VERTICAL FORCE LAW K_z AND CHEMICAL GRADIENT IN THE GALAXY

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At Tbilissi, Prof. Blaauw (1975) reported on results of uvby photometry of F-type stars and showed a relation between the quantity Δm_1 and the distance z to the galactic plane. This relationship could be interesting if Δm_1 is a non ambiguous indicator of metallicity. It was found that the mean relative metal abundance decreases by a factor of about one third between 0 and 700 pc. The same type of relationship was obtained by M. Grenon (1976) for K giants and shows a lower variation of the metallicity with z.

These approaches entail a very accurate photometry and in particular a good calibration of absolute magnitudes for distant stars. We propound here another and rather simple method of computing the variation of the metallicity with z which only uses data in the galactic plane but which allows to introduce an obvious relationship between the chemical properties of stars and the vertical dynamical structure of the Galaxy characterized by the force law K_z. We want to see the influence of the shape of this force law on the vertical chemical gradient. It is premature to claim to choose between different K_z simply from comparisons between the mean metallicity which we compute on the one part and the observed values at different heights z on the other part, because too large uncertainties are still present for large distances to the plane.

In the galactic plane, we will consider any population as a mixing of subpopulations of different metallicity and kinematic properties. At each height z, the mean metallicity $\bar{m}(z)$ is a mixing of metallicities of the subpopulations, the percentage of which is modified as z increases. It is easy to show that a $\bar{m}(z)$ function can be computed as

$$\bar{m}(z) = \frac{\sum_{i=1}^{4} m_i \theta_i^o p_i}{\sum_{i=1}^{4} \theta_i^o p_i} \quad \text{for 4 subpopulations}$$

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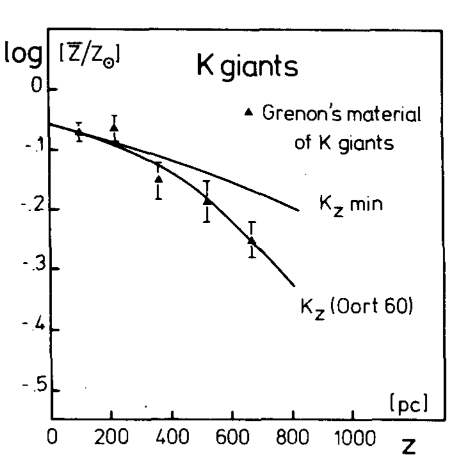
with

$$p_i = \frac{1}{\sigma_i^2} \int_0^2 K_z \, dz$$

σ_i = standard deviation of motions perpendicular to the galactic plane in the subpopulation i.

θ_i^o = percentage of the subpopulation i in the galactic plane.



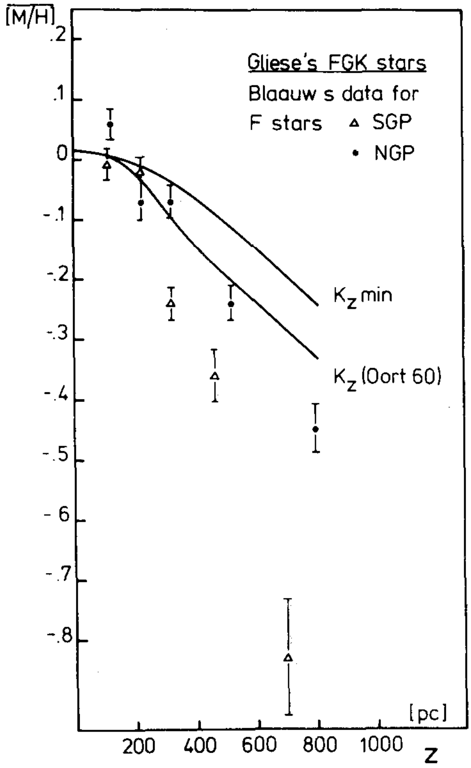


Fig. 1 The curves indicate the variation of the metallicity with the height z computed by using different force laws K_z and kinematical and chemical properties of samples in the galactic plane : a) K giants, b) FGK Gliese stars. The symbols ▲, ●, Δ indicate the observational data at different z-levels : a) Grenon's data, b) Blaauw's data.

We still have no completely reliable determination of the force law perpendicular to the galactic plane K_z. Uncertainties hold still for the apparently most elaborated computation of K_z proposed by Oort in 1960. Particularly the luminosity function plays an important role in this computation and the assumption of its constancy with z may be erroneous.

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We show two cases of computed $\bar{m}(z)$ for different possible force laws. The first example applies to a population of K giants. We use data from the Geneva photometry in a cone of vertical axis, near the galactic plane (less than 100 pcs). The z-component of the motion is given by the radial velocity slightly corrected for the latitude effect. The comparison of the computed $\bar{m}(z)$ is made with the $\bar{m}(z)$ values, expressed as log $(\bar{Z}/Z_{\odot})$, observed at any level z, recently given by Grenon (1976). The agreement is satisfactory if the force law is of the type Oort 1960. K_z minimum (as defined by Oort) seems to be inadequate (Fig. 1a). Reasonable fluctuations of percentages in the subpopulation at z = 0 have been introduced. The uncertainties inferred from are not indicated in the figure but are of the same order as the error bars concerning the observed values.

The second example concerns the Gliese stars earlier than K3 in order to avoid the well known important bias for later types. The function $\bar{m}(z)_{Gliese}$ obtained as the same slope (in the same system of units) as the one computed from K giants of the plane. If we compare it with data of $[\overline{M/H}]$ at different z-levels given by Blaauw for his F stars (Fig. 1b), the agreement seems to be slightly less good than in Fig. 1a. This may be due to the selection mode of the "observed" sample which can introduce some bias in favour of deficient faint stars. There is no evident reason for having a different vertical chemical gradient for the F, G and K stars but for the moment, and until we will have sound and reliable observational data in sufficient number for faint stars, such a disagreement is not too serious.

The present computation shows that the hypothesis of well-mixed dynamical state leads to coherent results and that a force law of type Oort 1960 or eventually increasing a little more sharply is consistent with observed values of the metallicity at different z-levels from the galactic plane.

References

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Oort, J. 1960 *Bull. Astron. Neth.* 494, 45

Once this work was finished, we made ourselves acquainted with a similar approach of the problem by Blaauw (Highlights of Astronomy, vol. 4, part 2, 1977, p. 51, Ed. E.A. Müller, Reidel Publ. Company, Dordrecht, Holland).