3. SPIRAL STRUCTURE OF OUR GALAXY AND OF OTHER GALAXIES

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Time and again Dr. B. Bok publishes his reviews on the state of optical searches of the spiral arms in our Galaxy. A great optimist at the beginning, concerning the agreement of different results, he became later more critical in his conclusions. But in his paper of 1967 he claims anew, as well established, that we can trace the spiral arms up to a distance of 14000 pc from the centre.

I could never agree that the spirals made of HI, or rather the gaseous rings, did confirm the optical spirals (then outlined), which make an acute angle with the radius.

In fact the two patterns, optical and radio, could not, and still cannot be reconciled at all.

Formerly the analogy with the most popular photographs of galaxies possessing only two arms was expected. Consequently only two arms in our Galaxy were searched. Nobody worried that a large number of complete revolutions was necessary in order to draw the spiral arms up to the sun or to a greater distance, though hardly there could be shown a galaxy with two complete revolutions of its spirals. At the same time, not so long ago it was suggested that there is a possibility that our Galaxy is a barred spiral. Recently some models with many arms were advanced. These divergences in the localisation of the spiral arms in our Galaxy can hardly allow for a satisfactory model.

The efforts made to construct a model of our Galaxy with many arms are fruitless because there exist no such numerous arms that emerge from the nucleus. If there are many 'arms', they represent in this case only bits of spirals and can be traced as continuous formations at most for $\frac{1}{4}$ of a complete revolution. Such galaxies are very different from the ideal symmetric models with many arms so far proposed. On the other hand the many arms model, especially with fragmentary arms, is easier to reconcile with the observational data.

The same is true with the dark matter. The scheme of a homogeneous layer was first proposed, then the contrary view of a multitude of average dark nebulae. Finally the topographic method of presentation was established. The same must be done with the spiral structure. We shall see what it is like, after we shall have good distance determinations, without the drastic efforts to adapt the observational data to abstract schemes.

To obtain a reliable idea of spiral arms in a giant galaxy, from observations made within a radius of 2000–2500 parsecs, is very difficult. The reason is that in real galaxies the structure of the spiral arms is complicated as a rule. We may compare M 33 and NGC 2403 with their broad coalescent arms and NGC 5364, 210. I may also mention the complicated patterns, which remind of the lace of the lines of a

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magnetic field. There are straight bands connecting the spiral arms, as in M 51, etc.

The simple geometrical models are needed by theoreticians, but the nature is much more complicated. Take, for instance, two volumes 1–2 kpc in radius (3 kpc for a giant galaxy) in different places of one and the same galaxy. Try to obtain concordant tracings of spiral arms reconstructed from these two volumes.

I will stress that taking simple patterns and adjusting them to conform to a scanty number of objects, small as compared to their separation, we can deceive ourselves. Especially because the impression of our finding depends in a striking way on the way we sketch our objects and join them by lines (Figure 1).

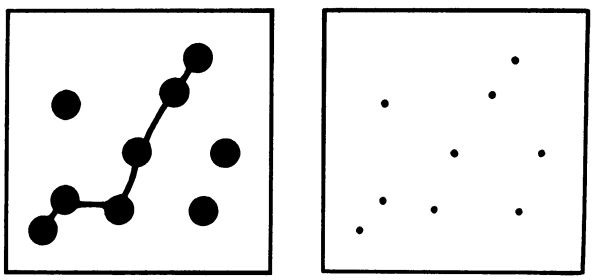

Fig. 1.

We are 8000 pc distant from the centre of our Galaxy and we look for the spiral arms still farther from the centre, beyond the solar position. We know the distribution of hot giants only approximately and at most up to a distance of 2–3 kpc from us. Even here some of them are hidden behind dark clouds, especially the more distant ones.

The nearest galaxy comparable to ours according to its dimensions, is M 31, a spiral considered to be even somewhat larger than our Galaxy. At a distance of 8000 pc from its centre the surface brightness is very low. The outermost borders of its spiral arms, very faint features, barely touch this limit. Further on no traces of spiral arms can be recognized. The features which Baade called the spiral arms V–VIII are but the loose groups of hot stars intersected by the prolonged great axis of M 31. They cannot be traced as real *arms*, even along some fraction of a revolution. Of course Baade did no attempt to trace them. So even in M 31, which apparently is larger than our Galaxy even the borders of unmistakable spiral arms are closer than 8000 pc from the centre. It appears that we do not know a galaxy with spiral arms extending beyond 8000 pc. (Of course under 'optical spiral arms' we understand always the distinct features above the general galactic light background, and not the small detached groups of stars. The spiral arms are more or less continuous.)

No spiral arms can be expected in the direction of anticentre in our Galaxy and less so up to 14000 pc.

Some concentration of objects called the Orion arm does not represent a regular arm.

My doubt of the reality of the spiral structures in the solar vicinity is supported by

the existence there of differential rotation. Radio observations of other galaxies made far from their centres supported my former conclusion that the distinctly visible spiral arms are situated in the region of a rigid body rotation. So they can hardly exist farther than the solar distance from the centre. In M 31 the differential rotation is observed in the region of the spiral arms. But this is an exception and Sandage holds even M 31 as a multiarm galaxy as NGC 5055 and 2841. Long ago I departed from the notion that the differential rotation destroys the regular shape of logarithmic spirals. However Marochnik and Suchkov claim that in their theory differential rotation and arms may coexist.

It is not proper to base the spiral arms on the 'coincidence' of localisation of hot stars and of H II regions. In fact we locate H II regions just where we locate the hot stars tentatively responsible for their luminosity.

The discussion of the 21-cm observations for the location of spiral arms uses a law of rotation which is postulated beforehand. Therefore the locations mentioned are not independent. On the other hand the broad ring of H I (this is just what really is seen on the map of densities) corresponds probably to the rings of H I described by M. Roberts. In many galaxies (not in M 31) the optical spiral arms are inside the H I ring.

The thin spiral arms, or rather the rings observed optically in NGC 488 are very rare. But when they are present they never make so many revolutions as are needed to extend them from the nucleus to a distance of 12–14 kpc.

I suggest not to be in a haste to construct a model of our Galaxy but to search the real patterns without bias.