# Optical high-resolution spectroscopy of young α-rich stars

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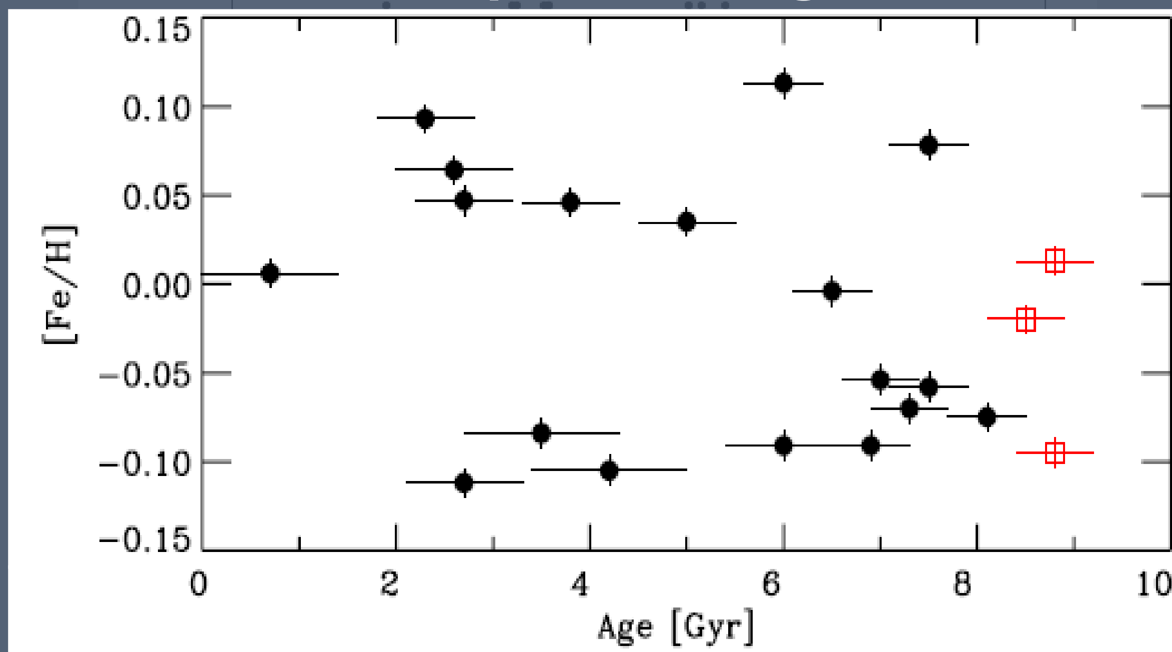
# Galactic Archaeology

Study of the history of chemical enrichment in Milky Way from chemical abundances of stars

Stellar age estimates have been limited

## [Fe/H] is not a perfect age-indicator

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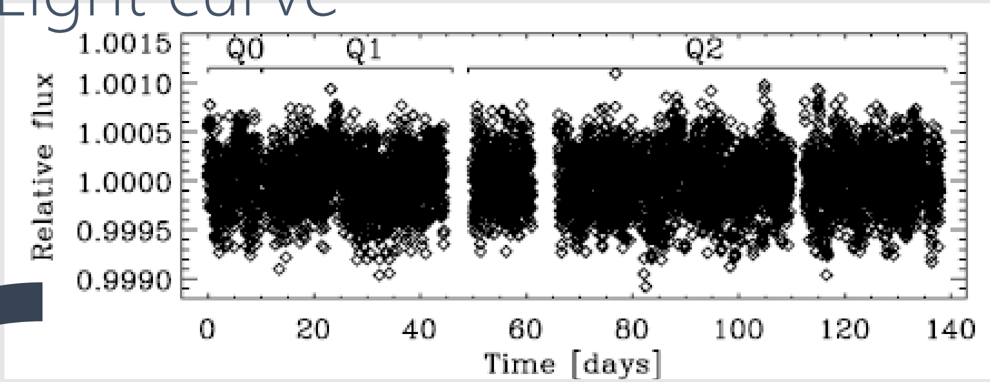
[Fe/H]: Proxy of age

