motion parameters of the Galaxy. The volume element containing the stellar population with which we have been concerned in this investigation does not contain a sufficient number of such elements to permit us to obtain a satisfactory general radial-motion law; it is of sufficient size only to indicate the large-scale irregularities that appear to exist.

VIII. The Differential Rotation Parameter

As a final remark about the properties of the field of motion of the very young stars we give in Table 2, as a function of R_0, the A-values derived directly from the parameters listed in Table 1.

TABLE 2

VALUES OF THE A-PARAMETER OF GALACTIC ROTATION DERIVED FROM THE VERY YOUNG STARS AND SHOWN AS A FUNCTION OF THE DISTANCE TO THE GALACTIC CENTRE

R_0 (kpc)	$A = -\frac{1}{2} R_0 \omega_0'$ (km/sec.kpc)	R_0 (kpc)	$A = -\frac{1}{2} R_0 \omega_0'$ (km/sec.kpc)
6	15·4	10	14·2
8·2	14·4	12	14·0

Discussion

Kerr: It is interesting to see a clumpiness in the stellar velocities similar to that of the gas. What is the average area covered by one of these "clumps"?

Weaver: The region of Perseus, for example, is about 800 pc wide and about 1·2 kpc long. It may possibly be longer but we have no data. The other regions are generally about 1 kpc in diameter.

Feast: Is it true to say that you have used the known associations as single points in your plot?

Weaver: Yes, associations, clusters, and single stars were considered as single points. This is because the peculiar motion of a cluster is about the same as that of a single star. For clusters, of course, the distance is generally better determined.

24. A HIGH-RESOLUTION STUDY OF M31

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The great nebula in Andromeda, M31, is a particularly interesting external galaxy, since it is a giant spiral system, presumably much like our own Galaxy, and is close enough to be resolved with existing radio telescopes. During parts of November 1962, and from December 5, 1962, to January 20, 1963, the 300-foot transit telescope of the N.R.A.O. at Green Bank, W.Va., was used in conjunction with the Carnegie multichannel H-line spectrograph to study M31. The following is a preliminary account of these first observations.

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The original multichannel receiver consisted of 57 channels, each having a half-power bandwidth of 10 kc/s, covering a total Doppler range of 208 km/sec (1·02 Mc/s). Because observing time on M31 was limited to a short period each day, an extra 36 channels of greater bandwidth were built, of 50 kc/s half-power bandwidth, covering a total velocity range of 525 km/sec (2·6 Mc/s). The wider range of frequencies covered by the 36 wide-band channels included the frequencies of the 57 narrow-band channels. It turned out, however, that except in the central parts of M31 where the hydrogen profiles were broad and weak, the 10 kc/s channels were more valuable, since the hydrogen peaks had details that were not resolved by the 50 kc/s channels.

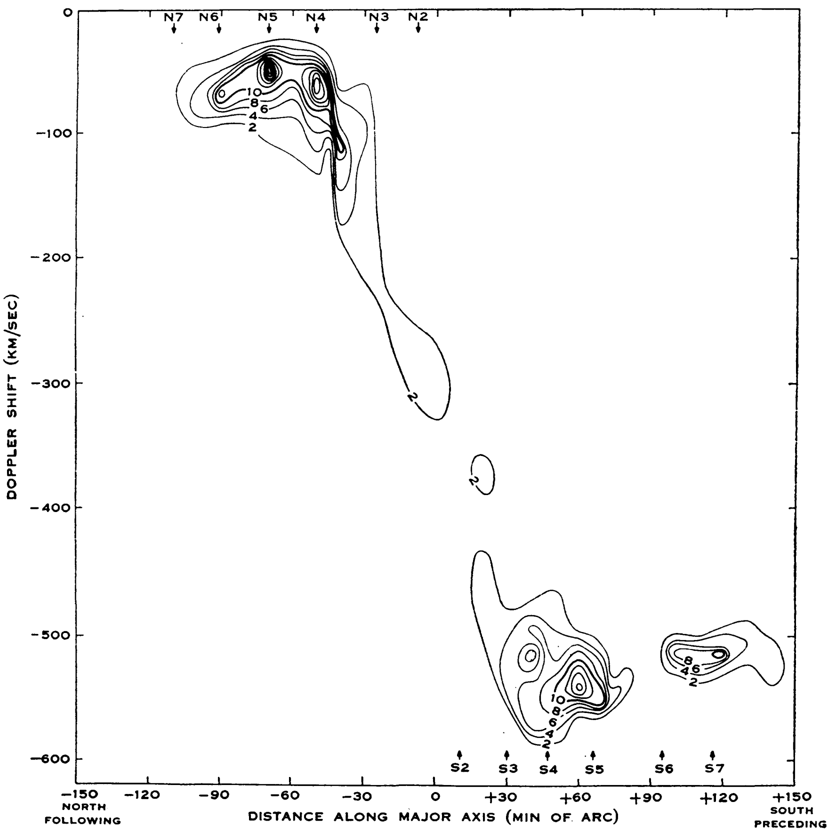

Fig. 1.—Observed antenna temperatures along major axis of M31. Velocity is with respect to local standard of rest. Baade's spiral arm crossings are shown.

