only poorly correlated with a polarity change due to any events, whether the event is idenfied or only apparent.
21. Supported by grants GA 523 and GA 602 from NSF. We thank Dr. J. D. Hays of Lamont Geological Observatory of Columbia University for a preprint of one of his papers (6).

30 March 1967

Observations of the Andromeda Galaxy at 11-Centimeter Wavelength

Abstract. *Observations of the Andromeda galaxy (M31) at 2695 megahertz reveal more detail than do earlier measurements at lower frequency. The region is highly confused but there is apparently a more dense clustering of sources within the optical outline of the galaxy than without. One source (OA33) near M31 has an interesting, flat spectrum.*

During August 1966, the 140-foot (42.7-m) radio telescope (*1*) at Green Bank was used to observe M31, the Andromeda galaxy, at a frequency of 2695 Mhz. The principal result of these observations is the map of Fig. 1, in which the discrete sources are superimposed upon a simplified optical isophote derived from the dimensions given by Holmberg (*2*). The general background radiation has not been drawn in; at 0.02°K antenna temperature and below, the radio isophotes become very difficult to describe because of noise and complex low-level radiation from the region of M31. Derived fluxes of the discrete sources have a corresponding uncertainty of 0.05 flux unit.

Comparison of this map with earlier maps at lower frequencies shows only general similarity. The 1415-Mhz map by Kraus *et al.* (*3*) was made with a fan-shaped beam which blends sources with the same right ascension and small declination differences. Similarly, the map by MacLeod (*4*) and by Dickel *et al.* (*5*) at 610 Mhz was made with an antenna beamwidth of 16′ (arc) which blends sources in a different way than does the 11′ beam used in the present survey. Comparison of the source positions obtained at these three frequencies shows good agreement for sources outside the optical outline of the galaxy and rather poor agreement within the optical outline. This discrepancy is presumably due to the different ways in which multiple sources are blended by the various telescopes. Outside the galaxy, the sources tend to be isolated. This fact suggests that some, at least, of the "interior" sources may actually be associated with M31. Beam blending of the complex of sources near and within the optical image of M31 may also account for the appearance of a "halo" in those radio maps (*6*) derived from wide-beam observations.

Spectral indices have been computed from the 610- and 2695-Mhz flux densities. These are termed "composite indices" in Table 1 to emphasize the possibility that confusion may have biased the flux densities, especially at the lower frequency. The generally broader beamwidths obtained at the lower frequencies would tend to result in steeper spectra than would be obtained were confusion not present. This reasoning follows from the fact that more sources are included in the beam at lower than at higher frequencies. One would thus expect to find steeper spectra in a region with a high density of sources than in a region with a low density, provided that all sources are measured with respect to the background of the low-density re-

