14. SPIRAL STRUCTURE AND THE ROTATION OF GALAXIES

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(Abstract)

There is no general agreement about either the location or the direction of winding of the spiral arms in our Galaxy. Since the measurement of the distances of gaseous nebulae is based on their association with hot stars, the locations of arms based on these objects are not independent.

We have found [1] that the location of most OB-stars and Cepheids does not agree with the concept of trailing arms. Morgan, Whitford, and Code [2] have found the expected trailing of the arms from their twenty-eight aggregates, but they have no data for the southern hemisphere, while, in addition, but a small percentage of the known OB-stars are represented in these 28 aggregates. The 21-cm radio observations have made the situation more confused. Moreover, these observations contradict a number of observational data from other spiral galaxies.

The arms in all galaxies are well represented by a logarithmic spiral $R = a.e^{b\phi}$ with a characteristic angle, $\mu = \text{arc ctg } b$, which ranges from 54° to 86°. At best, the radio observations could refer to a spiral with $\mu = 86°$, but this would make our Galaxy a rare exception to the general run of galaxies. Only 2 or 3 inner arms have been observed. Yet if $\mu = 86°$, at least 8–10 twines must exist.

None of the rotation laws so far suggested maintains logarithmic spiral arms, yet various arguments point to spiral arms as rather stable structures. We conclude that solid rotation is the only possible rotation law for spirals. Since curved bars are unknown, barred spirals must also rotate as solid bodies; Mayall [3] states that observations do not rule out solid-body rotation for the main body of M 31. A sharp change of angular velocity is seen just at the place where the spiral structure in M 31 and M 33 is vanishing. This confirms our conclusion that differential angular rotation and spiral structure are incompatible. Since the arms are not formed by rotation, they may either lead or trail. Conversely, even if the spiral arms are found to wind the same way in all galaxies, this cannot be due to rotational forces.

From optical observations in a sphere of 1·5 kpc around the sun, it has been established only that $\omega(R)$, the angular velocity, decreases from $R \sim 7$ kpc outward and for $R < 7$ kpc, $\Theta(R)$, the linear rotational velocity, begins to decrease inward. Hence, the evident spiral structure must vanish within $R \sim 7$ kpc and by $R > 8$ kpc, even its traces must disappear. Several observations confirm this. The 21-cm data have been misinterpreted; the velocities cannot be converted to distances so simply.

The dynamical models of the spiral galaxies must be revised. We must, possibly, remember the viscosity of the flat galactic layer; it contains much gas in which the free path of atoms is much shorter than the diameter of the Galaxy; it is not a vacuum.

REFERENCES

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[3] Mayall, N. U. *Publ. Obs. Univ. Michigan*, **10**, 19, 1951.