Metallicity gradients in the Milky Way thick disk as dynamical relic of a primordial chemical distribution

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We examine the evolution of the radial metallicity gradient induced by secular processes, in the disk of a N-body Milky Way-like galaxy. We assign a [Fe/H] value to each particle of the simulation according to an initial, cosmologically motivated, radial chemical distribution and let the disk dynamically evolve for ~6 Gyr. This direct approach allows us to take into account only the effects of dynamical evolution and to gauge how and to what extent they affect the initial chemical conditions. The initial [Fe/H] distribution increases with R in the inner disk up to R ≈ 10 kpc and decreases for larger R. We find that the initial chemical profile does not undergo major transformations after ~6 Gyr of dynamical evolution. The final radial chemical gradients predicted by the model in the solar neighborhood are positive and of the same order as those recently observed in the Milky Way thick disk.

BACKGROUD

Each particle in the initial configuration is tagged with a [Fe/H] label according to the initial radial chemical distribution (Spitoni & Matteucci 2011)

(see Fig. 2, dot-dashed line).

We recover, after 5 Gyr, the resulting metallicity-velocity correlations in the solar corona and for stars having height 2 kpc >|z|>1.5 kpc described in Fig. 3, such correlations are in qualitative agreement with the one shown by Spagna+2010 for the thick disk stars (Curir+2012).

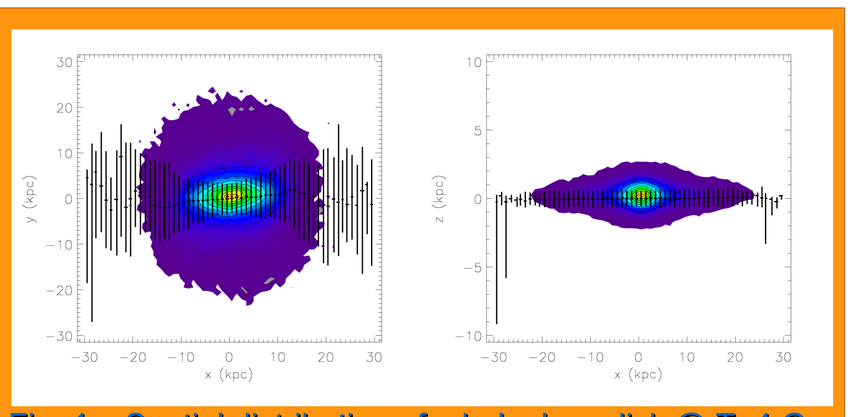


Fig. 1 – Spatial distribution of a bulgeless disk @ T=4 Gyr
Error bars represent dispersions σ_y (left), σ_z (right).

MIGRATION OF PARTICLES

Top: R_f/R_i, (R_i is the radius of a particle at initial time and R_f is that of the same particle at different times).

Bottom: $|z_f/z_i|$, at the same times.

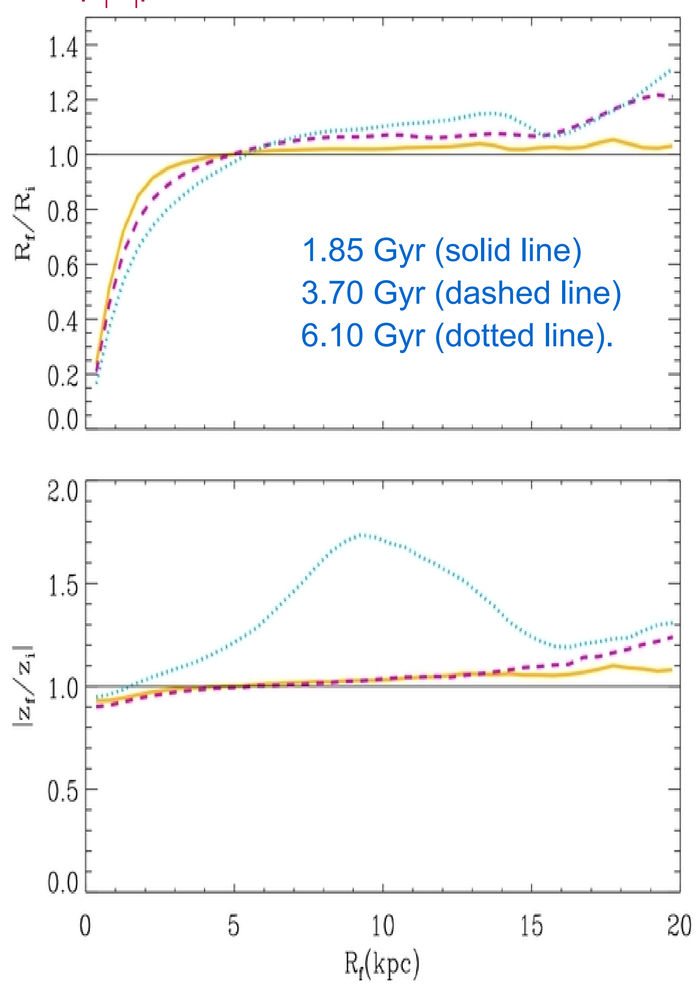


Fig. 4 – **profiles of median ratios**. The binning range over the *x*-axis is 0.5 kpc in both panels.

