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Unveiling a young thick disk in the Milky Way

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ABSTRACT

The thickness of a galaxy's disk provides a valuable probe of its formation and evolution history. Observations of the Milky Way and local galaxies have revealed an ubiquitous disk structure with two distinctive components: an old thick disk and a relatively young thin disk. The formation of this dual-disk structure and the mechanisms that develop the thickness of the disk are still unclear. Whether the disk thickness inherit from the birth environment or is established through secular dynamical heating after formation is under debate. In this work we identify a relatively young ($\sim$6.6 billion years old) geometric thick disk in the Milky Way, with a scale height of 0.64 kpc at the Solar Circle. This young thick component exhibits comparable thickness and flaring strength to the canonical old thick disk but is more radially extended and systematically younger. We also identify thin disk components that formed before and after this young thick disk. Detailed analysis of the solar vicinity structure suggests that the young thick disk marks the onset of a new phase of upside-down disk formation. These findings strongly discount the role of secular dynamical heating and support a turbulent, bursty birth environment as the primary mechanism behind thick disk formation. The existence of two thick disk components suggests that the Milky Way has undergone at least two episodes of turbulent and bursty star formation, likely triggered by galaxy mergers.

Данные

- Из обзора APOGEE выбрали:
- Звезды-гиганты
- Сигнал/шум спектров >50
- $e<0.7$
- Имеются оценки [Fe/H], [Mg/Fe], возраста, кинематики, позиции

