Insights into star formation and dispersal from the synchronization of stellar clocks

https://doi.org/10.1038/s41550-023-02132-4

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Date: 2023/12/15

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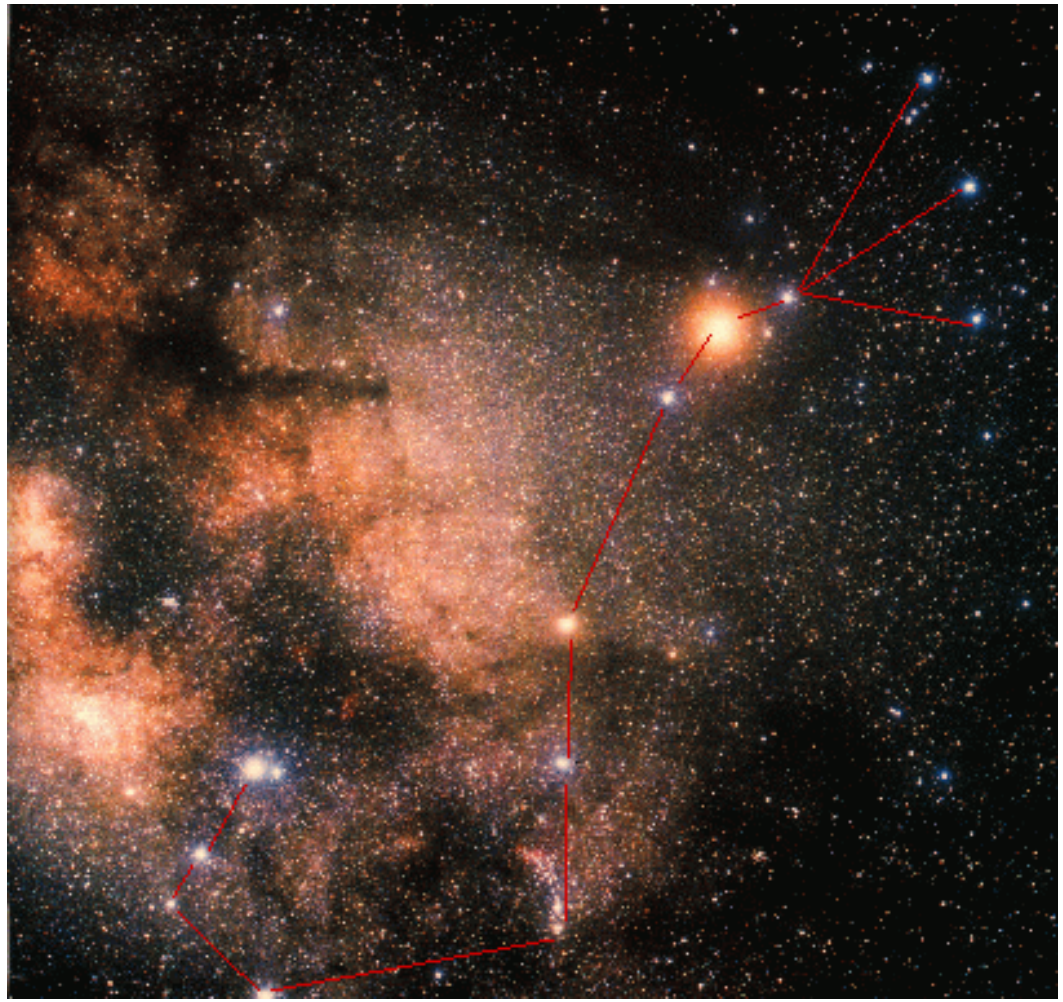
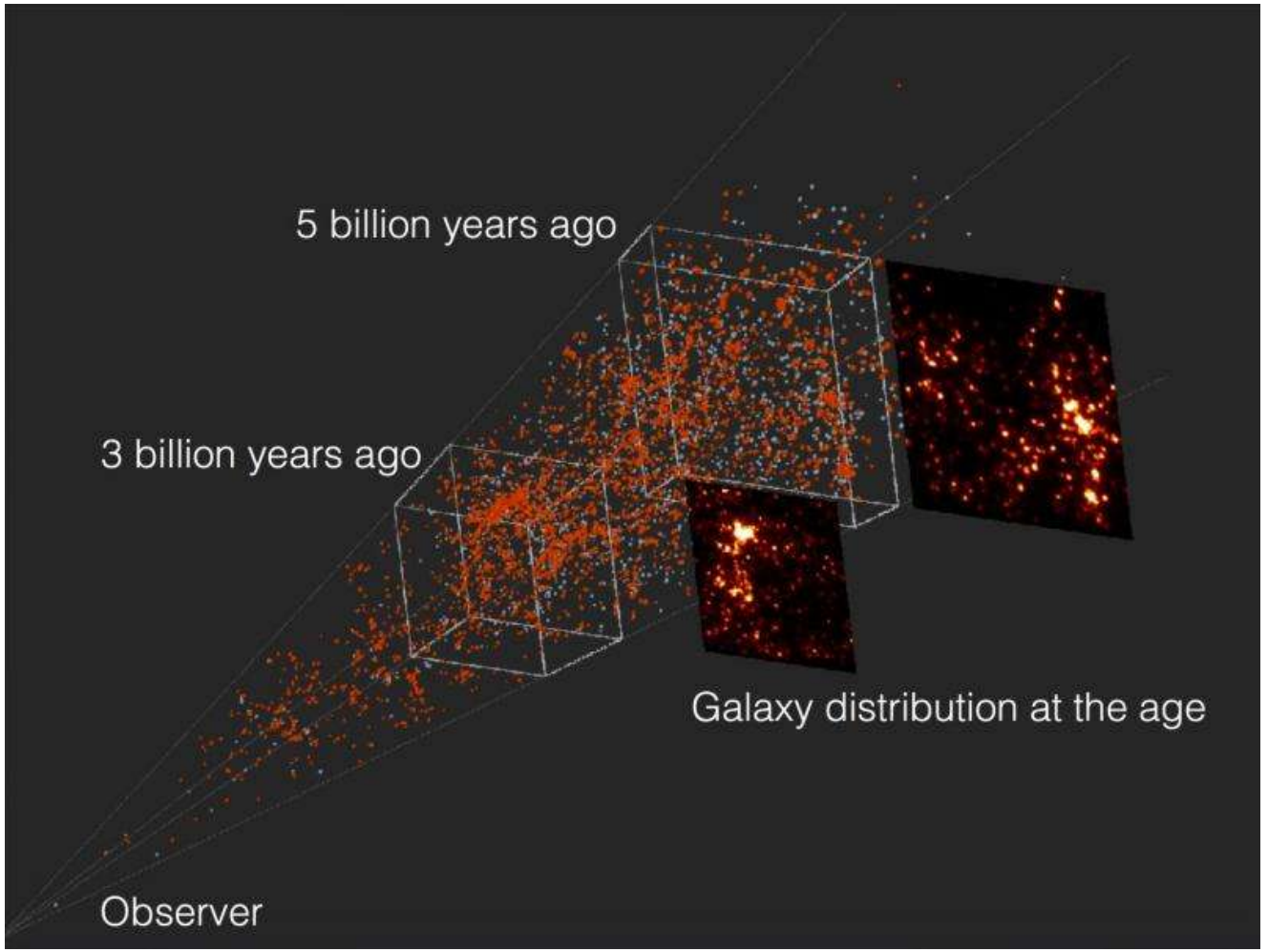
Introduction

