A NON-ESTABLISHMENT VIEW OF THE SYMPOSIUM

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Many interesting new results from studies of external galaxies as well as of the Milky Way Galaxy have been presented at this meeting. I shall confine my remarks to but a few observations which appear to be crucial in deriving an acceptable picture of the large scale structure in the Galaxy.

Do we know the extent of the Galaxy? Flat rotation curves appear to be the rule in disk galaxies rather than the exception. Dr. Jackson has presented direct measurements of the rotation curve for the Galaxy. It appears to be flat up to 17 kpc from the center. A substantial portion of the mass must be hidden in a "dark" halo to account for such a rotation curve. If the new determinations of the rotational velocity at the distance of the Sun, of 220 km s^{-1}, reported by Dr. Einasto and Dr. Knapp were to be adopted, the problem of missing mass in the Local Group will become further aggravated. A direct check of the contents and mass of the halo is called for. It is necessary to adopt a uniform terminology in order to refer to various aspects of the z-extent of galaxies such as the radio halo, cosmic ray halo, spheroidal central bulge and the like.

The mass distribution in the spheroidal bulge and in the larger halo has significant repercussions for the dispersion relation of the density waves in the disk for different values of the stability parameter Q. Some work in this connection has been published by Terzides (1977). The questions of persistence and amplification of spiral density waves will have to be reexamined in the context of the halo. It is also conceivable that the halo mass will have a dynamical effect on the warps in the outer parts of galaxies.

How well are the parameters of the "grand design" spiral pattern in the Galaxy known? Does one such pattern exist? These questions were not explicitly raised at the symposium. The relevance of inquiries of the type described by Dr. Wielen in his talk, to actual confrontation of observations with the theory is unclear unless the grand design spiral is assumed to exist. Dr. Clube has shown that if

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one starts with an assumption of the existence of a two-armed spiral in the Galaxy and if one then demands a bi-symmetry in the observed kinematics, one is forced to invoke an expansion velocity field. Such a velocity field contravenes observations in the solar neighbourhood as well as other observations spanning larger parts of the Galaxy. Further, it is well known that a two-armed tightly wound spiral pattern (e.g. Lin et al. 1969) which has been derived to fit the kinematics of HI in the first quadrant of galactic longitudes completely fails to account for the observations in the fourth quadrant. It is surprising to recognize that in spite of this anomaly tightly wound two-armed spirals are the basis of so many of the models discussed at the meeting. A four-armed 13° pitch angle spiral similar to one proposed by Dr. Y. P. Georgelin and presented at the meeting by Dr. Sivan has been shown by Dr. Henderson (1977) to fit some of the HI data both first and the fourth quadrants, as well as in the region outside the solar circle. The fit in the first quadrant alone is not any worse than for the two-armed tightly wound spiral model. It should be of interest to check the consistency of such a model in the context of the density wave theory both for its persistence and its expected amplitude.

Only a limited portion of the HI data, namely the extreme velocity edges of the profiles, has been fitted to a spiral structure in the Galaxy. The features of the data over the remaining part of the profiles are too confusing for unambiguous fitting with a model. It was hoped that, with the advent of new techniques and the detection of CO molecular lines from a large part of the Galaxy, it would be possible to resolve spiral features clearly. This hope has not materialized. Based on inadequately sampled maps, at one time it was claimed that CO longitude-velocity diagrams do not show the characteristic loops and arcs which have been conventionally identified with spiral arms in the study of HI observations. However, a more complete set of maps presented by Dr. Cohen of the Columbia University does show the existence of the expected spiral-like features. The problem of fitting a model spiral will critically depend upon the availability of data from the southern half of the Milky Way.

Much of the misunderstanding in the galactic structure stems from overinterpretation of a limited amount of observations. The HI distribution in the nuclear region of the Galaxy is one such example. Observations of HI mostly confined to the galactic plane have been interpreted earlier in terms of a disk with a one-third sector devoid of neutral hydrogen. A further examination of profiles covering latitudes on either side of the plane has led to a more likely model of HI distributed in an inclined tilted disk. CO data is consistent with such a distribution of gas in the nuclear disk. It is desirable to derive a dynamical model in which the apparent expansion velocities can be explained in terms of a coherent organized streamline structure in the field of force of the tilted disk.

Do we have a bar at the galactic center? A major limitation in arriving at an answer to this question arises from the lack of a specific model of a bar and from the relative ignorance regarding the kinematics of gas in and around the bar. There is a gap in the observations of the nuclear region between a region of radius a few parsecs studied with the [NeII] line emission and of radius a few hundred parsecs accessible for study with the molecular lines of CO. A new tracer appropriate for studies of this region is desirable. As of now there is no direct evidence for a bar at the center of the Galaxy. The tilted disk mentioned in the last paragraph is different in its appearance than the bars seen in a barred galaxy. An oval ring of radius between 3 and 4 kpc may be a manifestation of a bar-like potential at the center. An oval deformation of the central region can induce velocity asymmetries and apparent expansion velocities similar to what is observed in the Galaxy (Manabe and Miyamoto 1975, Sanders 1977). Such oval distortions are quite common in external galaxies. A feature like this can provide a driving force for a spiral pattern in the disk of the Galaxy. Is such a spiral pattern, together with the bar, self-consistent?

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