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Andromeda Galaxy: Extension of the 610.5-Megacyle-per-Second Map

Abstract. *A radio map of the Andromeda galaxy, M 31, made with the 400-foot (122 m) radio telescope at the University of Illinois has been extended northward to cover the full optical extent of the galaxy. Several condensations of radio emission appear along the major axis of the galaxy, and other radio features are resolved.*

A recent map at 610.5 Mc/sec of the nearby galaxy M 31 by MacLeod (*1*) with the 400-foot (122 m) radio telescope at the Vermilion River Observatory (VRO) of the University of Illinois has been compared by Arp (*2, 3*) with optical studies of the spiral structure of that galaxy. Arp's comparison of the optical and radio studies revealed the curious fact that the three major concentrations of radio emission along the major axis of M 31 correspond to the successive position where one of the spiral arms crosses the axis. The original radio map covered a range in declination from 39.9° to 41.7°, and in order to investigate further correspondence of the spiral structure and radio emission we have extended the map northward to a declination of 43°. The completed map of the whole region is shown in Fig. 1.

The procedure for making the extension to the map was the same used for the original section (*1*). Three drift curves obtained at each declination, spaced at intervals of one-half the beamwidth across the region, were averaged for the extension of the final map. Several declination cuts on a given right ascension were made in order to insure that the baseline level remained consistent from declination to declination. The 400-foot (122 m) radio telescope has a circular beam with a half-power diameter of 16 minutes of arc. The receiver was a Dicke-type radiometer with an electron-beam parametric amplifier, loaned by the Zenith Radio Corporation. The noise fluctuations (root-mean-square, rms) of the system are equivalent to an antenna temperature of 0.18°K at the input of the receiver. The units on the map are expressed in terms of the antenna temperature. Each contour represents 0.15°K above an arbitrary zero near the right ascension of 1 hour.

The three concentrations of radio emission along the major axis are shown within the outline of the galaxy in Fig. 1. Arp (*3*) indicates that these concentrations correspond with the crossings of the major axis (N 2, S 3, and N 4) of one of the spiral arms. The next northward crossing of this same arm, N 6, occurs at about 00^h45^m and 42.2°; no increased radio emission is indicated at this point. There is, however, a slight increase in radio emission along the major axis of M 31 near $00^h43.5^m$ and 41.8°. This position is near Arp's (*2*) axis crossing N 5 of the other spiral arm of the galaxy. This may be coincidental, since large numbers of discrete sources appear in this part of the sky.

Other radio maps of M 31 by Large, Mathewson, and Haslam (*4*) at 408 Mc/sec and by Kraus (*5*) at 1415 Mc/sec show a general outline for the galaxy which is similar to that on the map resulting from our present observations. However, the map by Kraus in particular shows a narrow spur of emission extending northward from the general disk component of the emission at a right ascension of about 00^h42^m. This spur does not appear on the present