- Age is one of the most fundamental parameters of a star, yet it is one of the hardest to determine as it requires modelling various aspects of stellar formation and evolution.

- However, estimating precise stellar ages for individual stars is complicated. For stellar clusters and associations containing coeval stars, it’s an excellent benchmarks to measure the age from evolutionary models or kinematics. The two methods is different in their back physical process. Thus, measure the discrepancy between the isochronal age and dynamical traceback age is meaningful.

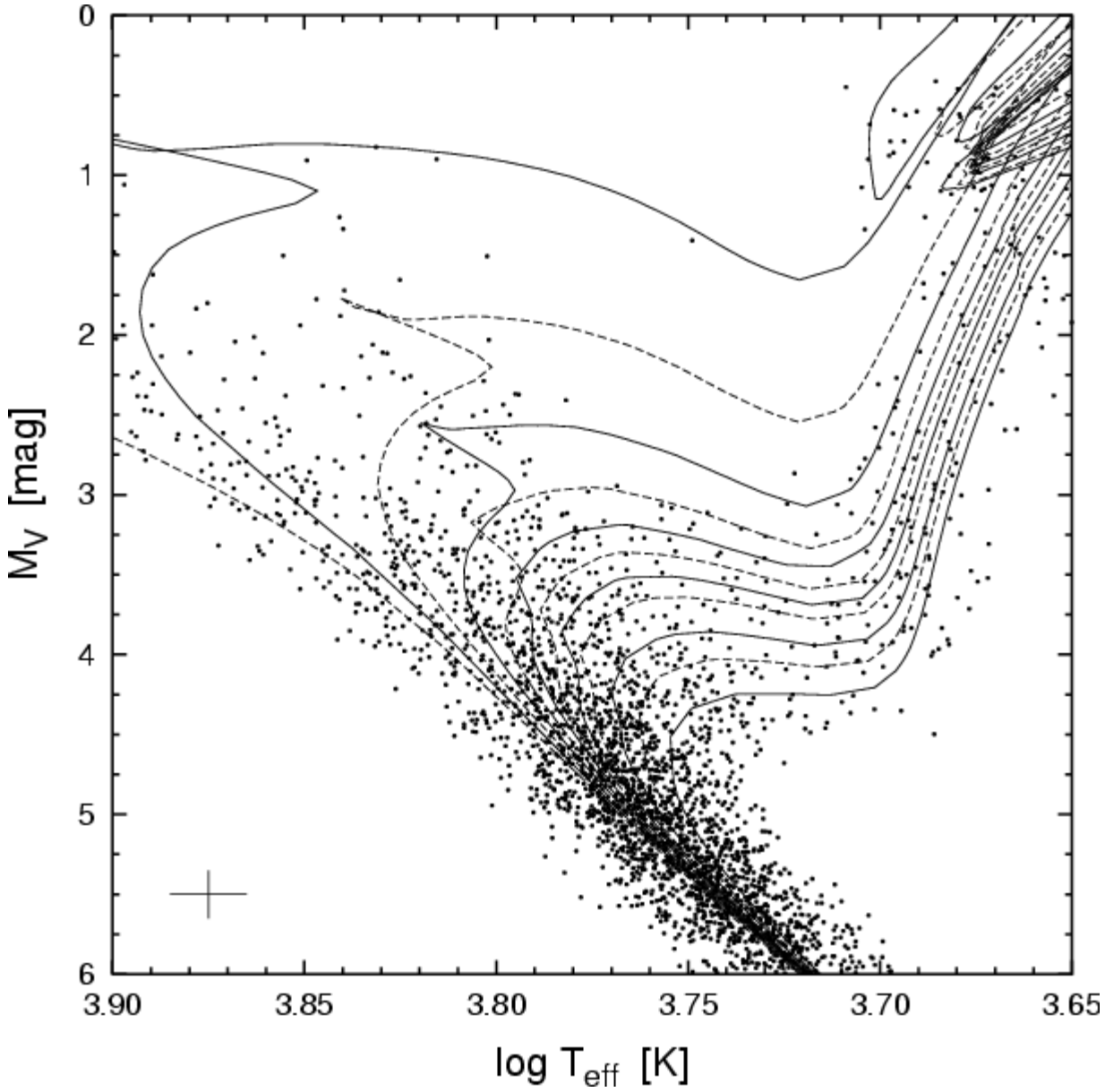



5 billion years ago
3 billion years ago
Galaxy distribution at the age
Observer

Isochronal age

- Isochrone-fitting is one of the most common techniques for determining stellar ages.

