggested identification, there is a very blue object, not visible on the red plates, about 54″ north of the radio position, 7″ preceding.

d) AO 0323+20

No object above the plate limits lies within 40″ of the radio position.

e) AO 0334+22

The section of the limb along which the source must lie is shown in Figure 2, together with the limits of error of the 4C right ascension (Pilkington and Scott 1965). Although object *a* lies further from the limb than the combined radio and optical positional errors, it is suggested as the possible identification.

f) AO 0434+26

The faint galaxy indicated in Figure 1 is the probable identification. The only other possibility appears to be the south-preceding brighter red object, about 40″ from the radio position.

g) AO 0450+26

There are several faint galaxies near the radio position. The brightest of these is suggested as the probable identification.

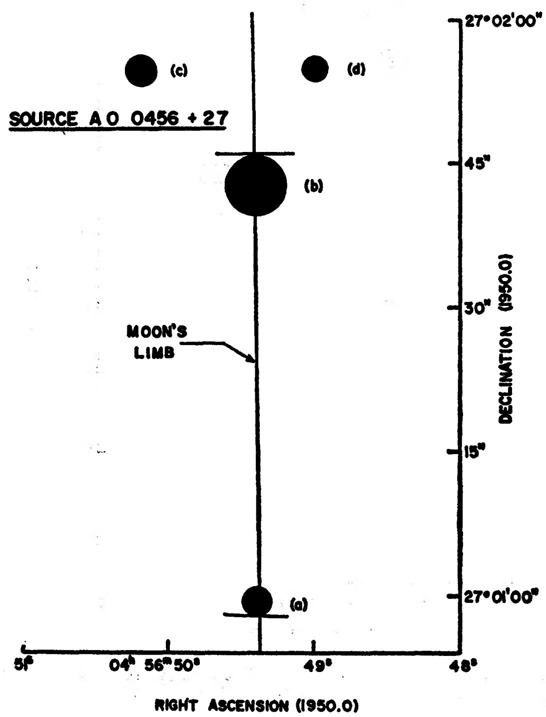

FIG. 3.—Section of the limb of the Moon near the point of occultation of AO 0456+27. Solid lines perpendicular to limb represent limits to the position along the limb determined by the scaling technique.

h) AO 0456+27

The section of the limb in the region of the radio source is shown in Figure 3. It runs through a small group of objects (*b*, *c*, and *d*), and through a faint galaxy *a*, object *c* being the bluest of the four objects. However, only objects *a* and *b* lie close to the limb and along that section defined by the scaling technique. Of these, *b* is considered the most probable identification.

i) AO 1041+12

Figure 4 shows the section of the limb along which the source must lie, the error rectangle defined by the measurement of pencil-beam position, and the positions of all optical objects close to the limb. The only objects which lie close to the limb and inside the error rectangle are the two faint galaxies *a* and *b*, and it is these objects which are indicated in Figure 1.

j) AO 1043+12

The blue stellar object indicated in Figure 1 is the probable identification. The brighter south-following blue object is not visible on the red plate and is almost certainly a plate flaw.

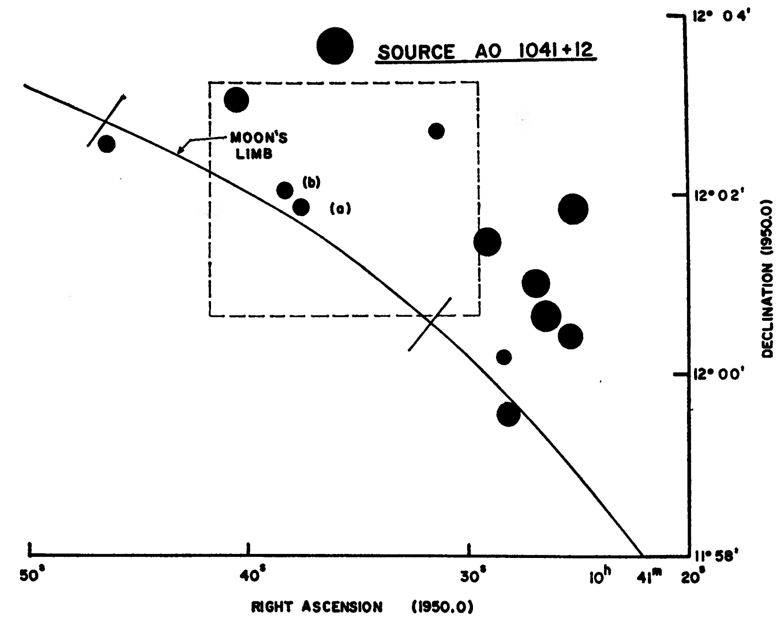

FIG. 4.—Section of the limb of the Moon near the occultation of AO 1041+12. Broken rectangle indicates 3 standard deviations of error about the mean pencil-beam position at 430 MHz. Solid lines indicate 3 standard deviations of error about the R.A. at 1400 MHz.

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