OBSERVATIONAL CONSTRAINTS FOR THE CHEMICAL EVOLUTION OF THE SOLAR NEIGHBOURHOOD

M. Grenon

Observatoire de Genève

The basic material for this preliminary investigation is formed of the Northern stars of Gliese's catalogue, completely measured down to the K5 spectral type in the Geneva system. The physical properties and new spatial velocities are derived and, after removal of non members of the local sphere, 230 stars can be used here.

For most of the stars, no individual age is obtainable and a kinematical age has to be used. As age estimator we prefer a weighted velocity f, equal to $c(U^2+2.5V^2+4W^2)^{1/2}$ the coefficients being proportional to $(\sigma_i/\sigma_u)^2$ which summarizes the information contained in orbital inclination and excentricity and appears to be a better age indicator for the old stars. The calibration of f versus age has been performed with Mayor's ages (1977) for F subgiants and ours for later types and is extended to halo stars.

For each star the mean galactocentric distance $\tilde{\varpi}$ is computed and a selection according to the f parameter shows that at given age, the distribution of abundances is largely dominated by large scale variations. A new value of the radial gradient of metal abundance is found to be

$$\gamma = \frac{\partial\,[Fe/H]}{\partial\tilde{\varpi}} = -0.07\cdot \mathrm{kpc}^{-1}$$

and about -0.10 for the youngest stars.

With increasing age, the mean $\tilde{\varpi}$ is rapidly decreasing and in the presence of a radial abundance gradient, the mean metal abundance $\bar{Z}$ is an increasing overestimation of the mean metallicity at a solar distance from the Galactic centre. For the computation of the variation of $\bar{Z}$ with time, the individual abundances have been reduced to $\tilde{\varpi}$ = 10 kpc using the adopted value of γ. The resulting temporal variation of $\bar{Z}$ is given in Fig. 1 and is found to be in excellent agreement with Larson's model 9

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for disk galaxies (Larson, 1975). After a rapid enrichment, the fraction of metals seems to increase at a low rate of about 0.001 by a billion years during the last $5 \cdot 10^9$ years.

In this context, the G dwarf problem has also been reconsidered. For the selection of long-lived stars, we have taken into account the dependence of T_{eff}, at given age and mass, as a function of metal content. According to the Peimberts (1976) and others, we have used the following relation between helium and metal content : $Y = 0.23 + 3Z$. Only a selection by mass interval appears to have a well defined physical sense. With a maximum age of 12 billion years, only the stars with a mass of $0.85\ M_\odot$ have to be retained and the validity range of our calibrations imposes a minimum limit of $0.65\ M_\odot$. This interval includes the late G and early K dwarfs of population I, but also some metal poor stars classified as F subdwarfs. These objects are systematically omitted by a selection according to a spectral type interval or a colour index interval, even if a blanketing correction is applied.

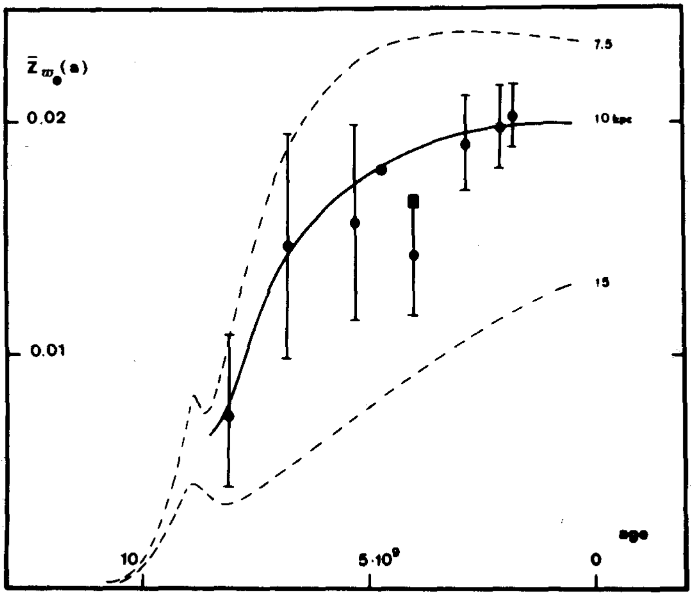

Fig. 1 Variation with time of mean metal content at 10 kpc, compared with Larson's model 9. Symbols : ⊙ → Sun, ▮→ M67 after metal gradient correction.