# Age Estimates from Asteroseismology

## Kepler / CoRoT enabled age estimates for red giants

Light curve




0.1%

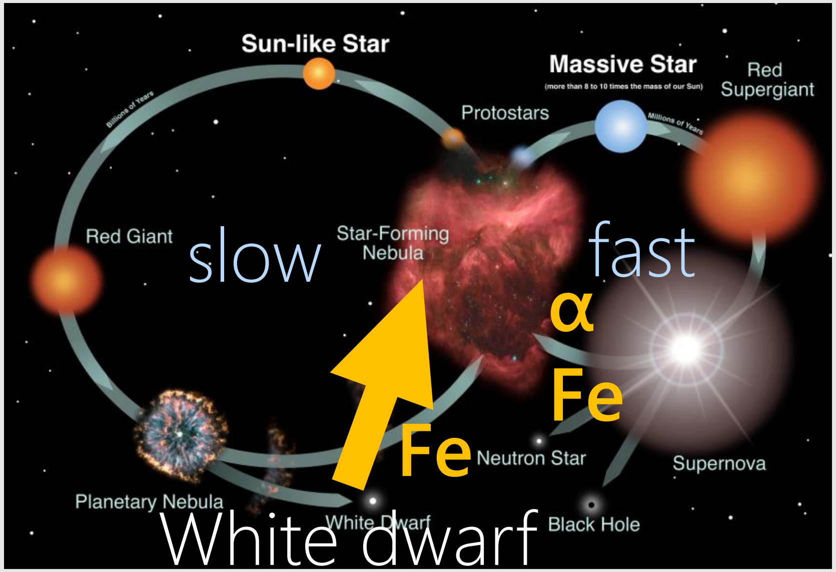
Fourier transform

Huber+10

$$M \propto \nu_{\max}^{3} \Delta\nu^{-4} T^{1.5}$$

age ~ $t_{MS}(M)$ <- stellar evolution theory

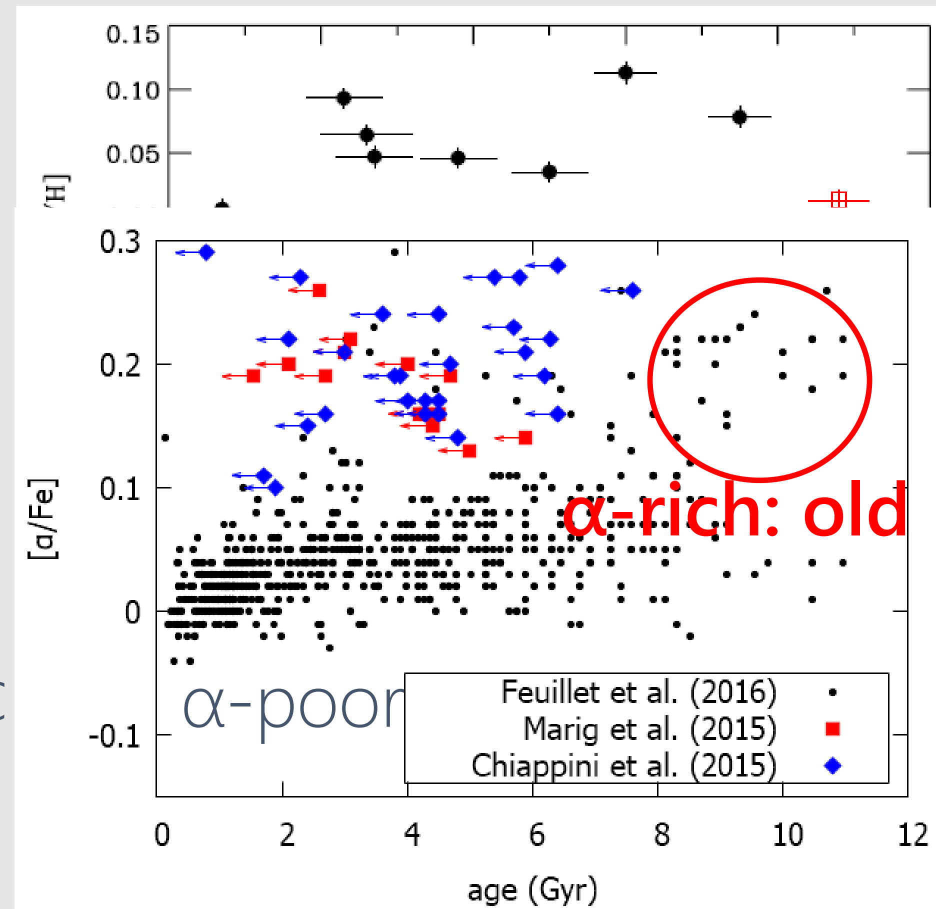
# Discovery of Young α-rich Stars




[α/Fe] decreases with time

α: O, Mg, Si, S, Ca, Ti

## Observations




Asteroseismology revealed the existence of young α-rich stars

not expected in simple galactic chemical evolution models

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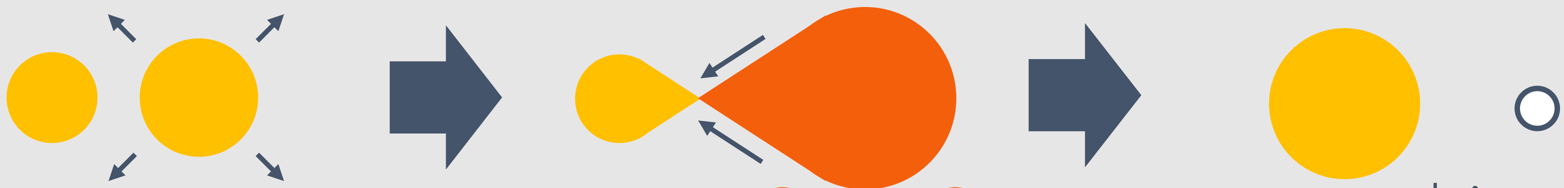
# Possible Origins

Chiappini+15, Martig+15, Izzard+17