CHEMICAL DISTRIBUTION

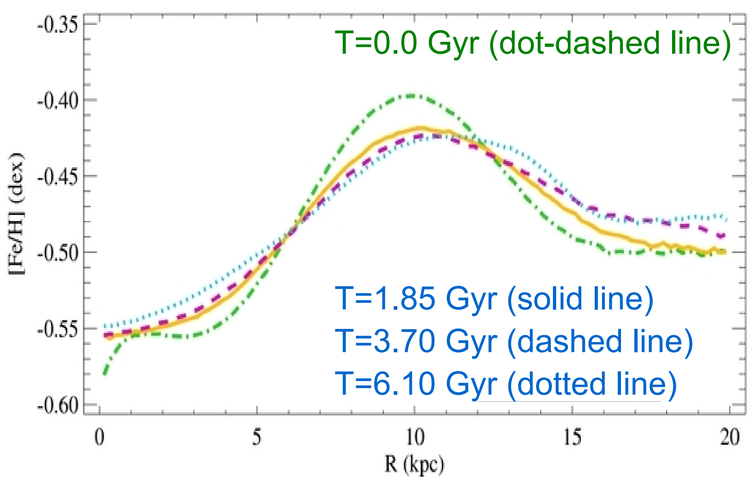
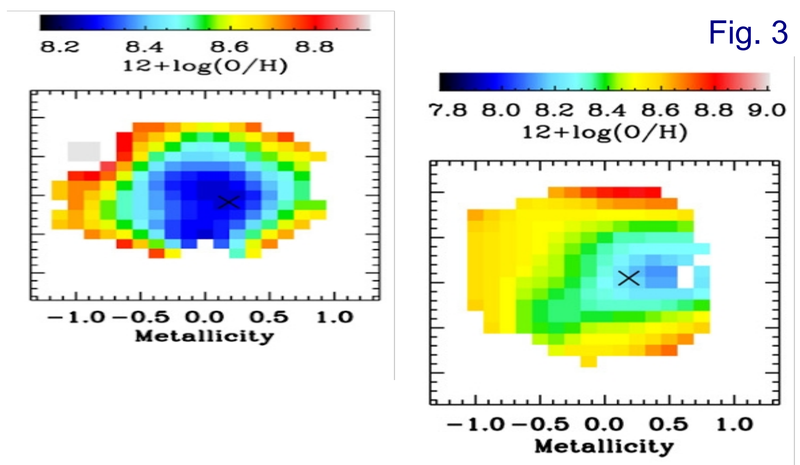


Fig. 2 - **Median radial chemical distribution** at the beginning of the dynamical simulations & later on, T>0.

The points are the median values of the data over bins 0.2 kpc wide.

Fig. 3



The assumed **chemical distribution is consistent with** the **recent results** published by Troncoso+2014, who studied a sample of distant galaxies at redshift Z>3 and found evidence for an inverse metallicity gradient, possibly produced by the accretion of primordial gas, which diluted the abundance of elements heavier than helium in the centre of the galaxies.

RADIAL CHEMICAL DISTRIBUTION

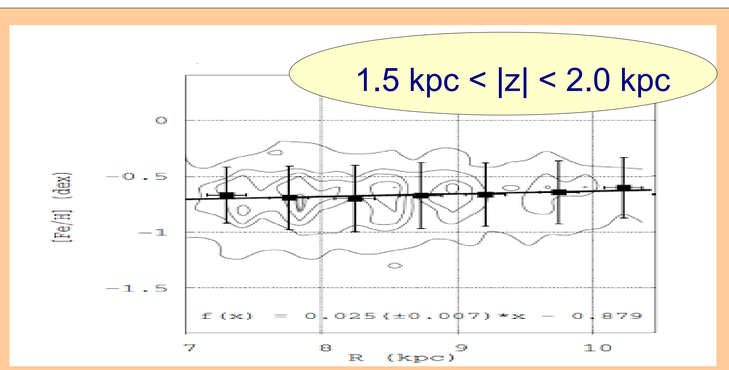


Fig. 5

The **radial chemical distribution** in the high z region of the barred disk after 5 Gyr (bottom) is in agreement with what is observed by Carrell+2012 for the thick disk dwarf stars in the Milky Way (top).