- Limitation: They are strongly dependent on the complex physical processes considered and are particularly uncertain for young, pre-main sequence stars and low-mass stars.

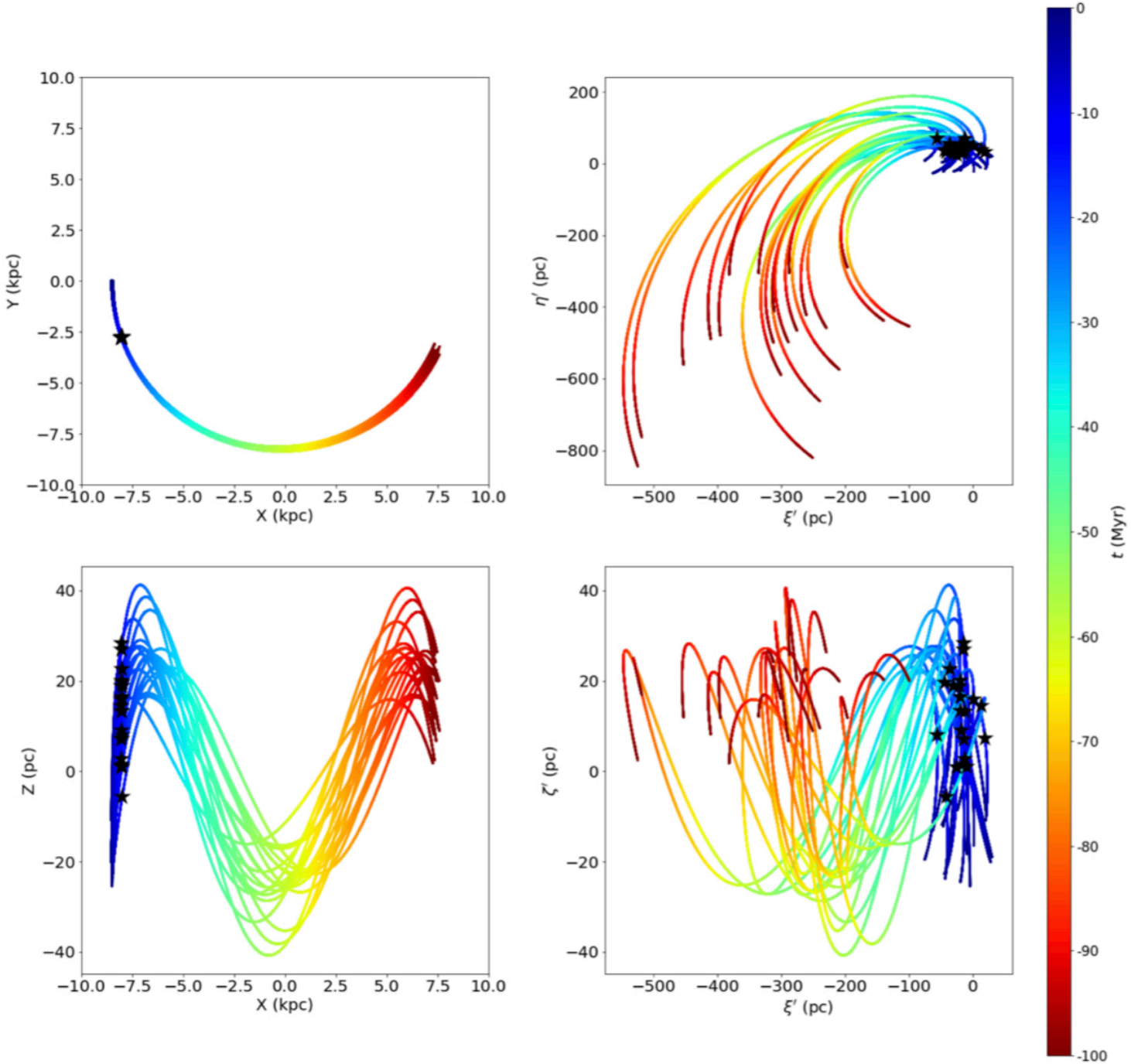


Dynamical age

- These ages denote the traceback time required for the system to reach its minimum volume configuration.