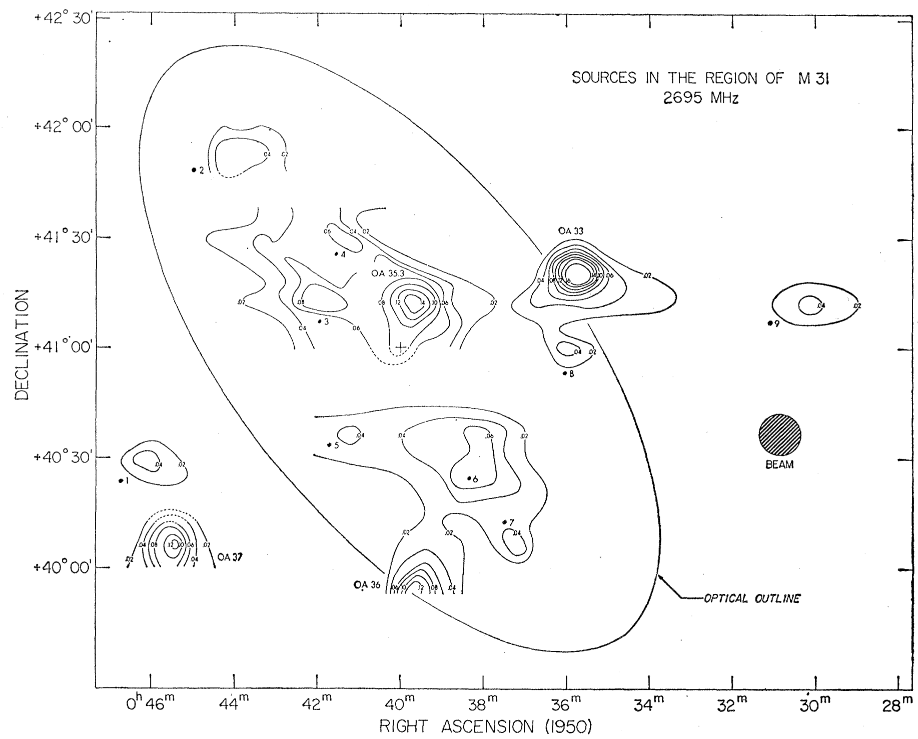

Fig. 1. Contours of constant antenna temperature at 2680 Mhz in the region of M31. Contours are labeled in degrees Kelvin.

Table 1. Characteristics of radio sources in the vicinity of M31.

Source No.	2695-Mhz position (1950.0)		Flux density (10^{26} watt m^{-1} hz^{-1})				Composite spectral index
	Right ascension	Declination	178 Mhz (*8*)	610 Mhz (*5*)	1415 Mhz (*3*)	2695 Mhz	
1	00h 46.m1	40°29′		0.6		0.1	−1.0
2	44.0	41°52′				.2	
3	42.0	41°13′				.3	
4	41.3	41°30′				.2	
5	41.2	40°36′		1.6		.1	−1.7
6	38.3	40°26′		1.7		.2	−1.3
7	37.2	40°07′				.1	
8	35.9	41°00′				.1	
9	30.1	41°12′				.1	
OA28.1*(*3*)			2.5	1.0	0.3		—1.4†
OA33	35.7	41°20′		0.6	.4	.5	−0.1
OA35.3	39.7	41°12′		1.9	.4	.4	−1.0
OA35.5				1.3	.3		—1.6†
OA36	39.7	39°53′		1.6	.7	.4	−1.0
OA37‡	45.4	40°06′	3.2	1.3	.8	.4	−0.9
OA38§			3.2	2.0	.8		—1.0†

* Identified with VRO 40.00.02, SRH; VRO determined by MacLeod *et al.* (*7*) and SRH determined by Scott *et al.* (*8*). † Spectral index determined between 610 and 1415 Mhz. ‡ Identified with VRO 40.00.03, SRH. § Identified with VRO 40.00.05, 3C24, SRH.

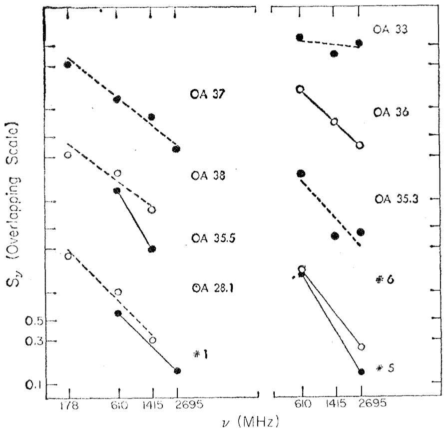

Fig. 2. Spectra of sources. Spectra are arbitrarily displaced for clarity.

gion. Following this line of reasoning one finds the average spectral index within the optical outline of M31 to be −1.4 and outside the optical outline to be −0.9. If one omits the source OA33, which is anomalous, the average index outside the optical outline is −1.1.

Source OA33 has a flat spectrum, similar to the spectra of thermal sources and many quasars. Preliminary measurement at Green Bank at 6-cm wavelength gives a flux density for OA33 of 0.5 flux unit (*9*).