## Binary interaction (Evolved blue straggler scenario)

Mergers / mass transfer -> mass increase -> look younger




## Peculiar formation site

Recent accretion of pristine gas to the Galaxy

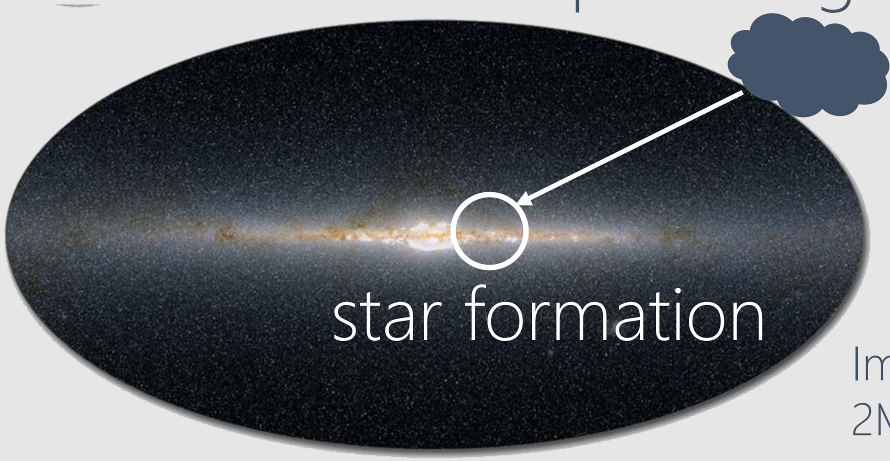



Image Credit:
2MASS/J. Carpenter, T. H. Jarrett, & R. Hurt

# Possible Origins

Chiappini+15, Martig+15, Izzard+17

**Binary interaction (Evolved blue straggler scenario)**

Mergers / mass transfer -> mass increase -> look younger

Chemical signature of these events?

Increased angular momentum?

High binary frequency?

**Peculiar formation site**

Recent accretion of pristine gas to the Galaxy

Characteristic chemical composition?

