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# Radial migration in the Galactic disc driven by a slowing bar

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# Introduction

Stars in the galactic disc can be scattered from their birth orbits to their present-day orbits.

1) the drifting of the angular momentum;

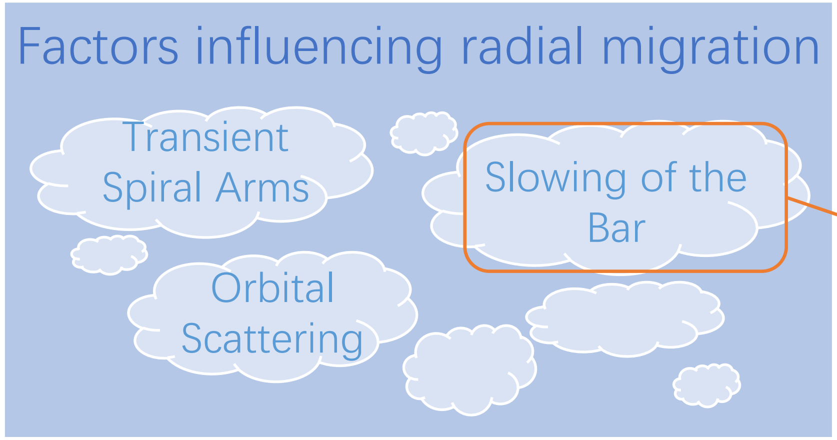
(Dubbed "churning" )

2) the radial oscillation or the radial action.

(Dubbed "blurring" )

**Radial migration could reshape the chemical properties of the Galactic disc.**

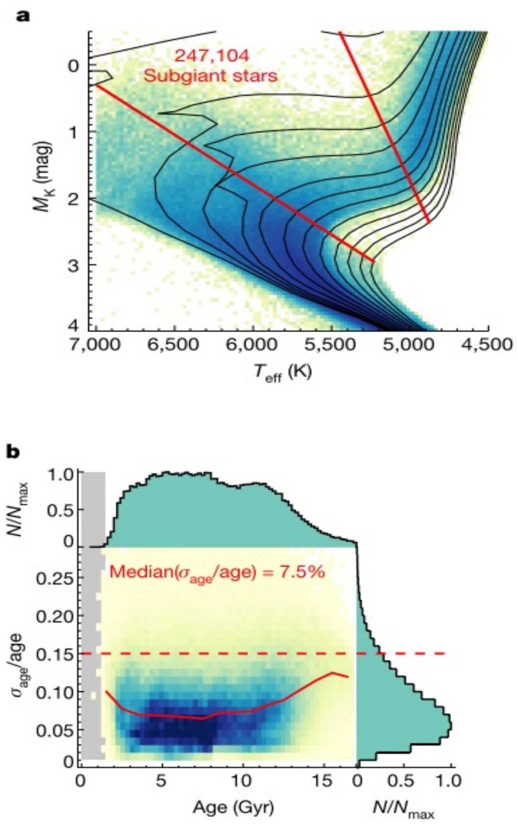
(the [α/Fe]-bimodality of the disc, the age-metallicity distribution,⋯)




This work investigates the effect of stellar radial migration, caused by the outward drift of the corotation radius induced by a slowing bar on the age–metallicity plane, through a comparison between simulations and observations.

# Sample

This work use the stellar parameter and isochrone age measurements of ~ 247 000 subgiant stars derived from LAMOST DR7 spectra by Xiang & Rix (2022).