As we look for projected densities, the stars are weighted by the ratio of time spent in a vertical oscillation on the crossing time of the local sphere, using for this purpose the quadratic relation given by Woolley (1968). The selection mode as well as the weighting function enhance the proportion of metal poor stars whose number appears much greater than generally accepted. Moreover, the cumulative distribution of abundances starts from Z nearly equal to zero and the G dwarf problem seems to be seriously reduced. But the underlying hypothesis that the stars now observed in the Solar vicinity are born at a Solar distance from the Galactic centre is not valid, especially for most of metal deficient and SMR stars. If we want to follow the chemical evolution at 10 kpc, using stars with $\tilde{\varpi}$ distributed in a wide range, here from 7 to 13 kpc, the stars with more extreme $\tilde{\varpi}$ values being rejected, we have to take into account the variation of the projected stellar density with $\tilde{\varpi}$, the radial gradient of abundances and the perpendicular motions. When the effects of these parameters are corrected, we get the cumulative distribution shown in Fig. 2.

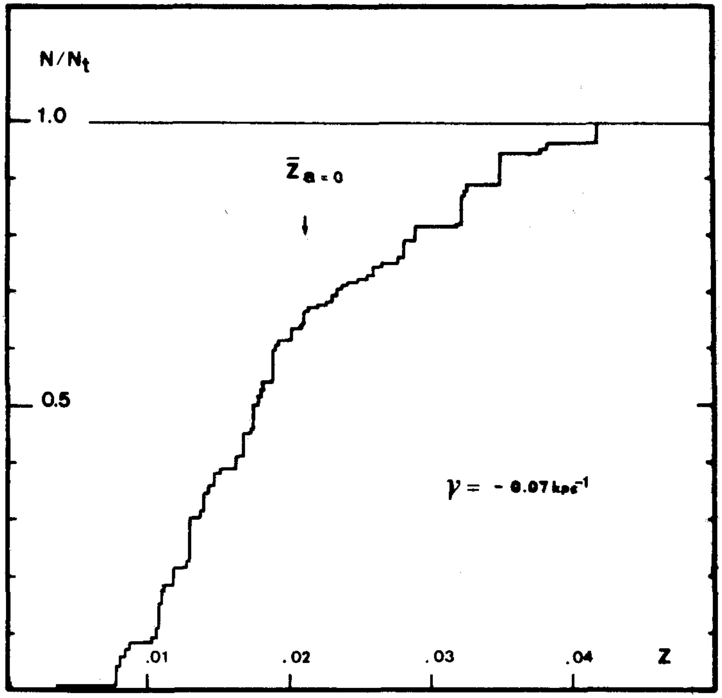

Fig. 2 Cumulative distribution of abundances of long-lived stars valid at 10 kpc from the Galactic centre. Arrow → present mean value.

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The deficiency in metal poor stars is now more severe than in the recently published distributions e.g. that of Pagel and Patchett (1975). The distribution grows linearly from Z = 0.007 to the mean present value of 0.021, the adopted mass fraction of heavy elements in the Sun being 0.018. The flattening of the curve for higher Z values is the result of the abundances scattering at a given age and birthplace.

With a maximum age for disk stars of about $9 \cdot 10^9$ years, Grenon (1975), we can deduce that the main stellar formation at 10 kpc has started rather lately in an enriched gas with a metal abundance reaching one third of the present value.

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