Optical high-resolution spectroscopy with a 8-10m telescope

# Data Acquisition

## Instrument

HIgh Resolution Echelle Spectrometer on Keck I

through **Subaru-Keck time exchange program**

when Subaru was in downtime

## Setting

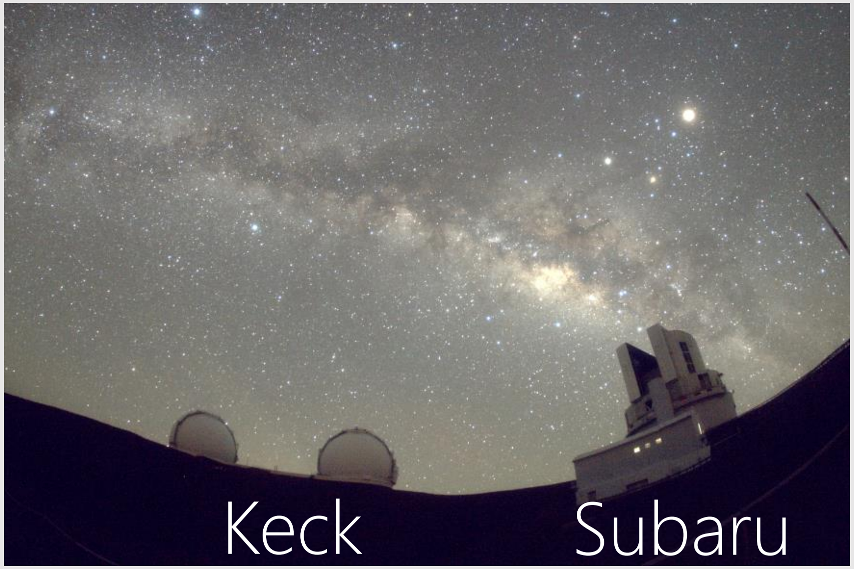
R~67000 (~4.5 km/s)

4200 < λ (A) < 8750

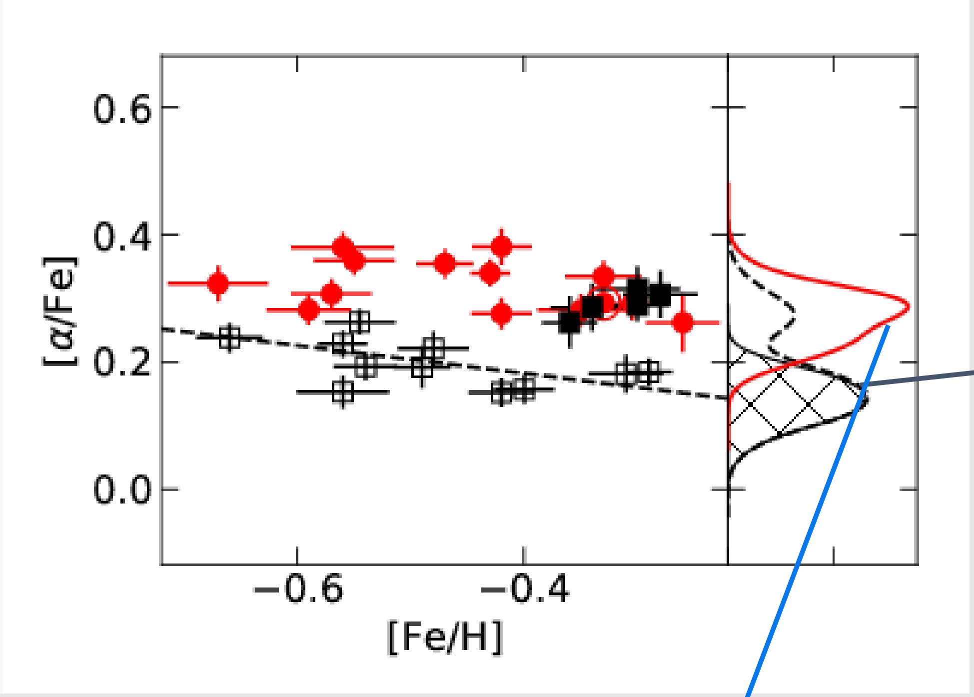
## Targets

14 young α-rich stars

+ 16 nearby giants (comparison)