- Limitation:

  Precise 3D velocities



Discrepancy

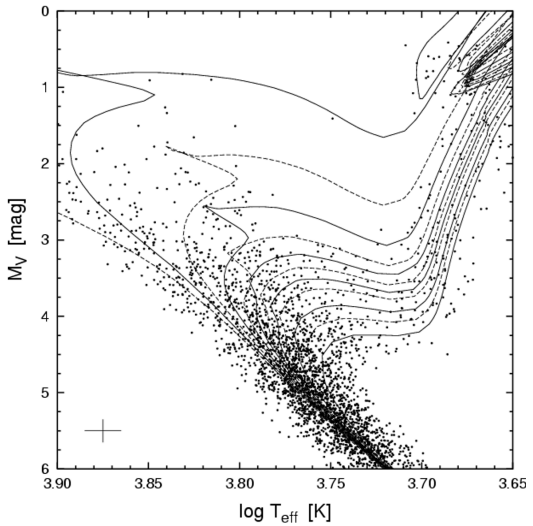
- When compare the ages derived from isochronal and dynamical traceback methods, there is a systematic discrepancy. Specifically, dynamical traceback ages are consistently younger.
- In article, researcheres select six young stellar associations and compare their isochronal age with dynamical traceback age, then find the average of the discrepancy as $\langle \Delta age \rangle = 5.5 \pm 1.1 Myr$.
- In their framework, the dynamical traceback ‘clock’ starts when a stellar cluster or association begins to expand after expelling most of the gas, whereas the isochronal ‘clock’ starts earlier when most stars form.

