

Chemical composition of HE1327-2326,
the most iron-deficient star known

最も鉄組成の低い星 HE1327-2326 の
発見と化学組成解析

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Frebel et al. 2005, Nature, 434, 871

Aoki et al. 2005, ApJ, in press

Background: metallicity (Fe abundance) distribution of halo stars

Until 2001, no halo star having $[\text{Fe}/\text{H}] < -4$ was known, nevertheless large efforts to search for metal-deficient stars.

Christlieb et al. (2002, Nature 419, 904) reported a star with $[\text{Fe}/\text{H}] = -5.3$ (HE0107-5240). This is a giant with a large excess of carbon ($[\text{C}/\text{Fe}] \sim +4$).

Many models have been proposed to interpret the low iron abundance and the excess of carbon in HE0107-5240. Further search for stars with $[\text{Fe}/\text{H}] < -4$ has been strongly desired.

A Subaru/HDS program: Chemical abundance patterns of the first generations of stars

Sample selection:

1) Objective prism surveys:

-HK-survey (Beers et al. 1985, 1992)

-Hamburg/ESO survey (Christlieb et al. 2003)

2) Medium resolution spectroscopy

ESO 1.5m, 3.6m; SSO 2.3m, KPNO 2.3m; etc.

3) HERES (Barklem et al., 2005)

A Subaru/HDS program:

Chemical abundance patterns of the first generations of stars

High resolution spectroscopy:

- $R=60,000$ for 4000--6800Å
- $S/N \sim 100\text{--}200 @ 4500\text{Å}$

2003 Dec. 2 nights (1 clear night)

2004 May/June 4 nights (3.5 clear nights)

2005 Feb/March 3.5 nights (3 clear nights)

2005 June 5 nights (scheduled)

Photometry

determination of atmospheric parameters

ESO/Danish 1.5m; KPNO 0.9m;