The excess noise of the receiver was 450°K (900°K effectively for H-line), and consequently the fluctuation level was too great to make measurements during the approximately 50 sec that a given point in M31 spends in the beam of the telescope. Therefore, a travelling feed was constructed at the Carnegie Institution by Mr. E. T. Ecklund, enabling us to track for 5^m40^s, which was enough time to make two independent 2·5 min integrations. Each day, it was possible to observe two different

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points in M31, together with several reference points before and after transit to give the instrumental baseline and the galactic background. Observations were made at intervals of 10′ along the major axis (assumed position angle 38°) to a distance of 2° 30′ from the centre, and along the minor axis at points ±10′ and ±20′ from the centre. The major axis observations are summarized in Figure 1, which shows antenna temperature as a function of velocity and distance from the centre along the major axis. The two halves of the nebula show somewhat different appearances, with fairly good continuity on the north-following half but a clear separation on the south-preceding side. The outer cloud on the south-preceding side extends well beyond 2° from the centre, and shows a peak temperature nearly two-thirds that of the principal concentration.

A comparison was made between the positions of the hydrogen concentrations and the optical spiral arms, as given by Baade (1958), who used bright blue stars as spiral arm indicators. On the NF side, Baade's arms N4, N5, and N6 agree well with the concentrations of neutral hydrogen, but along the SP side the agreement is not nearly as good. Only S7 agrees well with the peak of the concentration, and S6 actually falls in a minimum where there is very little hydrogen indeed. It is clear that the question of relations between the hydrogen spiral arms and the bright star arms is complicated, and that similar difficulties may well be present in interpreting such relations within our own Galaxy.

The symmetry of the rotational velocity can be examined by comparing the two halves of the figure. In the outer parts, the NF and SP halves superimpose rather well, but there are difficulties in the inner regions, where differences of 40 km/sec appear to exist between the velocity curves for each half. There also appear to be smaller deviations in the outer regions, particularly for the isolated cloud in the region +95′ to +145′. The peak temperatures do not fall along a smooth rotation curve, but differ by small amounts, of the order of 10 km/sec.

The density distribution is evidently different from that derived by van de Hulst, Raimond, and van Woerden (1957). In that work, which was done with the Leiden 25-m telescope, a strong central concentration was derived that cannot be seen in our observations. The maximum was probably introduced in the process of correcting for antenna beamwidth, which was necessarily greater with the 25-m dish (35′ as compared with 10′). The maximum in hydrogen density noted at about 1° from the centre by the Leiden workers is clearly evident in the figure.

The minor axis observations were examined for evidence of radial motions. No significant radial motions could be detected. The best fit of the curves taken at ±10′ along the minor axis indicated a net radial motion of 3±3 km/sec, in a contracting sense. In view of the estimated error, this contraction motion is not significant.

We wish to thank the 300-foot telescope observing crew for their services, and in particular we are grateful to Drs. D. S. Heeschen and F. D. Drake for their generous hospitality and assistance during our visit.

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Discussion

Davies: Measurements have been made at Jodrell Bank with 200 kc/s bandwidth to determine the neutral hydrogen distribution in M31. The prominent feature is a ring of neutral hydrogen at $\sim$ 10 kpc from the centre. The northern part of this ring contains more neutral hydrogen than the southern part.

Blaauw: How large are the differences between the rotational velocities one finds for given distances from the centre?

Burke: This depends on the velocity of the centre of mass. There appear to be velocity differences of about 20–40 km/sec within 6 kpc of the centre.

Davies: M33 shows a similar neutral hydrogen concentration in a ring $\sim 15'$ in radius.

Burke: This agrees with our result.

25. THE RADIO CONTINUUM EMISSION FROM THE GALAXY

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Study of the radio continuum emission from the Galaxy is of interest both from the viewpoint of the physics of the radiating processes and the light which these shed on physical conditions within the Galaxy, and also because the large-scale organization of the emitting regions gives information about the structure of the Galaxy as a whole. We are concerned here particularly with the latter aspect, that is, the question of galactic structure, and for this we need to know the distribution of the emitting regions throughout the Galactic System.

There is no inherent distance scale yet available for the continuum radiation and to determine its distribution along a given line of sight one must rely heavily on assumptions of similarity and the measurement of angles. For example, we assume that the thickness and general properties of the spiral arms are a function only of their distance from the nucleus. Thus the direction of the galactic centre is taken as origin and one must be able to make measurements all around it; this kind of investigation is therefore particularly suited for the southern hemisphere. Another possibility is a distance scale based on low-frequency spectral measurements and the differentiation of thermal and nonthermal components; this has not yet been fully explored, but may become important in the future.

It is now customary to think of three basic galactic distributions of the emission. These are the discrete sources (including HII regions), the corona (or halo), and the disk (principally spiral arm emission).

Discrete Sources

The galactic discrete sources comprise a population of localized emitting regions distributed along and very close to the galactic plane. They now appear to have separated out fairly clearly into two classes, supernova remnants, which emit by the synchrotron process, and HII regions emitting thermally. Both appear to be well concentrated towards the spiral arms. Recent high-resolution observations of these objects are discussed in other papers and so they will not be considered here.