A THEORY OF GALACTIC EVOLUTION

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..."there exist many galaxies where most of the light originates in an apparently flat rotating disk, and where the random stellar motions appear to be small compared to the systematic circular motion i.e. they are apparently "cold." Our own Galaxy is such a system, and it does not seem to suffer any large scale, large amplitude, short-time-scale instability"... Ostriker and Peebles, Ap. J. 186, 467, 1973.

The generally agreed foundation of galactic theory could not be more clearly expressed. Yet the second sentence is no longer true. That many radio-astronomical kinematic observations are still interpreted in a way that gives substance to such theory directly contradicts the evidence of nearby stars (Clube 1978). The pre-1950 analysis of stellar motions in the solar neighbourhood was seriously distorted by failure to recognise the existence of a young disc population (Pop $I^{I} \lesssim 5.10^{8}$y) and an old disc population (Pop I^{II}) with different kinematic properties. The origin of the error can be traced to an erroneous assumption that Kapteyn's two drifts and Schwarzchild's velocity ellipsoid were completely equivalent. Drift I represents the predominant Pop I^{I} and has an outward motion in the Galaxy relative to Drift II representing Pop I^{II}. This outward motion of 40 kms^{-1} is now reflected in observations of Sgr Aw in the galactic centre and the symmetrically placed inner spirals known as the 3 kpc arm and the +135 kms^{-1} arm. Detailed study of the spiral arms shows that the observed structure is temporary, unstable and probably the result of very energetic processes in the central region of the Galaxy. That spiral arms are such a common feature of galaxies suggests they originate in a recurrent galactic process. Unusual violent behaviour in the centres of other systems suggests galaxies evolve by quasi-periodically producing material that first moves out and then comes in, all the time spreading out under the influence of differential rotation. The clue to the origin of this process may well lie in galactic nuclei themselves (cf. van der Kruit et al. 1972), but there is no proven physical mechanism.

W. B. Burton (ed.), The Large-Scale Characteristics of the Galaxy, 239–241.

REFERENCES

Clube, S. V. M.: 1978, Vistas in Astronomy 22.
van der Kruit, P. C., Oort, J. H., and Mathewson, D. W.: 1972, Astron. Astrophys. 21, 169.

DISCUSSION

Oort: There is one class of objects for which there can hardly be doubt that they form an old, and presumably well-mixed, population, vis. the planetary nebulae near the galactic center. They show a velocity of the LSR close to zero and not +40 km s^{-1} as you suggest. The random motions are high and the mean errors is therefore about 10 km s^{-1}, so that unfortunately there is considerable uncertainty in this result.

Clube: The planetaries are in principle well suited to a determination of the motion of the LSR, but absorption obscures our view of the nuclear bulge at positive b, and furthermore the situation is complicated by the negative motion of objects between us and the galactic center. Allowing for these effects (Clube, 1978), the motion of the center is 74±36 km s^{-1}. As you say, there is considerable uncertainty, but the result is not inconsistent with the expanding model.

Bok: A similar test to the one just suggested by Prof. Oort for the velocity of the LRS relative to an old component could be based on the system of globular clusters. Have you made this test?

Clube: The radial motion of the "nearby" globular clusters appears to be similar to that of disc stars. The few objects near the center have a large velocity dispersion and do not give a definitive result.

Burton: There is a whole collection of observational material, comprised of the spectral line data of HI, H recombination lines, CO, and other molecules, which shows a pronounced tendency to accumulate near zero radial velocity near $\ell = 0°$. This accumulation represents gas lying along a transgalactic path. That it is centered near 0 km s^{-1} rules out, in a way which seems to me very definite, the possibility that the local standard of rest determination could be 30 km s^{-1} in error. Braes (B.A.N. 17, 132) used this sort of argument in his test of Kerr's suggestion of a general galactic expansion.

Clube: Because of limitation on time, I discussed only a small amount of the optical evidence, but obviously no determination of the motion of the LSR can be made without reference to the important data which you mention. Most of the zero velocity emission near $\ell = 0°$ is contributed by material which has a shallow velocity gradient in galactic longitude and is evidently nearby. The remainder cannot be presumed to be uniformly weighted along a transgalactic path unless the optical depth is small. There is good evidence that this is not the case for

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receding material on the far side of the Galaxy (Clube, 1978). Braes' test is therefore defective. Although my model of diminishing radial motion with galactic radius is similar to Kerr's and originates from much the same observed features, the specific difference in our motions of the LSR can in fact be attributed to entirely different treatments of absorption.

Stark: There is a narrow, very deep absorption feature seen by several observers in the direction of Sgr A in the HCO^+ and HCN $J = 0 \rightarrow 1$ transition, which deviates from a LSR velocity of 0 km s^{-1} by less than 2 km s^{-1}. Thus, there are in fact narrow velocity molecular features at 0 km s^{-1} towards the galactic center.

van Woerden: The very narrow HI absorption component near zero velocity seen in absorption against Sgr A arises in a very nearby cloud, at $\sim$ 100 pc distance, as shown by Riegel and Crutcher (Astr. and Ap. 12, 43) and earlier workers (e.g., Heeschen, 1955). Because of its distance, this absorption component carries no information about possible outward motion of the local standard of rest.

DISCUSSION (after Dr. Grosbøl's talk)

Contopoulos: Have you considered the case of a much larger value of the angular velocity of the spiral pattern, e.g., Ω_s = 32 km s^{-1} kpc^{-1}?

Grosbøl: Not yet, but it will be done shortly.

DISCUSSION (after Dr. Upgren's talk)

Wielen: I am puzzled that you do not find the classical asymmetric drift in the V-component of the solar motion for objects with increasing velocity dispersion.

Upgren: These stars do not include halo members, nor stars with very high velocity. For disk stars only, the drift of the V-component is not noticeable.

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