# Confirmation of α-richness



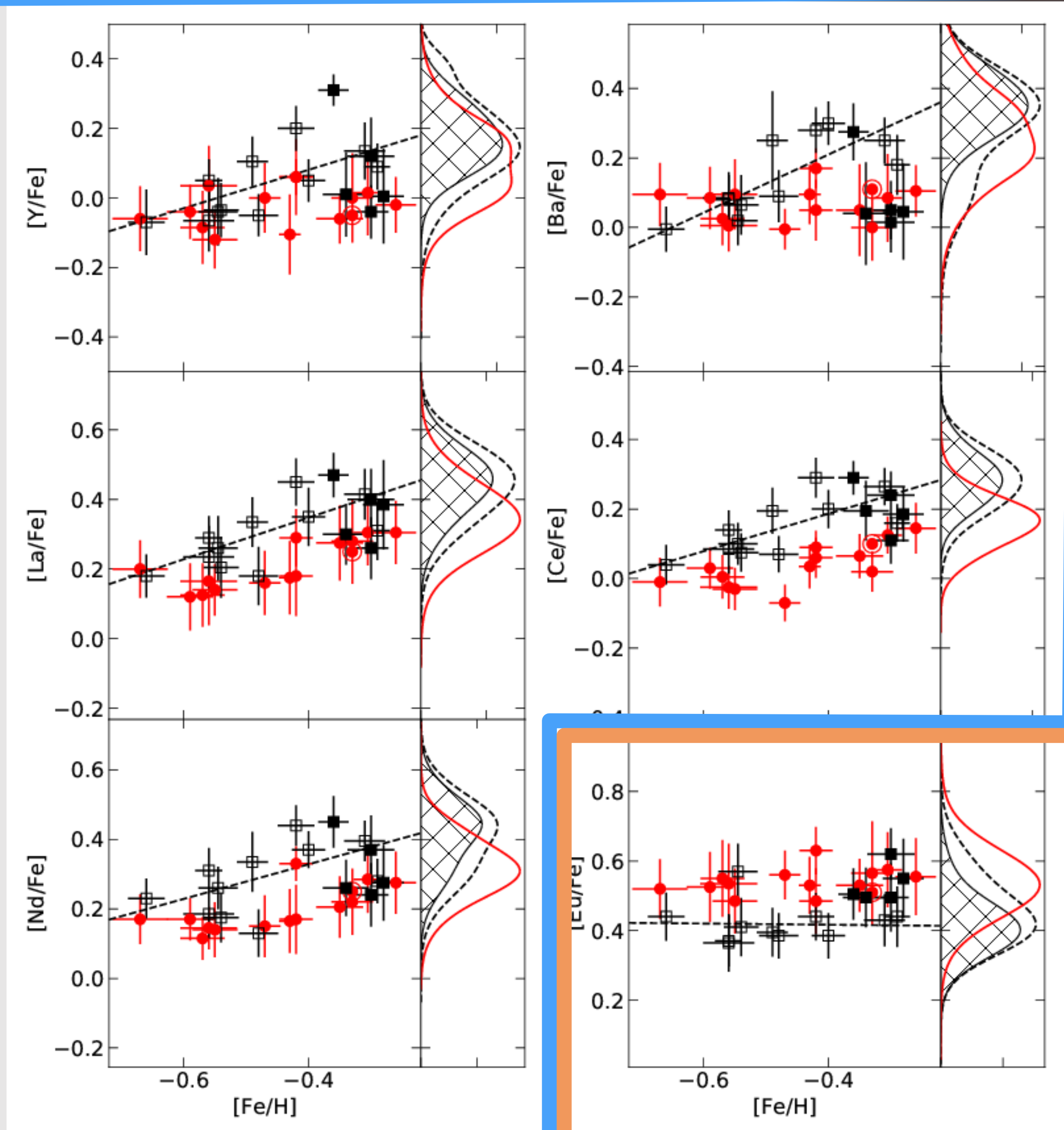

■□ comparison stars

● young α-rich stars

Comparison stars show clear bimodality

**α-enhancement is clearly confirmed**

# High-r / low-s Process Abundances




■□ comparison stars

● young α-rich stars

***s*-process (AGB)**

**(slow-enrichment)**

young α-rich: low