No obvious HII region in the area of OA33 is visible on the atlas prints from the 48-inch (1.2-m) Palomar telescope. This source deserves further study.

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Drilling on Midway Atoll, Hawaii

Abstract. *Two holes drilled through reef sediments into basalt have established a geologic section through the Miocene. Midway was built above the sea by flows that were weathered and partially truncated in pre-Miocene time. After submergence, volcanic clays were reworked and covered by limestones. Overall submergence was interrupted at least twice by emergence. The limestones have been leached, recrystallized, and partially dolomitized.*

Midway atoll and its neighbor Kure, at the northwest end of the Hawaiian chain that stretches for 1600 miles (2550 km) across the central Pacific (Figs. 1 and 2), have long been regarded by geologists as the oldest members of this island group. Field evidence suggests that volcanism was initiated on the northwest, progressing southeastward to the Island of Hawaii, where volcanic activity still persists (*1*). As lavas were piled upon the sea floor to form the first islands, the load depressed the crust and the islands slowly subsided. This apparently was a slow process; coral reefs capping some of the former islands were able to maintain their tops near sea level by growing upward. Thus the islands at the northwest end of the chain are now atolls; the younger islands to the southeast are composed of volcanic mountains fringed with coral reefs. If such, in brief, has been the history of the Hawaiian Islands, there should be a geologic section beneath the reef islands recording much of Hawaii's history. To test this postulated history, Ladd proposed in 1960 that a deep hole be drilled on Midway, this atoll being selected over its neighbor Kure for logistical reasons.

Before the expensive process of drilling was attempted, seismic and magnetic surveys were carried out to determine the approximate thickness of the postulated cap of reef rock. Two brief seismic surveys were made by George Shor and his associates of the Scripps Institution of Oceanography. The first, strictly a land survey along the south side of Sand Island, was made in 1963 (*2*); the second survey was made in the lagoon, in December 1964, specifically to determine the thickness of coral beneath the northern part of the lagoon (*3*), where a magnetic low had been reported by the Naval Oceanographic Office (Project Magnet) (*4*). The geophysical surveys indicated the presence of a significant section of sediments beneath the islands on the south, with a progressive thickening northward under the lagoon.

Two holes were drilled during the summer of 1965 (Fig. 1). The first, on Sand Island, entered basalt at 516 feet (1550 m) and was continued to 568 feet. The second, the Reef hole, was drilled from a barge resting on the northern edge of the lagoon floor. It entered basalt at 1261 feet and was continued to 1654 feet. In each hole some 400 feet of post-Miocene limestones were penetrated, below which was a thin zone of upper Miocene (Tertiary *g*) sediments. In the Reef hole the upper Miocene sediments were underlain by approximately 500 feet of lower Miocene limestones (Tertiary *e*), and these, by about 170 feet of reworked volcanic clays, some lignitic, also of early Miocene age.

The drill was a truck-mounted Failing Model 2500 with reinforced tower (*5*). Cuttings and cores to a depth of 70 feet were taken with rock bit and conventional diamond core barrel. At depths greater than 70 feet a rubber-sleeve core barrel, yielding a 3-inch (7½-cm) core, was used almost exclusively. In the deeper of the two holes, three 1-inch oriented cores were taken (*6*). The size and amount of casing used and the amounts of core recovered are shown in Table 1. Sea water was used as drilling fluid with salt-water mud.

The first hole was drilled on Sand Island without difficulty. The geophysical surveys had indicated a thickening of the section to the north under the lagoon; consequently the site for the second hole was a flat sandy area just inside the reef on the north side of the lagoon, where the depth of water at high tide was 8 feet. This site was cleared of minor coral growth, and a course through the coral-studded lagoonal terrace was mapped by divers and marked with buoys.

The drill and all equipment, weighing 120 tons, were loaded aboard a steel barge measuring 120 by 30 feet. The barge, furnished by the U.S. Navy, was then towed to the drill site by a Navy LCM. After being jockeyed into position at the drill site, the barge