Выборка

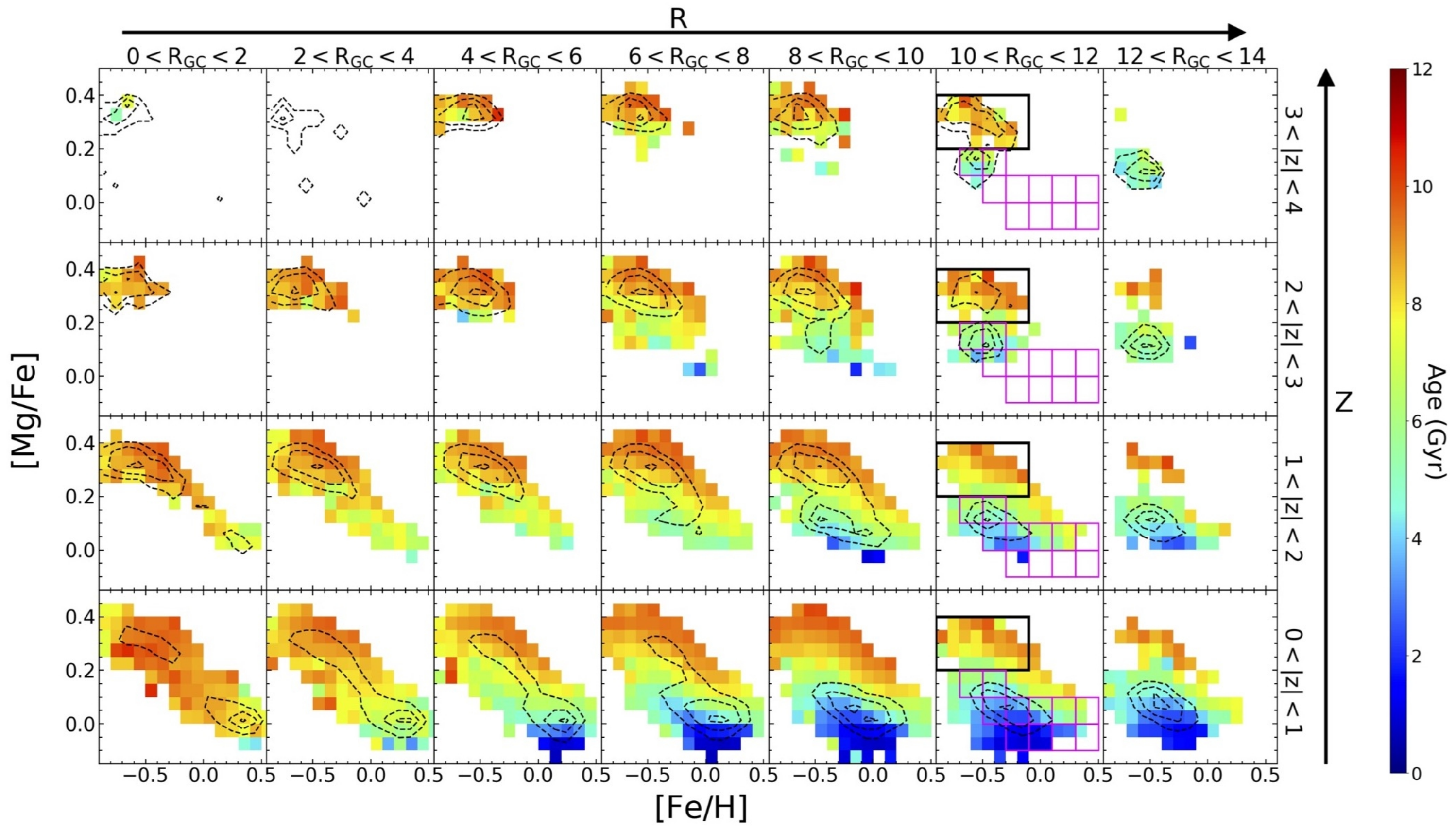

Figure 1. Averaged age map of APOGEE stars in the [Mg/Fe]-[Fe/H] diagram across the Galaxy. [Mg/Fe]-[Fe/H] distributions are examined within the ranges of $-0.9 < [Fe/H] < 0.6$ and $-0.15 < [Mg/Fe] < 0.5$, as a function of radius ($0 < R < 14$ kpc in horizontal direction) and height ($|Z| < 4$ kpc in vertical direction). Dashed contours outline the density distribution at level of 20%, 50%, and 90% of the peak density in each panel. Pink and black boxes in the sixth column highlight the low- and high-α mono-abundance populations for which the scale height is presented in Figure 2.

