A NEW VALUE FOR THE ROTATION SPEED OF THE SPIRAL STRUCTURE

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The basic model of our Galaxy, like the Schmidt (1965) model, obeys the density law $\rho(R)$ for the Galaxy based on divers evidence, less or better known from observation. The interpretation of the interstellar hydrogen radio profiles yields the rotation curve and the run of the force component in the radial direction. The Oort constants A, B known from radial velocities and proper motions of nearby stars, the distance from the Sun to the galactic center R_o established from the distances of RR Lyrae stars, the local density and density gradients in the vicinity of the Sun, known from the star counts, are involved in this basic model of the Galaxy. The r.m.s. velocity component in the z direction yields the approximate mass distribution in this direction. The model surface density is computed by integrating the density along the z direction in the model. The local surface density in the Schmidt model is 114 solar masses per pc^2; it depends rather strongly on the assumed density variation in the outer part of the Galaxy.

The basic model of the Galaxy is closely connected with the density-wave model of spiral arms (Lin et al., 1969). The rotation speed of the spiral pattern Ω_p, the angle of inclination of the spiral arms i and the amplitude of the density wave gravitational field V_1^* are the parameters defining the single density-wave pattern. The evaluation of these parameters is subject to the investigation of the kinematics and distribution of young stars in the solar vicinity, of the gas distribution and kinematics in the galactic plane and of stars migration process after formation in the spiral arm.

The theoretical investigation based on the solution of the Vlasov equation, Poisson equation and hydrodynamical equations led, under given simplification (Lin et al., 1969), to the dispersion relation for the density waves :

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$$[2\pi\sigma\ G\ F_\nu(x)\ x]/[|k|c^2(1-\nu^2)] = 1 \qquad (1)$$

$$x = k^2\ c^2/\kappa^2 \qquad (2)$$

$$k = m/[tg(i)\ R] \qquad (3)$$

$$F_\nu(x) = [(1-\nu^2)/x]\ \{1-[\nu\pi/\sin(\nu\pi)]\ [1/2\pi] \int_{-\pi}^{+\pi} \exp[-x(1+\cos s)]\ \cos(\nu s)\ ds \qquad (4)$$

$$k = 2\pi/\lambda \qquad (5)$$

$$\nu = m(\Omega_p - \Omega)/\kappa \qquad (6)$$

λ is the wavelength, ν is the frequency, i is the inclination of the spiral arms, Ω_p is the rotation speed of the spiral arms, $\Omega(R)$ is the rotation curve of the Galaxy, m is the number of arms, κ is the epicyclic frequency, σ is the surface density, c is the r.m.s. dispersion velocity of stars in the direction of the radius, G is the constant of gravity and k is the wave number.

This dispersion relation connects the wavelength of the spiral wave with the frequency. What is the correct solution of equation (1)? Taking the surface density σ from the Schmidt model and adopting any value for the r.m.s. dispersion velocity in the radial direction, the dispersion relation (1) determines the relation between the wavelength and frequency. This is what led Yuan (1969a,b) to state:"...the relevant values for the pattern speed lie in the narrow range of 11-13 km $s^{-1}kpc^{-1}$ ...". The word "relevant" means that the form of the spiral arms, which is defined in the observations of interstellar hydrogen, is in close connection with the shape of the equidensity curves as are defined by the integration of relation (1).

The value σ, the surface density in the galactic plane, is in fact determined with very low accuracy. We have not many reasons to limit ourselves exactly to the value defined by the Schmidt model. I would like to show you the dependence of the solution of dispersion relation (1) on the surface density, retaining the same rotation curve as adopted in the Schmidt model. We take the r.m.s. dispersion velocity in the radial direction high enough to avoid the local instabilities (Toomre, 1964):

$$c = 14.45\ \sigma\ [M_\odot pc^{-2}]/\kappa[km\ s^{-1}kpc^{-1}] \qquad (7)$$

For the local wavelength of the density wave we adopt the value 3.7 kpc (Fig. 1). We observe a strong dependence of the rotation speed of the spiral structure Ω_p on the surface density. The inaccuracies in the surface density are reflected in the inaccuracies of the rotation speed of the spiral structure. Let us conclude that with regard to the inaccuracies in the surface density σ the value of the rotation speed of the spiral structure is not limited by a narrow range of values, as stated by Yuan.

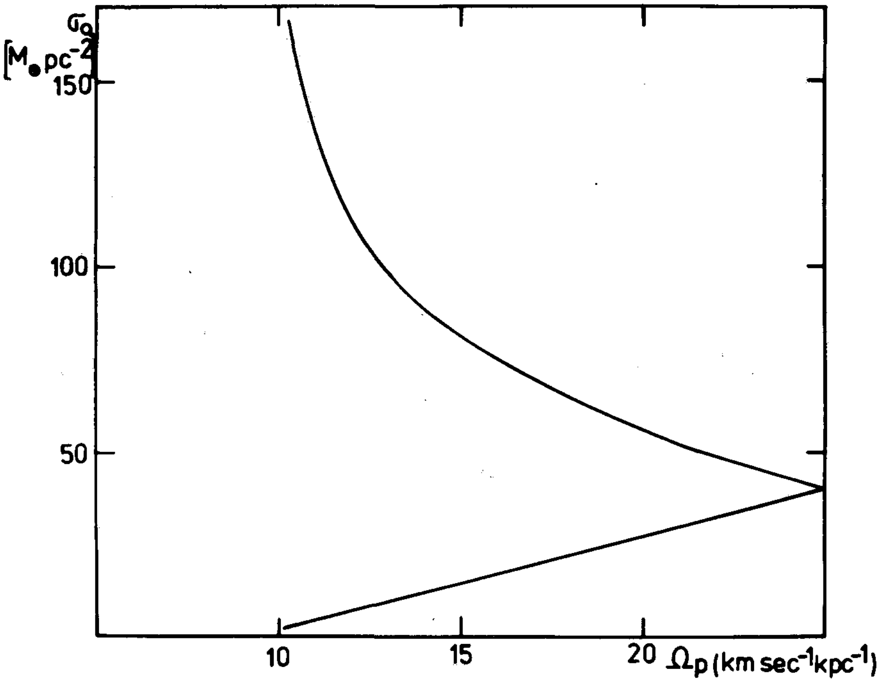

Fig. 1 The dispersion relation

In studying the migration process of open clusters (Palouš et al., 1977) we found that there were two values, Ω_p = 13.5 km $s^{-1}kpc^{-1}$ and Ω_p = 20 km $s^{-1}kpc^{-1}$, which equally fit the results. The second value enabled us to resolve that the space close to the Sun where the open clusters under examination are located is populated by groups of objects with certain preferred periods of formation. Each of these periods is separated from the next by a time interval of some 300 - 400 10^6 years. The length of a period seems to be about 200 10^6 years. This is caused by a combination of two different effects:
a) By the kinematical selection effect due to the fact that the very young objects with limited dispersion speed could not arrive in the Sun's vicinity from the whole galactic plane, but from a limited region only. The length of these periods is undoubtedly influenced by the size

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of the region where we now find the open clusters under examination.
b) By the fact that the stars are formed within the spiral arms.

The common areas defined by the kinematical selection effect and by the spiral arms are the parts of the galactic plane from whence the young stars in the solar neighbourhood probably originate. The shape and size of those regions define the length and time interval separating the periods mentioned above.

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