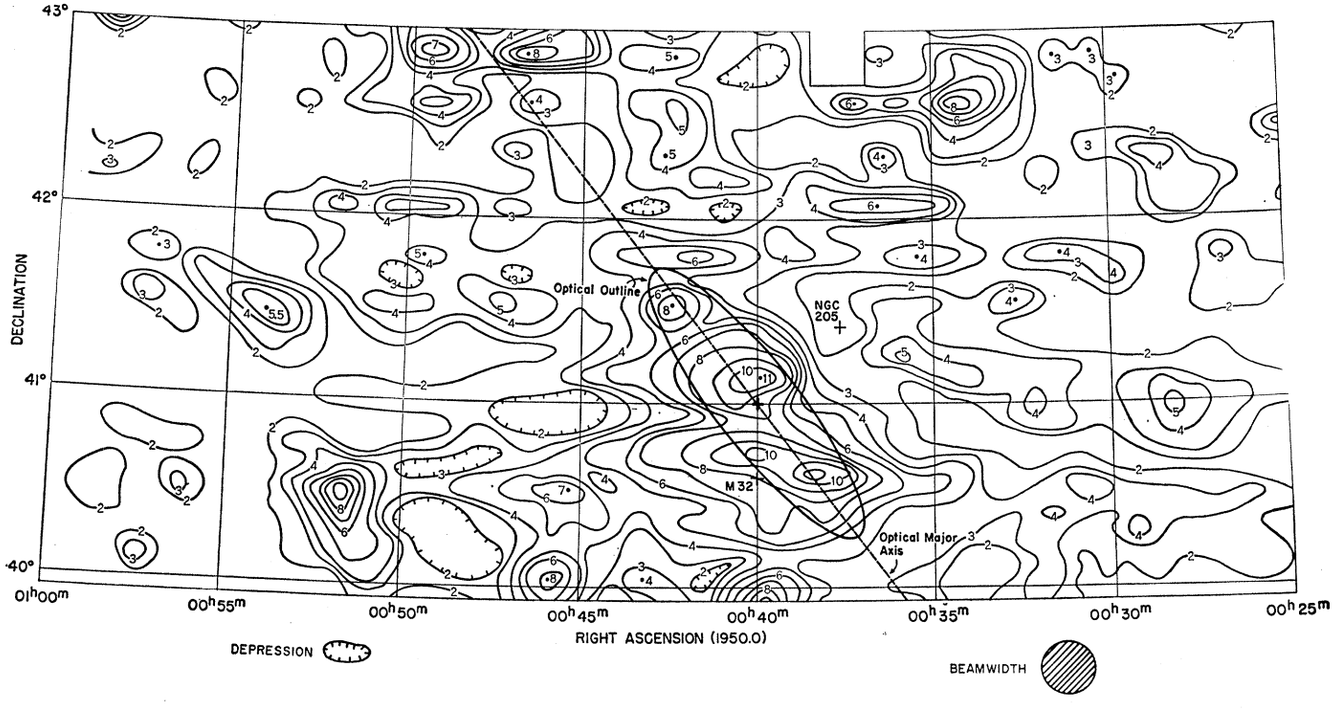

Fig. 1. A radio contour map of the galaxy M 31 at 610.5 Mc/sec made with the 400-foot radio telescope at the Vermilion River Observatory of the University of Illinois. The units on the map are expressed in terms of the antenna temperature. Each contour represents 0.15°K. The optical outline of the galaxy is also indicated with a dark cross at the center. The positions of the dwarf galaxies M 32 and NGC 205 are shown also.

map but does overlap the distinct sources at declinations of 41.8°, 42.6°, and 42.8° and may be an instrumental effect due to the fan-shaped beam of Kraus's instrument at Ohio State University.

The cluster of sources on the VRO map near 00^h48^m and 42°45′ does not appear to be present on the 1415-Mc/sec map by Kraus (*5*), but an increase of emission near that position is apparent on his 600-Mc/sec map. This difference suggests that these sources may have a steep spectral index. The dwarf galaxy NGC 205 lies in a slight hollow of emission but the depression is not great enough to be shown by another contour.

The radio emission from M 31 does not appear to extend along the major axis much beyond the optical outline. There does seem to be, however, a rather irregular emission structure extending beyond the optical outline along the approximate direction of the minor axis. The general elongation of the weak contours in the east-west direction may be partly due to the difficulty of preserving absolute calibration of the antenna from one scan to another on adjacent declinations. However, some of the effect appears to be real, and a similar elongation is noticeable on the 38-Mc/sec map by Kenderdine and Baldwin (*6*) and also slightly on the 1415-Mc/sec map by Kraus (*5*).

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Autocatalytic Synthesis of a Viral RNA in vitro

Abstract. *Experiments with an RNA-dependent RNA polymerase ("replicase") purified from* Escherichia coli *infected with an RNA bacteriophage (Qβ) demonstrate that the enzyme generates a polynucleotide of the same molecular weight as viral RNA; the "replicase" cannot distinguish the polynucleotide from its own RNA genome. By starting reactions at input ratios below the saturation levels of template to enzyme, autocatalytic kinetics of RNA increase are observed. The data are consistent with the conclusion that self-propagation of complete viral genomes is occurring in this simple system.*