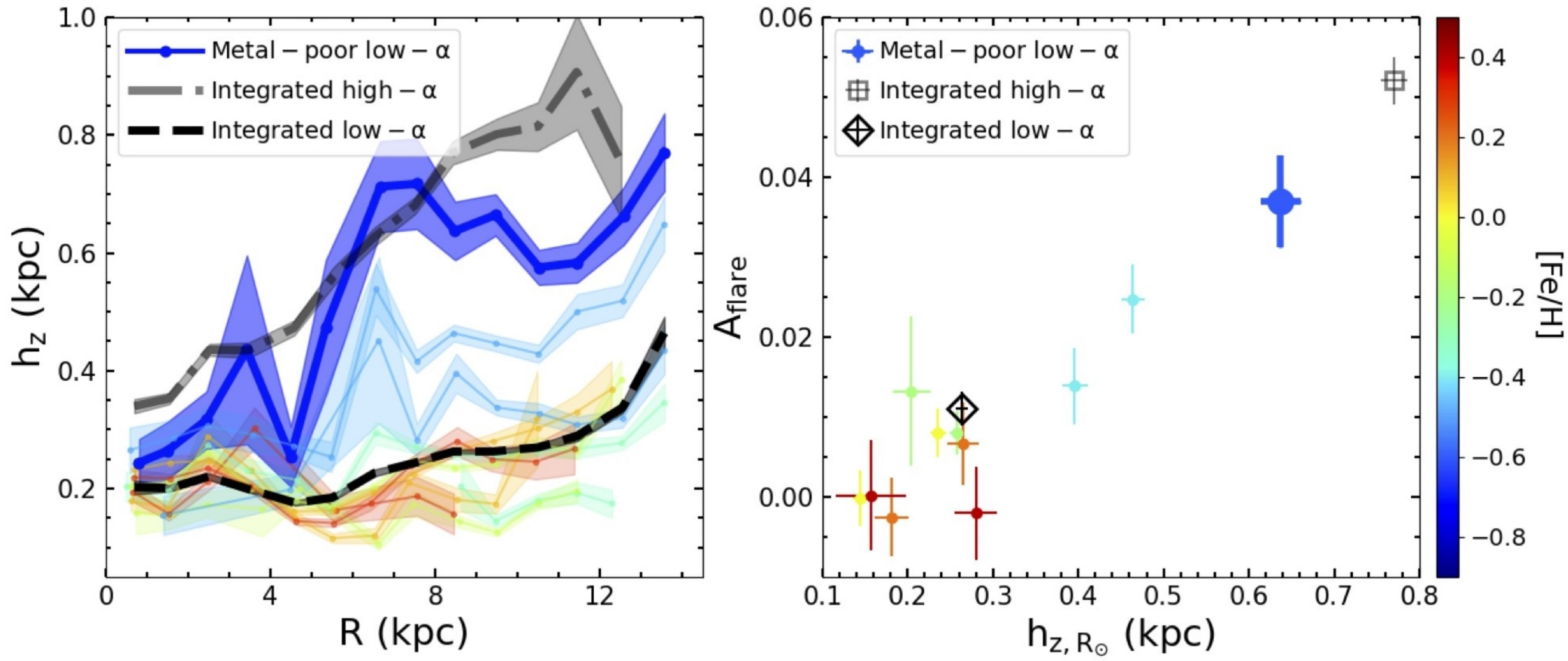

Figure 2. Vertical structure of mono-abundance and integrated populations of the Milky Way. *Left:* scale height as a function of radius for various disk components. The gray dash-dotted and black dashed lines indicate the scale height radial profiles of integrated high- and low-α populations, marked by the black and pink boxes in Figure 1, respectively. The colourful lines represent the radial profiles of low-α populations, split into mono-abundance space in [Mg/Fe] and [Fe/H], color-coded by [Fe/H]. Note that the vertical axis spans only $\sim$7% of the distance range of the horizontal axis. *Right:* Flaring strength ($A_{\rm flare}$) versus scale height at solar Galactocentric radius for high- and low-α populations. The flaring strength is represented by the best-fitted slope of the scale height radial profile. The metal-poor low-α population emphasized in the main paper is marked with a thickened line in the left-hand panel and an enlarged circle in the right. Shade regions and error bars represents 1σ uncertainties of the estimates of flaring strength and scale height.

Построены пространственные распределения MAP с учетом селекции

Ухитрились выделить две последовательности возраст-металличность

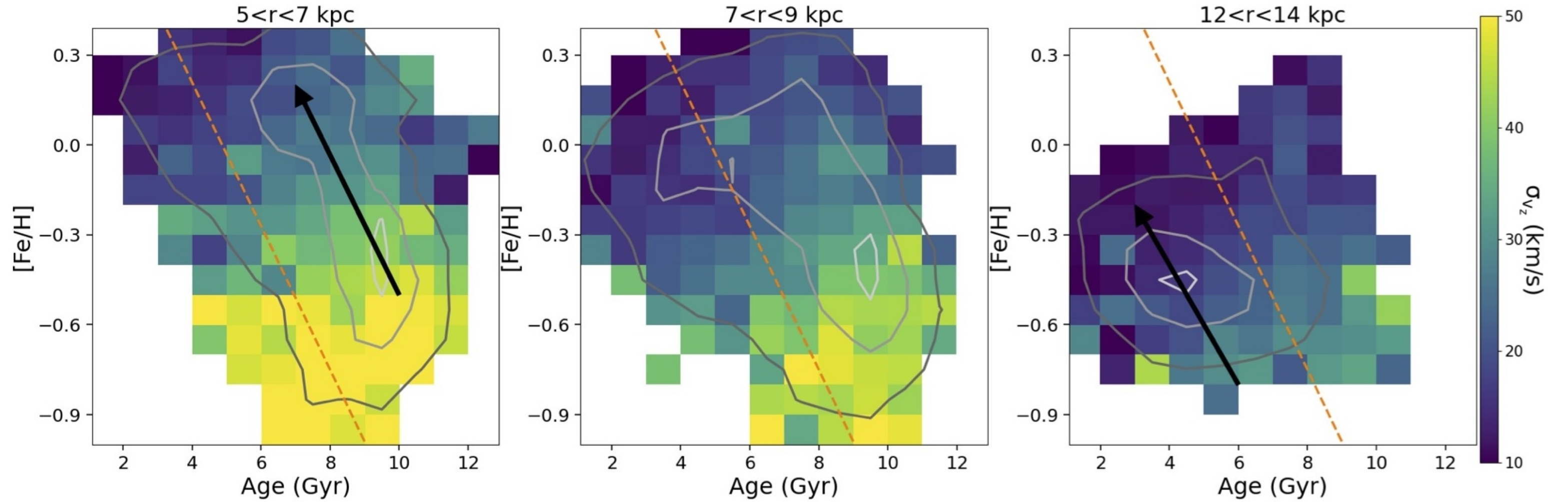

Figure 4. Distribution of vertical velocity dispersion in age-[Fe/H] plane at three radii. Raw APOGEE sample is used to calculate the velocity dispersion. Grey contours in each panel outline the density distribution with level of 30%, 60%, and 90% of the peak density. Black arrows in the left and right panels indicate the trend of decreasing vertical velocity dispersion along the two age-metallicity sequences that are predominated in the inner and outer Galaxy, respectively. Orange dashed line is used to separate the two age-metallicity sequences.

