Chemical abundances in the ancient Milky Way : G-type SDSS stars

Automated determination of T_{eff}, logg, [Fe/H] and [α/Fe]

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Abstract:

We have developed TGMETα in order to determine T_{eff}, logg, [Fe/H] and [α/Fe] for large samples of FGK stars observed at various spectral resolutions. Tests on several hundred echelle spectra of reference stars degraded to low resolution (R=1.000) indicate typical rms precisions of $\sigma(T_{eff})$~150 K, σ(logg)~0.44, σ([Fe/H])~0.15 and σ([α/Fe])~0.06.
We have used TGMETα to determine atmospheric parameters and α-abundances from ~15000 SDSS stellar spectra. Thanks to this very large sample we have investigated the vertical, radial and rotational properties as well as the abundance ratio of α elements to iron, [α/Fe], of samples representative of the thick disk and the halo.

1) Automated analysis:

- The observed SDSS spectra were downloaded from the SDSS database, wavelength calibrated, straightened, shifted of radial velocity, linearly re-sampled and convolved at R≈1.000 by Allende Prieto et al. 2006ApJ…636..804A.

- TGMETα computes the distance between the target spectrum and each spectrum of a synthetic library (reduced χ^2). The atmospheric parameters of the target spectrum are computed by averaging those of the 8 nearest synthetic spectra.

- TGMETα has been tested with ELODIE spectra degraded at low resolution (R=1.000). We compared values with those from several reference catalogues in the literature.

The rms precisons are:

• T_{eff}: rms= 150 K ; logg: rms= 0,44 ; [Fe/H]: rms= 0,15 ; [α/Fe]: rms= 0.06

Offset corrections have to be applied in order to take into account the different scales of the synthetic grid versus the literature determinations. At this resolution, TGMETα provides a maximum value of [α/Fe] =+0.45.

2) Reference spectra:

- Our reference library is the grid of synthetic spectra from Barbuy et al. (2003A&A…404..661B)

- *$\lambda\lambda$4590-5610Å*

- *T_{eff}: 4000 to 7000 K in steps of 250 K.*

- *logg from 0.0 to 5.0 in steps of 0.5.*

- *[Fe/H]:-3.0 to -0,5 in steps of 0,5 dex, then -0,3 ; -0,2 ; -0,1 ; +0,0 ; +0,3.*

- *[α/Fe]: +0,0 ; +0,2 ; +0,4 ; +0,6*

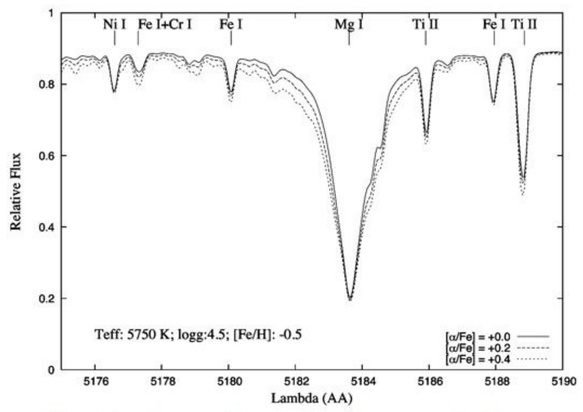
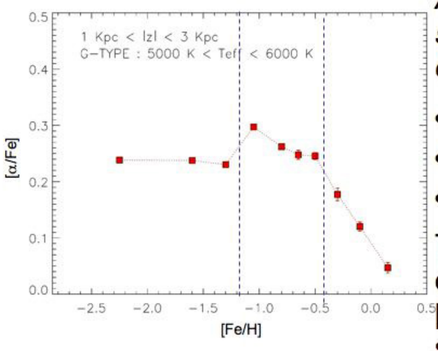


Fig. 1: A section of the spectral range used in this study for several model atmospheres included in the grid.

3) [α/Fe] vs [Fe/H] of G-type stars:

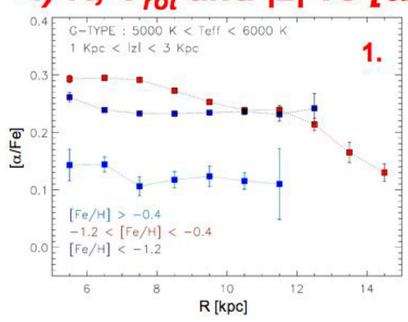


At 1 kpc < |z| < 3 kpc, where the thick disk is supposed to be dominant, 3 regimes are observed:

•The halo regime, [Fe/H] < -1.2
•The thick disk regime, -1.2 < [Fe/H] < -0,4
•The thin/thick disks regime, [Fe/H] > -0,4

The thick disk appears to be more enriched in α elements than the halo. The "knee" observed at [Fe/H]~ -0,4 is due to the contribution of thin disk stars

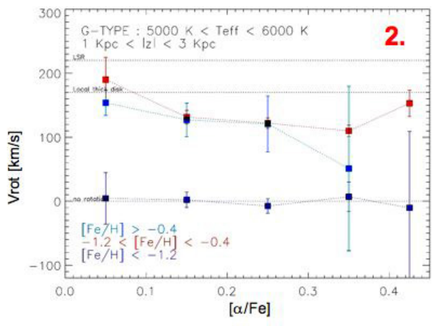
4) R, V_{rot} and |z| vs [α/Fe] in the 3 regimes:



1: A radial gradient is only observed in the thick disk regime.