RADIAL METALLICITY GRADIENTS

Our estimates at 6.1 Gyr from the dynamical *N*-body simulation

For comparison, what measured by Carrell+2012 at |z| > 1.5 kpc, through:

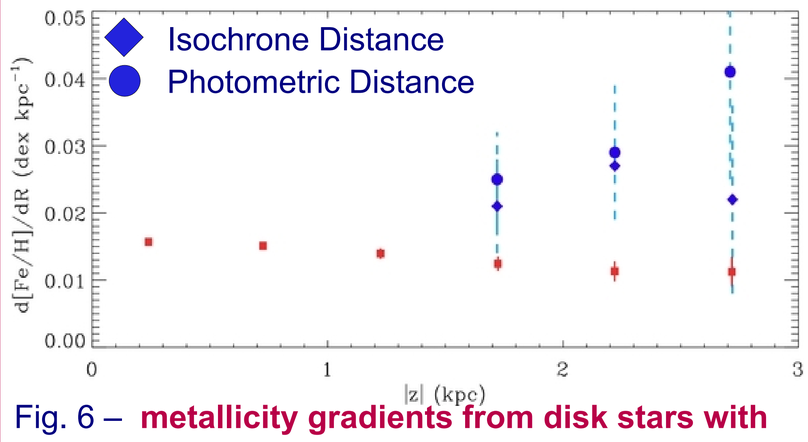


Fig. 6 – **metallicity gradients from disk stars with 7.0 kpc <*R* < 10.5 kpc**.

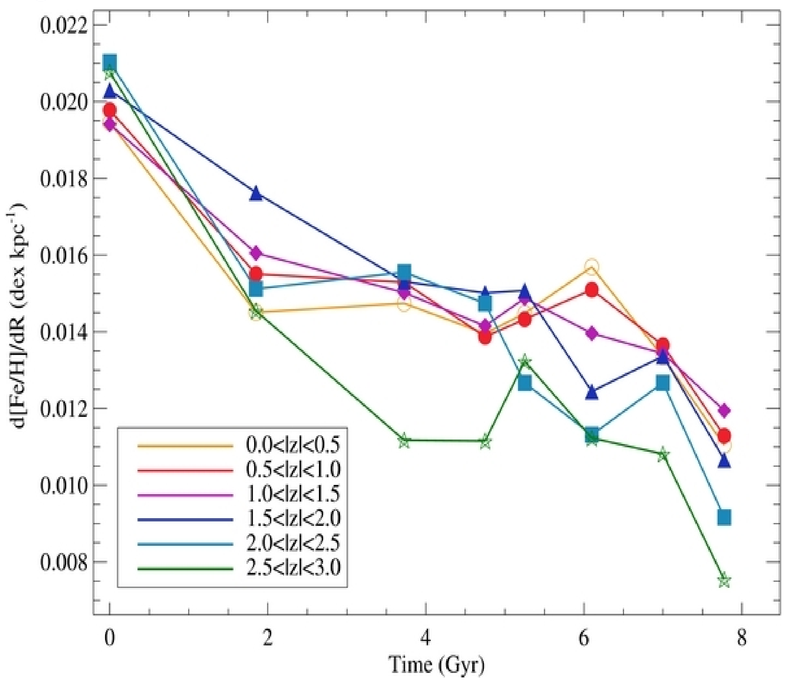
The abscissa of each point is the mean height of the particles in the respective bin (broad 0.5 kpc in *R* or |*z*|).

The error bars on the vertical axis are 3σ width of the distribution, as 1σ errors would be hardly appreciated in this figure.

...EVOLUTION

of the radial gradient in the solar annulus @ layers in |z|

Fig. 7



REMARKS @ IAU Symposium 309

Vienna 7-11 July 2014

Our results indicate that, the positive radial metallicity gradient in the solar neighborhood observed in the MW thick disk is consistent with a thick disk population showing an early positive [Fe/H] radial gradient in the inner disk (*R* < 10 kpc) and negative in the outer disk (*R* > 10 kpc). In the context of the inside-out formation scenarios of the galactic disk (Spitoni & Matteucci 2011; Mott+2013), such a gradient "inversion" derives from the strong infall of primordial gas that can occur at early times in the inner disk.

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