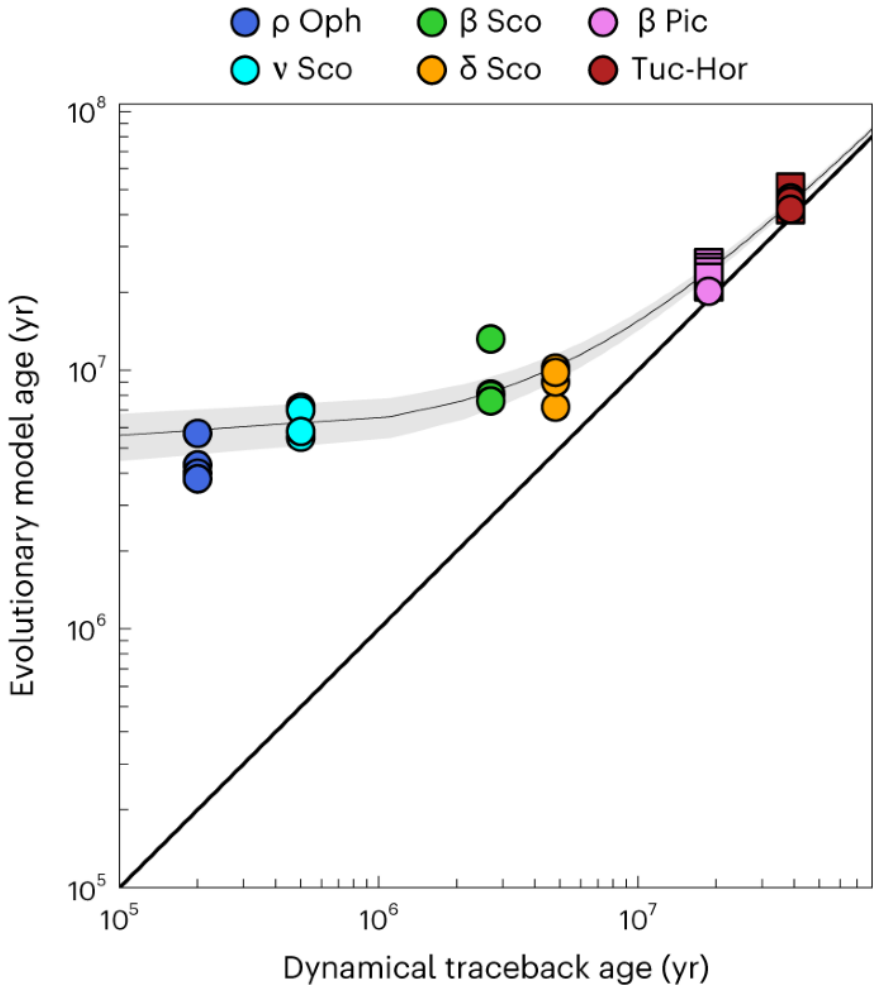
Data analysis

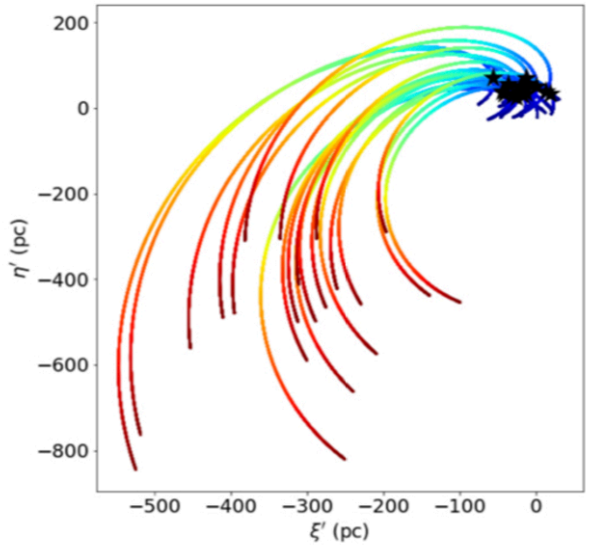
Table 1 | Properties of the young stellar associations considered

Association	*N*	*d*	DT age	Isoc. age	Δ_{AgeAll}	$\Delta_{AgeIsoc}$	Δ_{AgeLit}
		(pc)	(Myr)	(Myr)	(Myr)	(Myr)	
ρ Oph	415±20 (ref. 36)	139	0.0±0.3 (ref. 36)	3.8–5.7	4.4±1.0	4.3±0.6	
ν Sco	143±12 (ref. 36)	139	0.3±0.5 (ref. 36)	5.5–7.2	6.1±1.0	5.2±0.9	
β Sco	182±13 (ref. 36)	153	2.4±1.7 (ref. 36)	7.6–13.2	6.7±2.6	5.6±1.6	
δ Sco	425±21 (ref. 36)	142	4.6±0.6 (ref. 36)	7.2–10.2	4.5±1.3	2.6±1.1	
β Pic	236±15 (ref. 29)	40	$18.5^{+2.0}_{-2.4}$ (ref. 29)	20.2–24.0	4.6±2.0	1.7±3.0	5.3±1.9
Tuc–Hor	94±10 (ref. 40)	47	$38.5^{+1.6}_{-8.0}$ (ref. 40)	41.8–46.3	6.7±3.8	3.3±5.6	7.8±6.6
Mean					5.5±1.1	3.8±1.5	6.6±1.8
Mean excl. ρ Oph					5.7±1.1	3.7±1.7	

