SPIRAL STRUCTURE: DENSITY WAVES OR MATERIAL ARMS?

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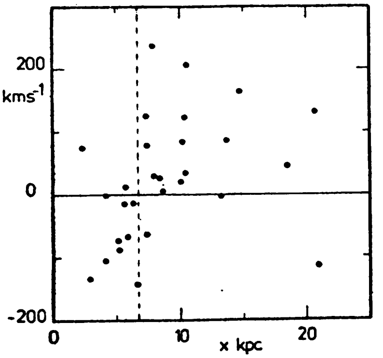
Recent studies (Frenk and White 1980, 1982) of the (x, y, z) and ($\Pi$, $\theta$) distributions of the Galactic globular cluster population have given $R_o = 6.8 \pm 0.8$ kpc and $\Pi = 51 \pm 26$ kms$^{-1}$ for the inner halo. The observations leading to these solutions are well illustrated by the $\rho$ vs. x plot in figure 1 (Clube and Watson (CW), 1979) for the globulars with the best determined data within $|l|, |b| < 20°$. The independently determined $R_o$ value clearly divides the distribution in such a way that most of the objects on the nearside of the G.C. approach the Sun while those on the farside recede, the probability that this arrangement arises by chance from a "stationary" distribution being $\sim 0.002$.




The average value of $\Pi$ for the inner halo ($R < 4$ kpc) based on figure 1 is $76 \pm 15$ kms$^{-1}$ in broad agreement with Frenk and White though the formal significance may be underestimated because of an inappropriate choice of rest frame. Since the globular population is equally represented on either side of the G.C., the best current choice may be considered the average of the $\rho$'s within $R < 4$ kpc, and we thus obtain $\Pi \sim 76 \pm 14$ kms$^{-1}$ while $\Pi_\odot \sim 13 \pm 15$ kms$^{-1}$. (The average of the extrema gives $\Pi_\odot \sim 42 \pm 30$). It has previously been shown (Clube 1978) that the 3 kpc and +135 spiral arms of the HI disc, interpreted as an optically thick, kinematically bisymmetric system in the core of the Galaxy, give corresponding values of $\Pi = 95(\pm 1)$ and $\Pi_\odot = 40(\pm 1)$ kms$^{-1}$. The evidence therefore, if correctly interpreted, seems to indicate both the inner halo and central disc expand together, presumably because of similar recent dynamical histories which may not in the circumstances be attributed to any kind of gas dynamical action. Indeed, should gravity be the most likely driving force, material spiral arms are probably implied and the observed phenomena presumably derive from a recent pre-existing steady state halo and centrally condensed disc through effects that are in some way equivalent to suddenly removing or introducing mass in the galactic centre (e.g. Clube 1980). The weight of evidence overall may not demand this kind of



*E. Athanassoula (ed.), Internal Kinematics and Dynamics of Galaxies, 161–162.*

explanation at present, but the possibility that spiral arms are recurrently produced, short-lived material bodies first moving outwards from the nuclear regions and then inwards under the influence of the Galactic potential field, should not be overlooked. It is therefore premature to interpret observed spiral arm streaming in the outer parts of external galaxies as exclusive evidence for density waves (e.g. Visser, 1980): it may equally be the residual motion of spiral arms injected into the outlying disc.

These conclusions are currently being tested in two ways. First by observing inner halo RR Lyrae radial velocities to check the globular cluster results. Spectra have so far been obtained (Rodgers 1977, CW 1980) for 31 RR Lyraes in the Plaut fields, and basing their distances on $M_v = 1.0$ corresponding to the above $R_o$ value (Clube and Dawe 1980), it is already clear that negative values outnumber the positive values 4.2 to 1 on the nearside of the GC, giving much the same mean value and spanning the same range as the globular clusters. Although these results add weight to the globular cluster picture, RR Lyraes in the low obscuration windows in the G.C. will clearly provide the most direct determination of $\Pi_\odot$. Observations of $\sim$40 such stars have now been obtained and should soon throw further light on this question.

The second test is based on a new study of early type stars in the solar neighbourhood, r < 2 kpc (CW 1982). Eliminating Gould's Belt, it has been shown that the more concentrated spiral arm O, B stars represent a significantly different kinematic population from the remaining more widely dispersed disc O, B stars. The actual space motions of these two groups turn out to be very similar to those of Drifts I and II respectively occurring among later type stars within r < 200 pc. Drift I has an outward motion $\sim$30 kms$^{-1}$ relative to the better mixed Drift II, and if the identities have been correctly established, it is impossible in the case of our Galaxy to attribute spiral arm streaming to density waves: indeed the picture of widely distributed material arms moving through an underlying disc substratum seems increasingly appropriate. If both these Drifts are represented by HI clouds, the disc overall at $R \sim R_o$ will appear to be expanding at some average velocity of the two Drifts in general accord with Kerr's expansion 7-10 kms$^{-1}$.

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