We have reported the purification of RNA-dependent polymerases (termed "replicases") from *Escherichia coli* infected with the RNA bacteriophages MS-2 and Qβ. (*1*, *2*). Both enzymes were purified to the point where they exhibited a requirement for added RNA. Since the two bacteriophages are unrelated (*3*) we tested the expectation (*1*) that virus-induced "replicases" would show a preference for their homologous RNA. Comparison of the MS-2 and Qβ "replicase" isolated from the same host confirmed (*2*) the predicted requirement for homology. Neither enzyme can function with the other's RNA, nor can it function with a host of other RNA species, including the host ribosomal and sRNA (*4*) varieties. Each "replicase" recognizes the RNA genome of its origin and requires it as a template for effective synthetic activity.

The discriminating selectivity of the Qβ "replicase" for its homologous RNA is illustrated in Table 1, which records the response to a variety of heterologous RNA species and authentic Qβ-RNA. The second column of the table shows that the heterologous RNA molecules, in addition to being inactive as templates, are unable to interfere significantly with the template function of Qβ-RNA. It is evident that the "replicase" can be used as a diagnostic tool to detect homology to its own genome.

The analysis of a presumed replicating reaction centers on the nature of the product. If the concern is with the synthesis of a viral nucleic acid, data on base composition and nearest neighbors, while of interest, are hardly decisive. The crucial issue is whether replicas are being produced. To answer this question, information on the sequence of the synthesized RNA is required. Evidence of similarity between template and product would provide as-

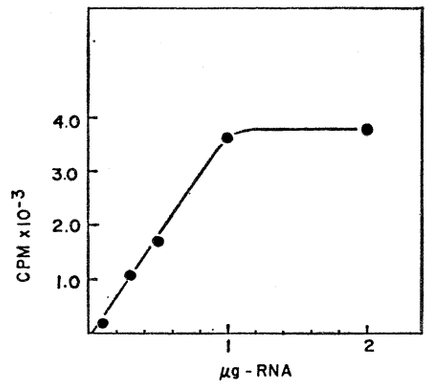

Fig. 1. Template saturation of "replicase." In addition to 40 μg of enzyme protein, each standard reaction volume of 0.25 ml contained (in μmole): tris HCl, *p*H 7.4, 21; $MgCl_2$, 3.2; CTP, ATP, UTP, and GTP, 0.2 each. The reaction mixture was held for 20 minutes at 35°C and cooled in an ice bath, and the reaction was terminated by the addition of 0.15 ml of neutralized saturated pyrophosphate, 0.15 ml of neutralized saturated orthophosphate, and 0.1 ml of 80 percent TCA. The precipitate was transferred to a membrane filter and washed seven times with 5 ml of cold 10 percent TCA. The membrane was then dried, and its radioactivity was counted in a liquid scintillation spectrometer (*2*). The washing procedure yielded zero time values of 80 count/min with input of 1×10^6 count/min. The labeled UTP^{32} was synthesized (*1*) and was used at a concentration of 1×10^6 count/min for each 0.2 μmole. The enzyme was isolated from *E. coli* (Q13) infected with bacteriophage Qβ (*2*).

Table 1. Template selectivity of Qβ-replicase. Standard reaction volumes were 0.25 ml and contained the components in the concentrations specified in the legend for Fig. 1. Each reaction contained 40 μg of enzyme protein and 1 μg of the RNA indicated. When two templates are included, 1 μg of each is present. The reactions were run for 20 minutes at 35°C and then treated as described in Fig. 1. The UTP^{32} was the labeled phosphate; the activity was such that the incorporation of 4000 count/min corresponds to the synthesis of 1.06 μg of RNA. sRNA had been tested in an earlier experiment and showed no effect on synthesis in the presence of Qβ-RNA. The numbers represent the counts incorporated into acid-precipitable nucleic acid in 20 minutes.

RNA	Single template	Single template of column 1 + Qβ-RNA
Qβ	4929	3873
Turnip yellow mosaic virus	146	3383
Coliphage MS-2	35	3584
Ribosomal RNA (*E. coli* Q13)	45	3042
sRNA (*E. coli* Q13)	15	
Satellite virus of tobacco necrosis virus	61	3625
None	30	