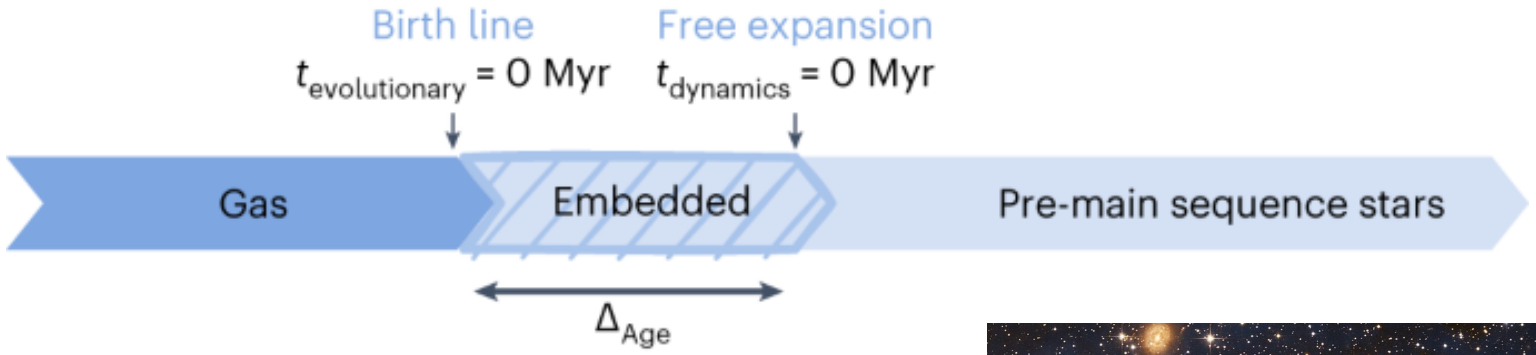
Data analysis



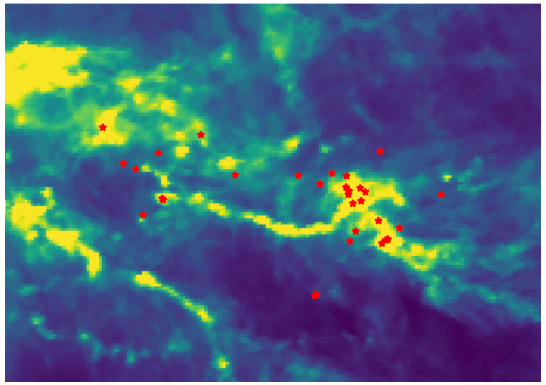




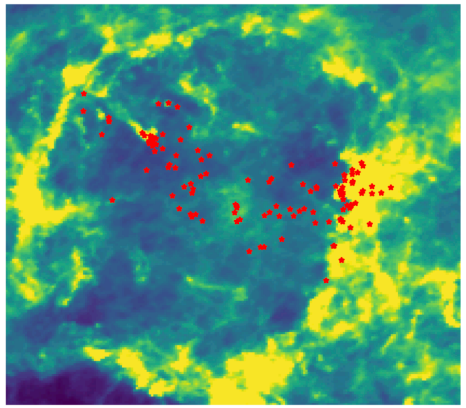
Evolution



Direct Association

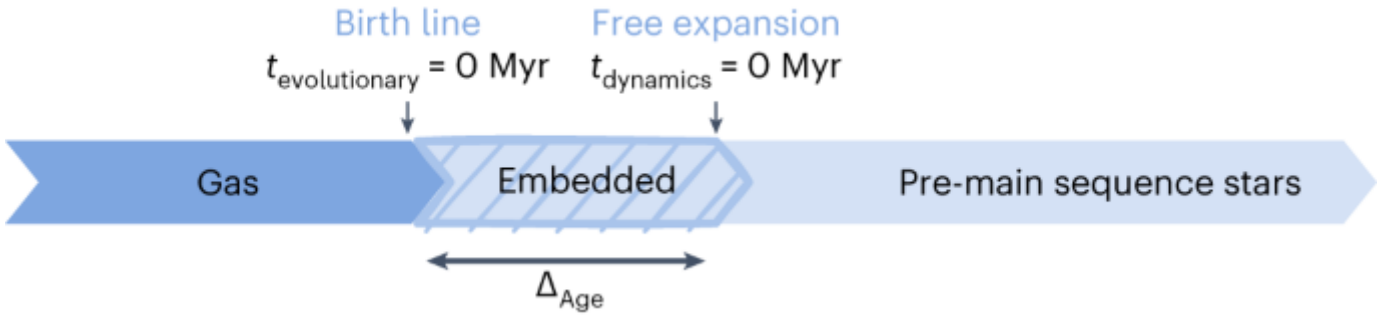


Bubble Associations



Zhou, Li & Chen submitted

Data analysis



- The initial time for evolutionary models is difficult to establish and there are generally two suggestion. Some authors have suggested that stars are born when most of the material in the envelope has collapsed onto the disk and the central protostar becomes observable at infrared wavelengths, whereas others place the time zero a bit earlier, at the moment when the core becomes optically thick.
- A dynamical traceback age is the time since a group of stars was most concentrated.
- the mean of Δage?

Data analysis

- Additionally, they investigate the relationship between Δage and the number of members in the association.