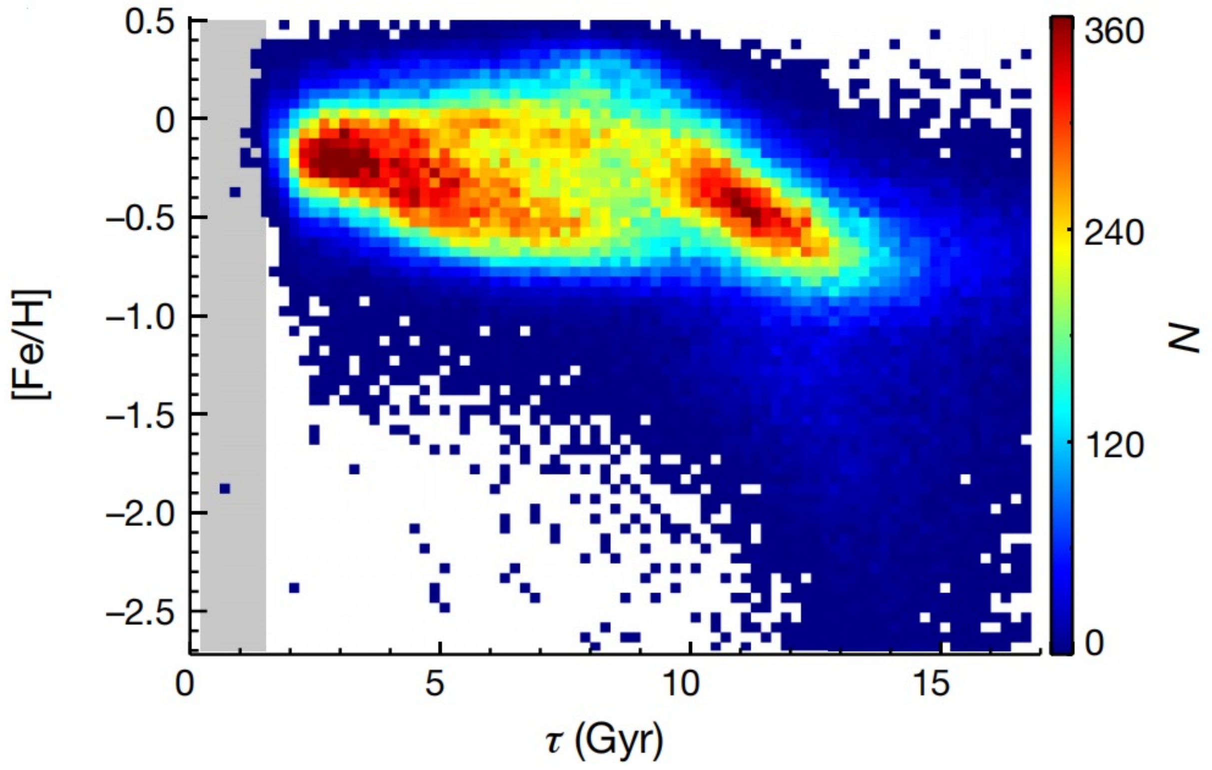




figure from Xiang, M., & Rix, H.-W. 2022, Nature, 603, 599,doi: 10.1038/s41586-022-04496-5

# SIMULATION

This work performs a test particle simulation using a realistic Galactic potential.

The Galactic potential is set following Dillamore et al. (2024a) and Portail et al. (2017).

Dillamore,A.M.,Belokurov,V.,& Evans,N.W.2024a,MNRAS,532,4389,doi:10.1093/mnras/stae1789

Portail,M.,Gerhard,O.,Wegg,C.,& Ness,M.2017,MNRAS,465,1621,doi:10.1093/mnras/stw2819

The setup of the slowing bar:

The bar begins to 'grow' at 4 Gyr, reaching its maximum speed at 5 Gyr, after which it starts to decelerate.

initial pattern speed:

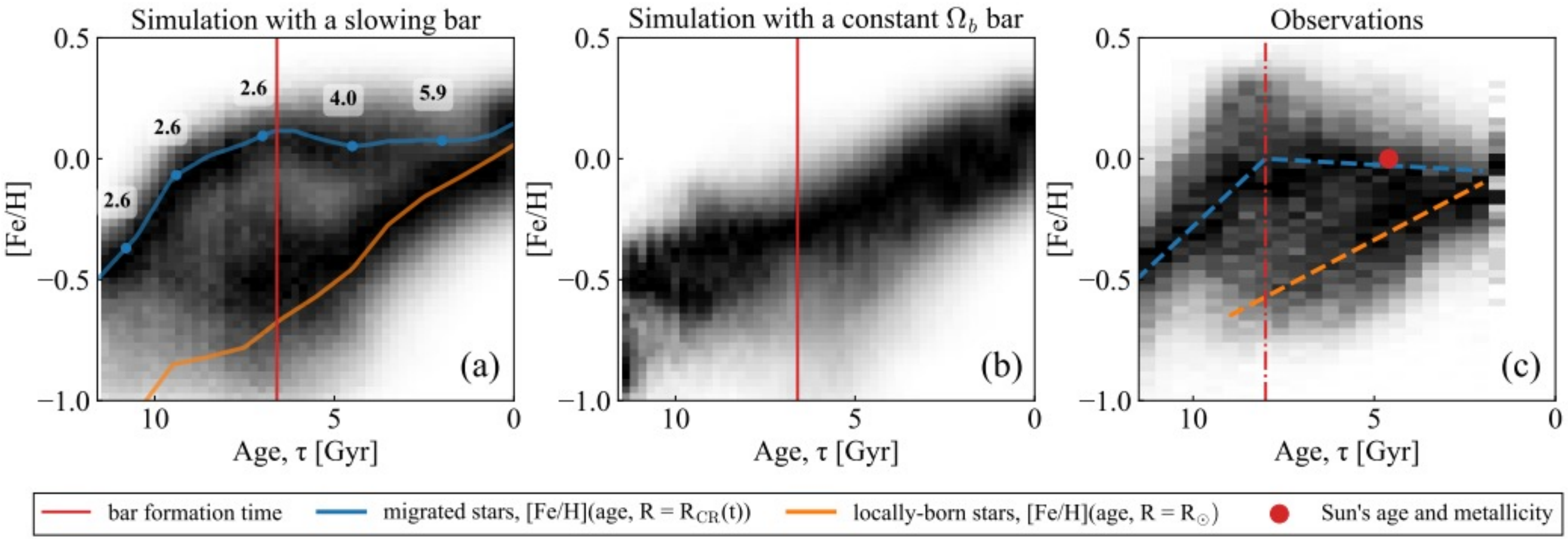
$$80\ km \cdot s^{-1} \cdot kpc^{-1}$$

constant slowdown rate:

$$\eta = -\frac{\dot{\Omega}}{\Omega^2} = 0.003$$

Dehnen,W.2000,AJ,119,800,doi:10.1086/301226

# RESULTS

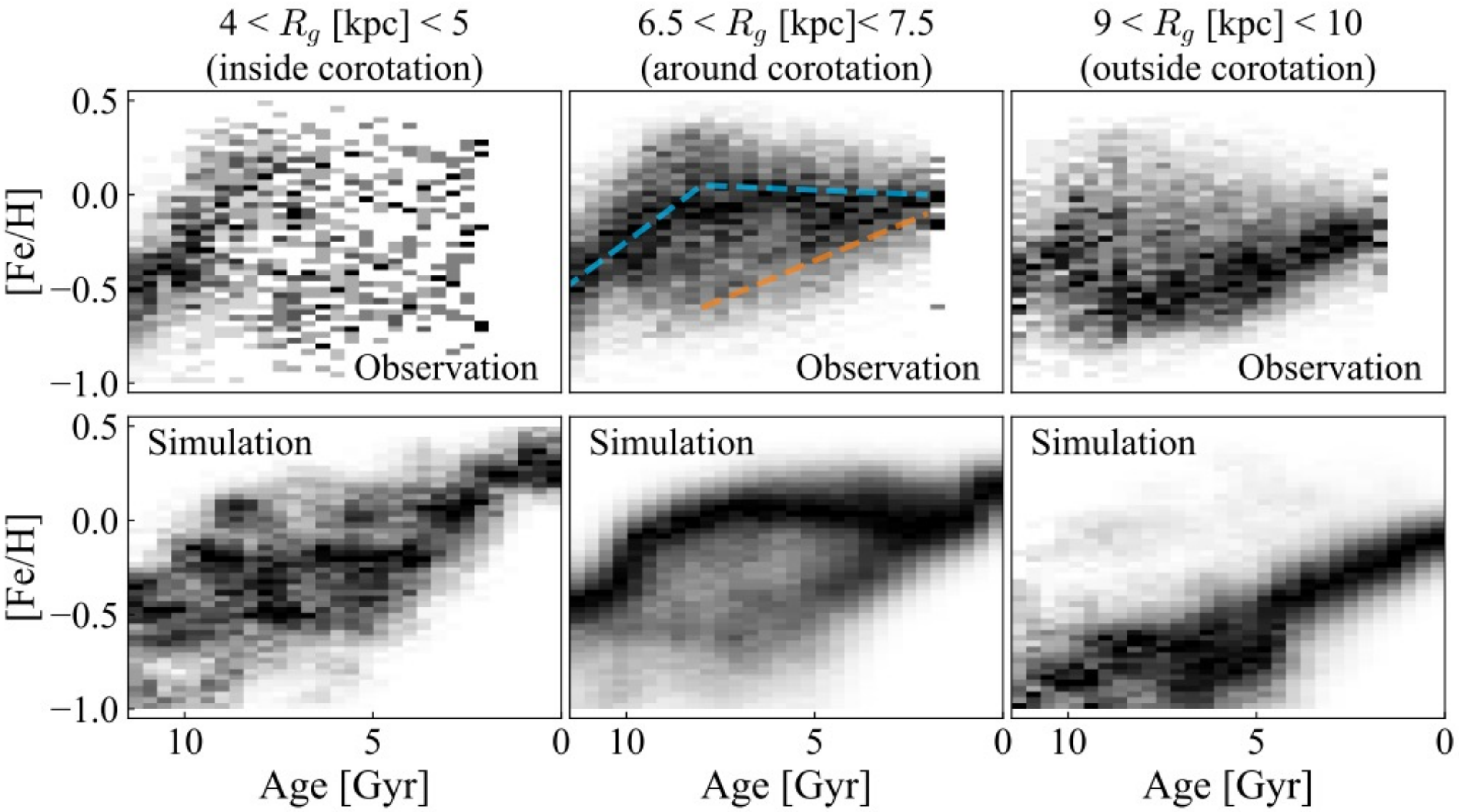



**panel (a)**: the age-metallicity plane of the test particle simulation with a slowing-down bar. The blue line shows the metallicity evolution for stars that formed at the corotation radius of their corresponding age, $[Fe/H](\tau, R_{CR}(\tau))$, where the blue dots and annotation denote $R_{CR}(t)$ at the respective times in units of kpc; the orange line shows the metallicity evolution of stars that formed around the solar circle, $[Fe/H](\tau, R_{\odot})$.The red line indicates the moment of bar formation.

**panel (b)**: the same as panel (a), except that the galactic bar is rotating with a constant pattern speed at all times.

**panel (c)**: the column-normalised age-metallicity distribution of the subgiant star sample we constructed based on Xiang & Rix (2022), where the red circle indicates the Sun in this plane. The blue and orange dashed lines are used to denote the upper and lower age-metallicity sequences, and the red-dashed line labels the turning point of the upper sequence.