А вот тут вообще сюр: второй толстый диск образовался после тонкого

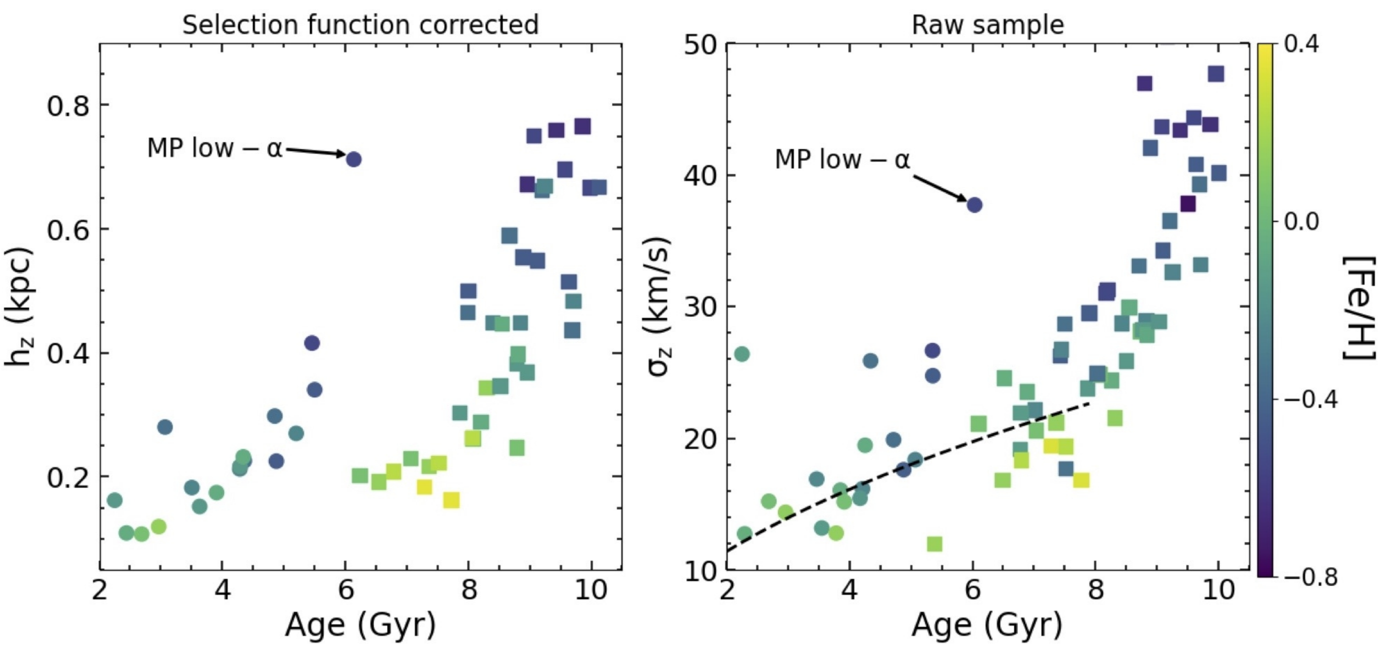

Figure 5. Scale height and vertical velocity dispersion as a function of stellar age for mono-abundance populations (MAPs). MAPs along the old and young age-metallicity sequences are indicated as squares and circles, respectively. The separation of these two sequences is defined by a straight line in the age-metallicity plane. Color coding reflects the metallicity of each MAP. The scale height is calculated from the intrinsic density distribution of MAPs after correcting for the selection function, whereas the velocity dispersion is derived from the raw sample data. Dashed curve in the right panel represents the power law with a slope of 0.5, illustrating the predictions of secular heating scenario (Martig et al. 2014).

Выводы:

- Формирование толстого диска не имеет никакого отношения к секулярному динамическому нагреву.
- А к чему имеет отношение формирование молодого (6.5 млрд лет) толстого диска во внешней области?
- Идея про первое сближение с Sgr-dw выглядит слабо: [Mg/Fe]=+0.15 означает довольно длинную вспышку звездообразования