***r*-process**

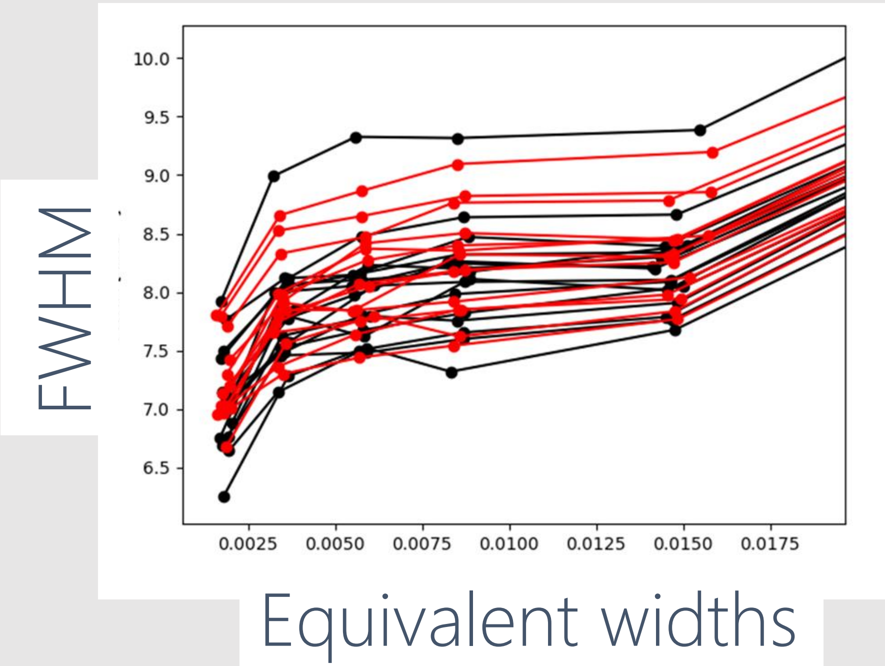
**(fast enrichment)**

young α-rich: high

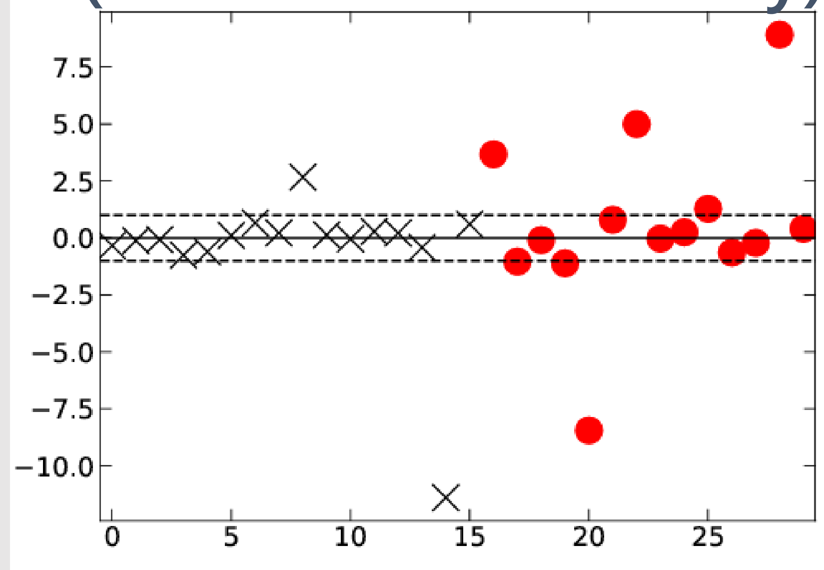
**Chemically-old again**

# Line Widths / Radial Velocity

## Line widths




## RV difference (APOGEE – This study)




- No signature of rapid rotation
- Slightly higher binary frequency -> binary interaction