# RESULTS

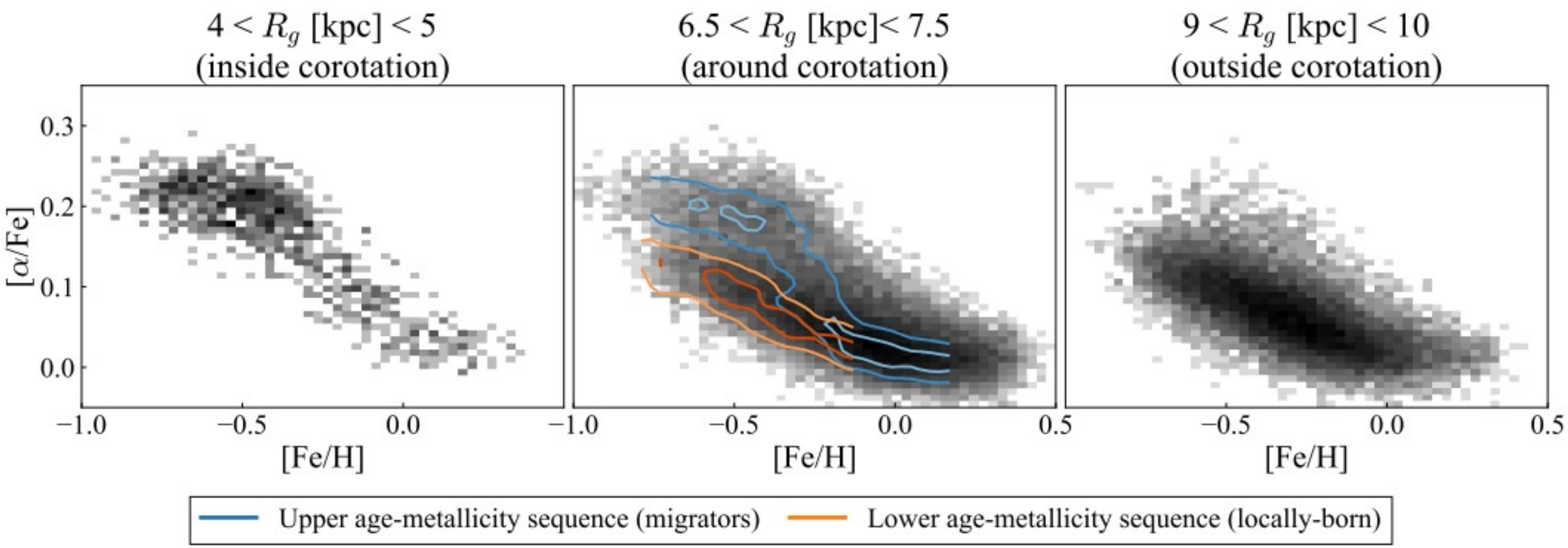



The dependence of the age-metallicity distribution on guiding radius sheds light on the origin of the two age-metallicity sequences. The observation that the upper sequence is the strongest around the corotation radius further supports this argument that the stars in the upper sequence are migrated due to the corotation resonance.

**Top panels**: the observed age-metallicity (column-normalised) distribution of the subgiant stars in various guiding radii bins. The blue and orange dashed lines in the middle panel denote the migrated and local age-metallicity sequence.

**Bottom panels**: the age-metallicity (column-normalised) distribution of the test particle simulation witha slowing down bar in different guiding radii bins.