- Future expectation

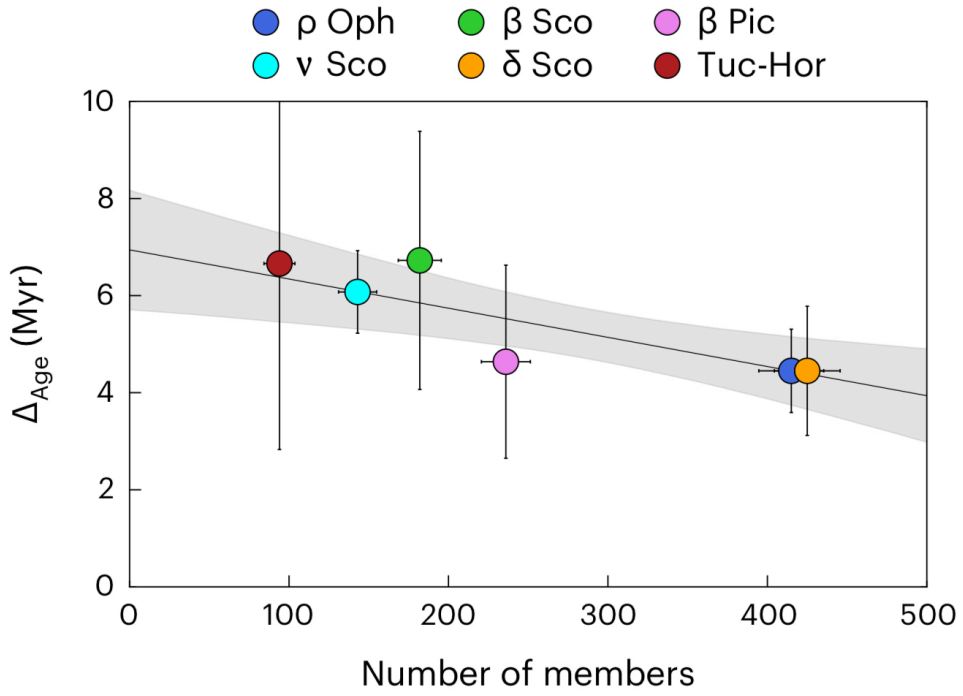


Fig. 3 | Δ_{Age} as a function of the number of association members. The data points and errors are listed in Table 1 under the columns $\Delta_{Age\ All}$ and *N*. The black line shows the best fit and the shaded area the 1σ uncertainties.

Summary

- Dynamical age is a time scale which imply the expansion of a stellar cluster or association.
- Isochronal age is based on stellar evolutionary model, usually using the PARSEC models, it could represent the time when the stellar start to form.
- The discrepancy Δage between the dynamical age and isochronal age indicates the time a young star remains bound to its parental cloud before moving away from its siblings.It could provide further information on the impact of local conditions and stellar feedback on the formation and dispersal of stellar clusters.

THANKS!