Comparison young α-rich stars

# No Clear Signature of Mass-Transfer

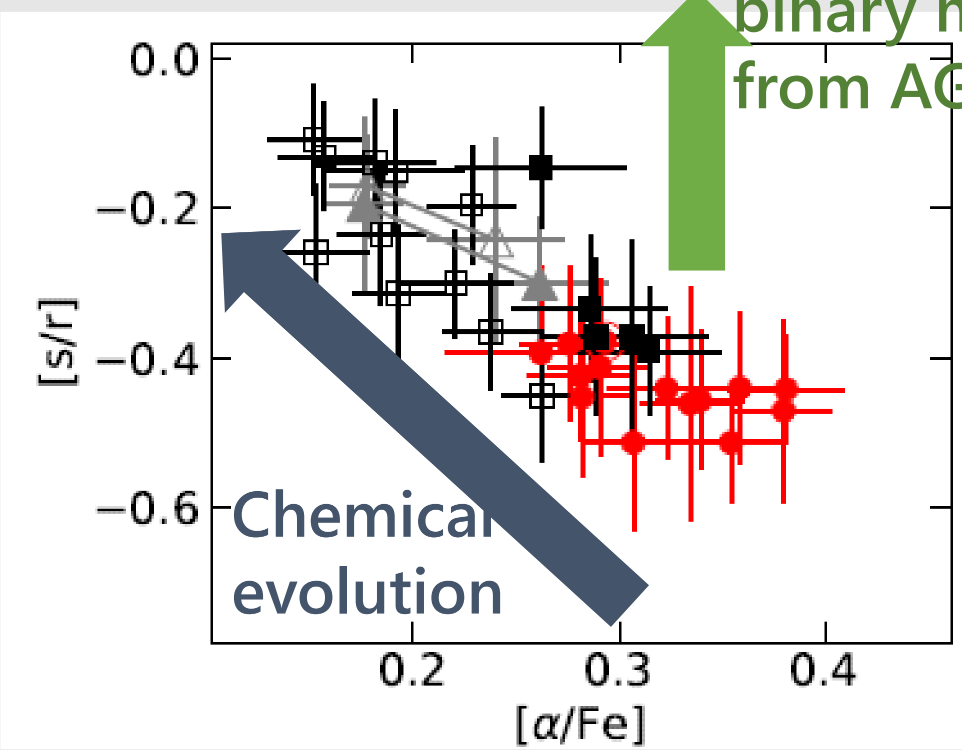
**Surface anomalies due to binary mass transfer?**

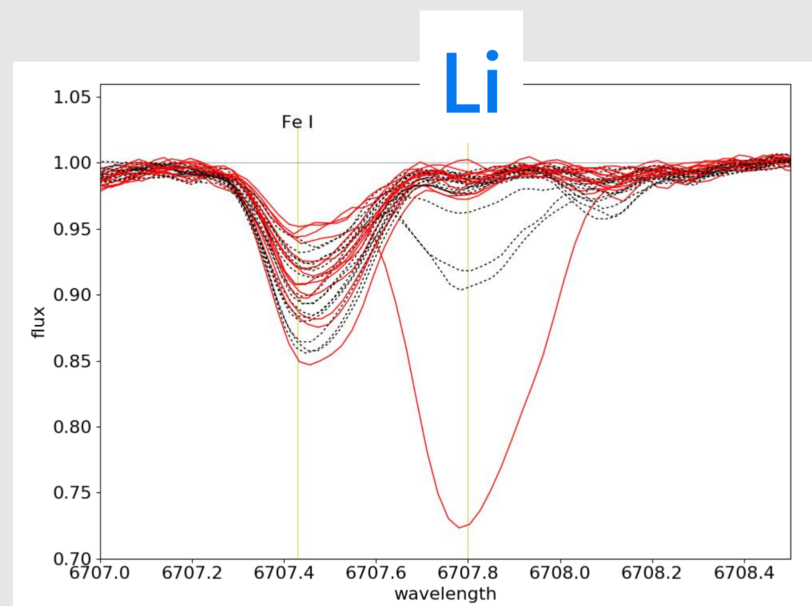
high *s*-process elements:

signature of mass accretion from <u>AGB stars</u>

young α-rich stars have normal *s*-process abundances

**binary mass transfer from AGB stars**



# Remaining Possibilities

**Mass accretion from companion (excluding AGB stars)**

- ✔ slightly higher binary frequency
- ✔ no chemical signature

**Needs further RV monitoring**

**Stellar mergers**

- ✔ no chemical signature
- ▲ not rapidly rotating
  (note slow down timescale is very short)

# Summary

Young α-rich stars are α-rich like old stars but estimated to be young

By obtaining optical spectra, we

- confirm high-α abundances
- reveal similar *n*-capture elements abundances to old stars
- find no signature of rapid dotation
- find slightly higher binary frequency

**Conclusion**:

- **young α-rich stars are likely to be formed by binary interaction without any signature in a single spectrum**
- **Time exchange program is very effective to keep competitiveness even when Subaru is in downtime**