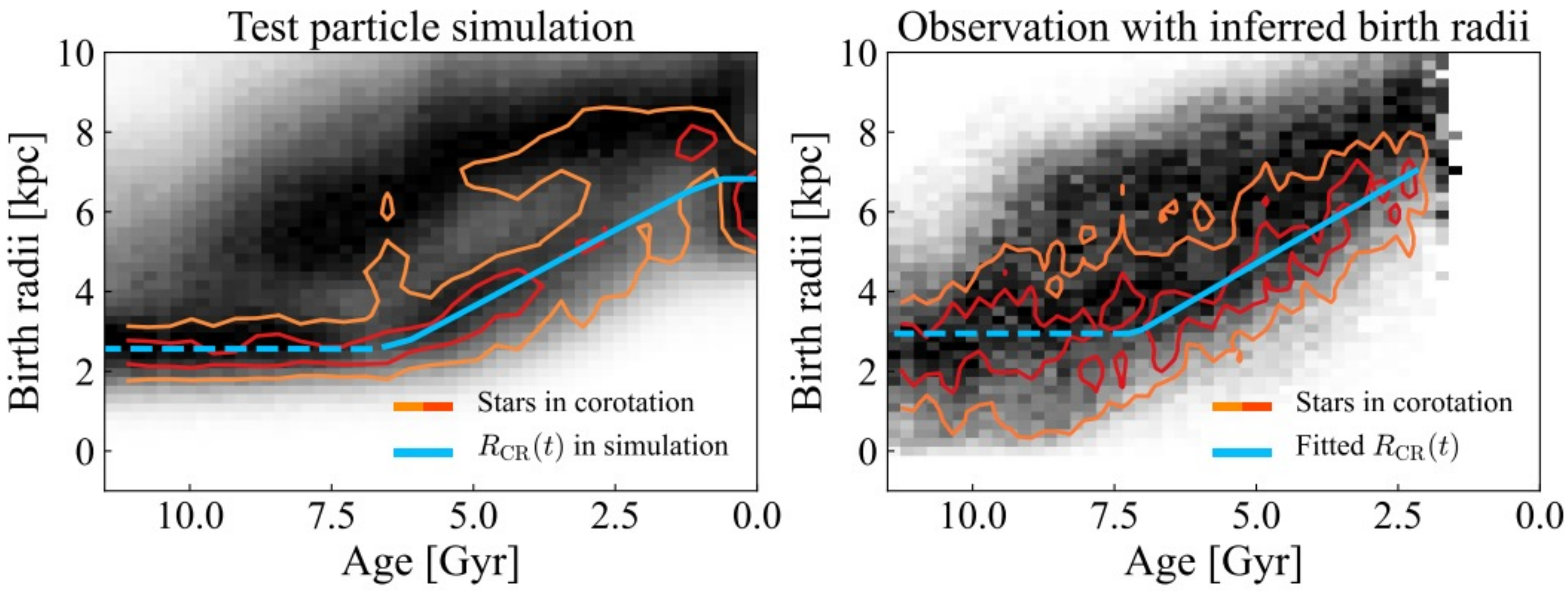
# RESULTS




The (non-column-normalised) [α/Fe] − [Fe/H] distribution of the observed stars in three guiding radii bins. **In themiddle panel**, the blue(orange) contours show the column-normalised distribution of the stars in the upper(lower) age-metallicity sequence.

The [α/Fe] − [Fe/H] distribution naturally separates into two distinct sequences, the sequence of migrated stars (high-[α/Fe]), and the sequence of local stars (low-[α/Fe]). The high-[α/Fe] migrated stars are born in the inner Galaxy ($R \lesssim 4$ kpc) before the bar starts to decelerate. With the slowing of the Galactic bar, the corotation resonance picks up stars at larger Galactocentric radii, which have lower [α/Fe] values, causing a quick drop of [α/Fe] for the migrated sequence at higher metallicity. The orange sequence is composed of the stars formed around the solar circle and hence has a lower [α/Fe] value.

# RESULTS




**Left panel**: the background is the column-normalised distribution of the test particles in the simulation in the age-birth radii($R_b$) plane, and the contour shows the same distribution of the selected particles that are corotating with the bar. The blue line indicates the temporal evolution of the corotation radius in the test particle simulation, in which the dashed part is for the time before the bar formation, and the solid line is after the bar formation.
**Right panel**: the same to the left panel but for the observed stars with the birth radii inferred in Lu et al. (2024b).

This work uses both simulations and observational data to infer the evolutionary history of the Milky Way bar's deceleration. By analyzing stellar populations that have undergone radial migration due to bar resonance, the work infers the bar's slowdown rate and its initial conditions.

**Conclusions:**

•The bar began to decelerate around $6\sim8\ Gyr$ ago;

•The initial pattern speed of the bar was $80\ km\cdot s^{-1}\cdot kpc^{-1}$, corotation radius was$2.9\ kpc$;

•The bar's slowdown rate is $0.0025-0.004$

Lu,Y.L.,Minchev,I.,Buck,T.,et al.2024b,MNRAS,535,392,doi:10.1093/mnras/stae2364

# Conclusion

- This work demonstrates the scenario explains the two distinct age-metallicity sequences observed in the solar vicinity: the plateauing upper sequence is interpreted as stars dragged outwards by the expanding corotation of the decelerating bar and the steeper lower sequence as stars formed locally around the solar circle. The upper migrated sequence dominates at guiding radii around the current corotation radius of the bar, R ~ 7 kpc, but rapidly dies away beyond this where the mechanism cannot operate.

- This results suggest that bar-driven radial migration provides a natural explanation for the observed [α/Fe] bimodality. The two age–metallicity sequences occupy distinct regions in the [α/Fe]–[Fe/H] plane, giving rise to the bimodal distribution.

- Using the current population of stars trapped at corotation and adopting birth radii from Lu et al. (2024b), they infer that the Galactic bar likely formed and began slowing down around 6–8 Gyr ago. initial pattern speed: $80\ km \cdot s^{-1} \cdot kpc^{-1}$, slowdown rate:$\eta \sim 0.0025 - 0.004$.

Thanks