In the halo and thin/thick disks regimes, trends remain flat.

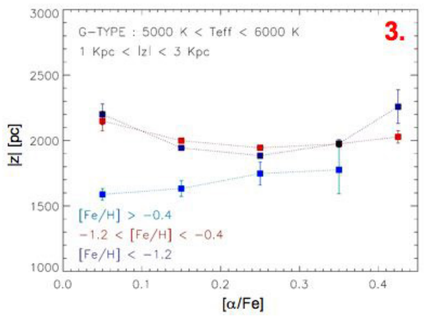
Squares: mean values of [α/Fe] in 1 kpc bins.



2: V_{rot} in the thick disk regime is just below of the canonical value of the local thick disk. In the halo, the trend is flat. This confirms the dominant contribution of halo stars at [Fe/H]< -1.2.

The large dispersion in thin/thick disks regime is an indication of the mix of the stellar populations.

Squares: mean values of V_{rot} in 0.1 dex bins.

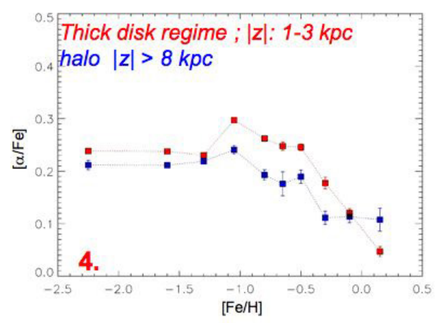


3: The thick disk and halo regimes have similar trends and are higher above the galactic plane than the thick/thin disks regime.

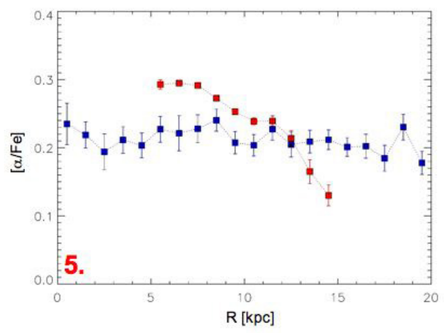
Moreover, an increase, may be due to the contribution of thick disk stars with high [α/Fe], is observed in the thick/thin disks regime.

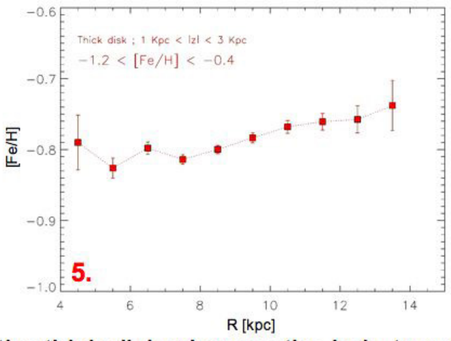
Squares: mean values of |z| in 0.1 dex bins.

5) Comparison: thick disk / halo



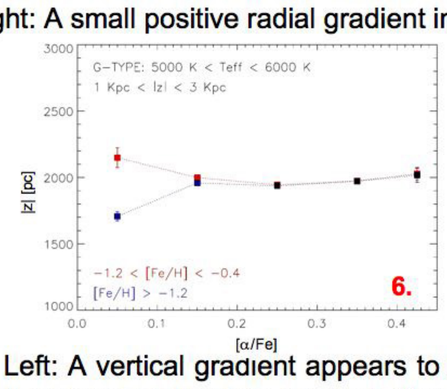
4: halo stars, selected with |z| > 8 kpc, have lower [α/Fe] than the thick disk stars.

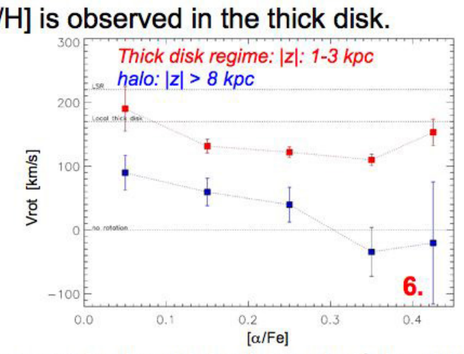




5: Left: A radial gradient in [α/Fe] is present in the thick disk whereas the halo trend's is flat.

Right: A small positive radial gradient in [Fe/H] is observed in the thick disk.





6: Left: A vertical gradient appears to be present in the thick disk only if the thin/thick disk regime is taken into account. Thus the vertical gradient found cannot be attributed to the thick disk.

Right: The thick disk has a V_{rot} near the value of the canonical thick disk. A significant contribution from halo stars is not excluded. For the halo, a correlation between V_{rot} and [α/Fe] is observed. This fact were not observed in the Fig. 2 for nearby halo stars. There may be a contribution at large distance from accreted satellite debris at low [α/Fe] ?

Summary: Results presented here, provide new constraints on galactic thick disk formation models. We find evidence for a strong negative radial gradient in [α/Fe] with a lack or small one in [Fe/H] in the thick disk. Moreover, there is a lack of vertical gradient in both [Fe/H] and [α/Fe]. These features have to be reconciled with the timescale of the thick disk formation as well as with the SFR, IMF, infall of gas or accreted satellite debris.