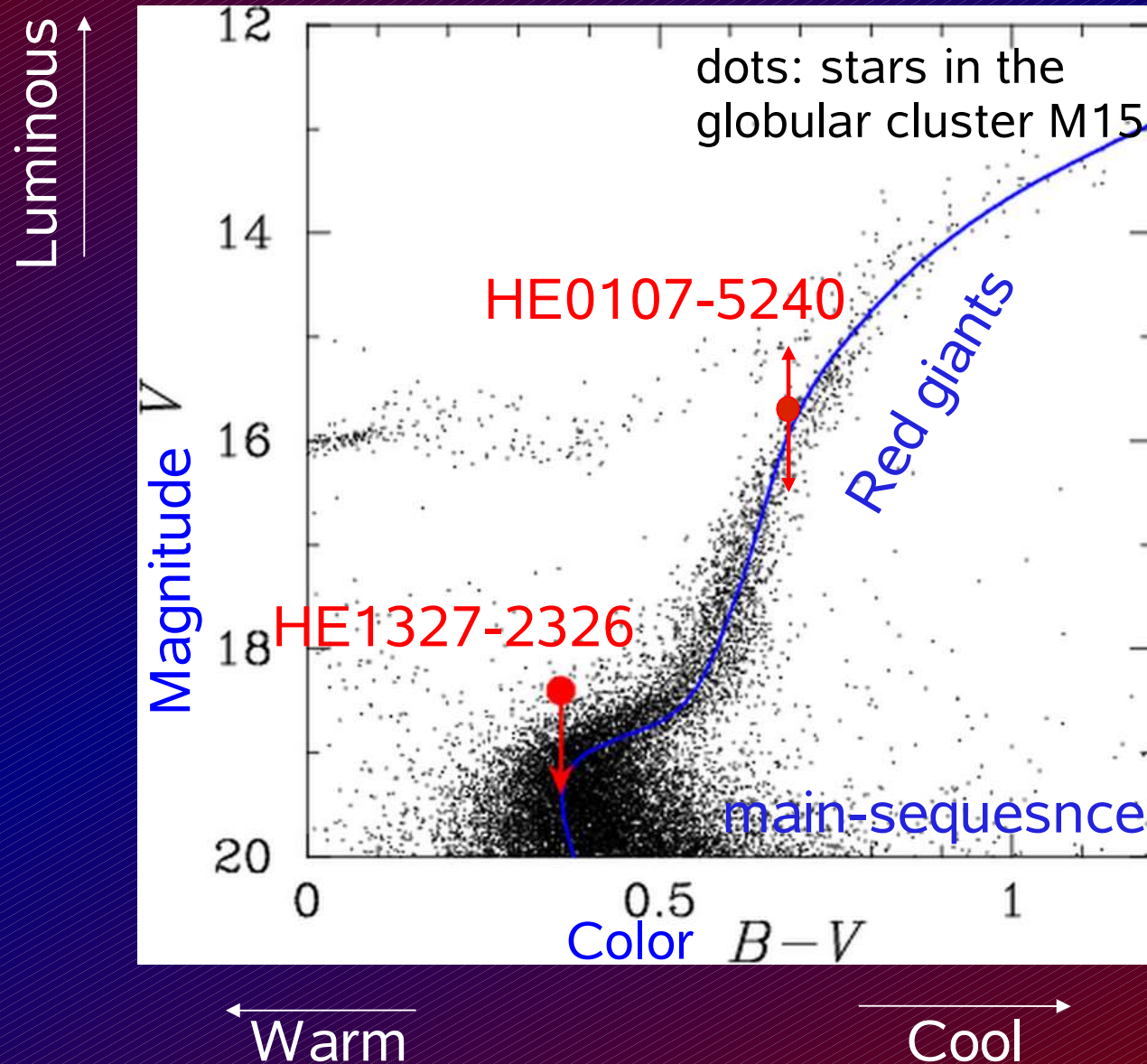
CTIO 0.9m; MAGNUM



HE1327-2326: the most iron-deficient star known



Evolutionary status of HE1327-2326:
very close to main-sequence = an unevolved star



1. Iron abundance

Medium resolution spectra



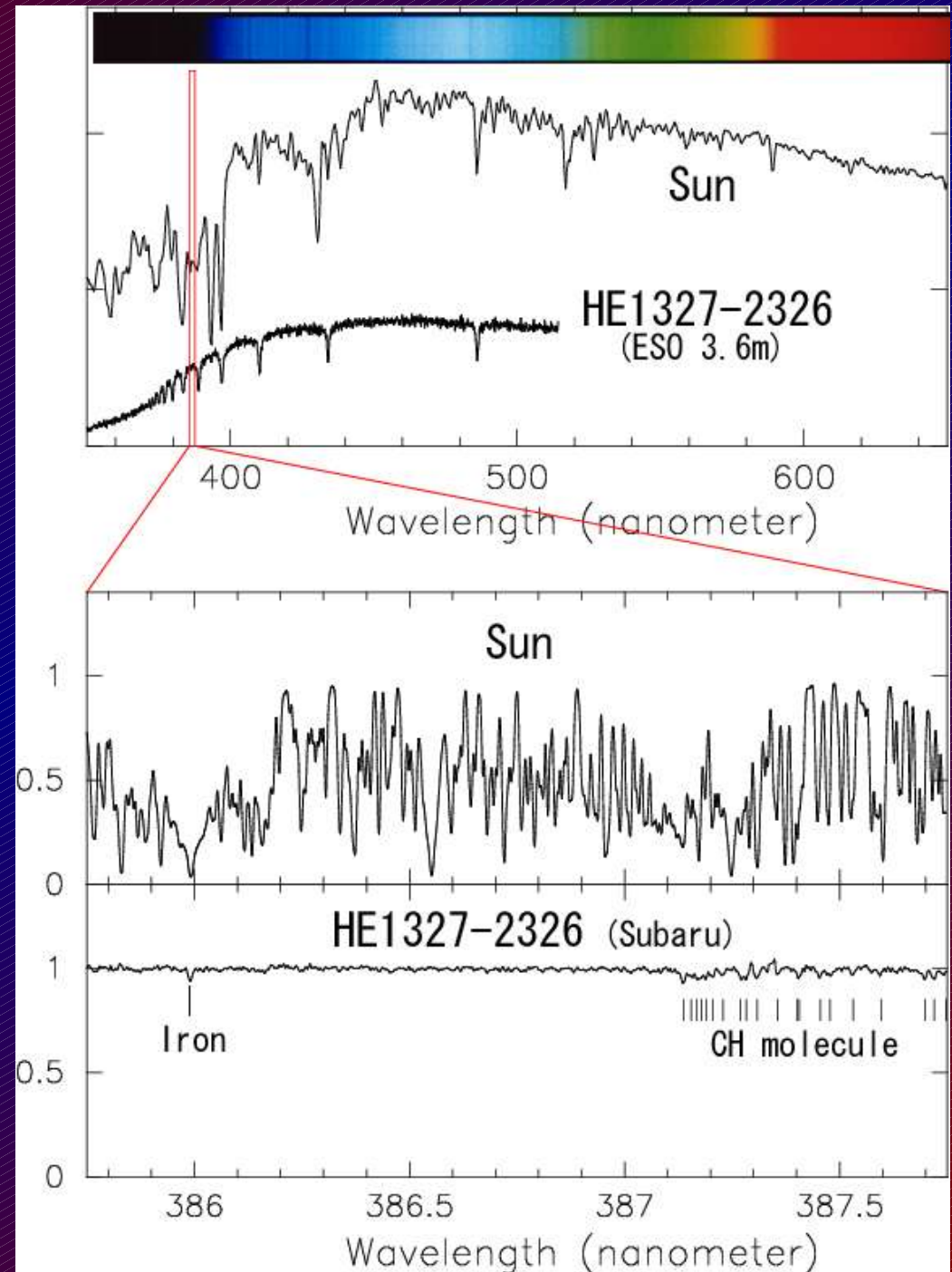
High resolution spectra →

very weak Fe lines

→ $[Fe/H] = -5.4$

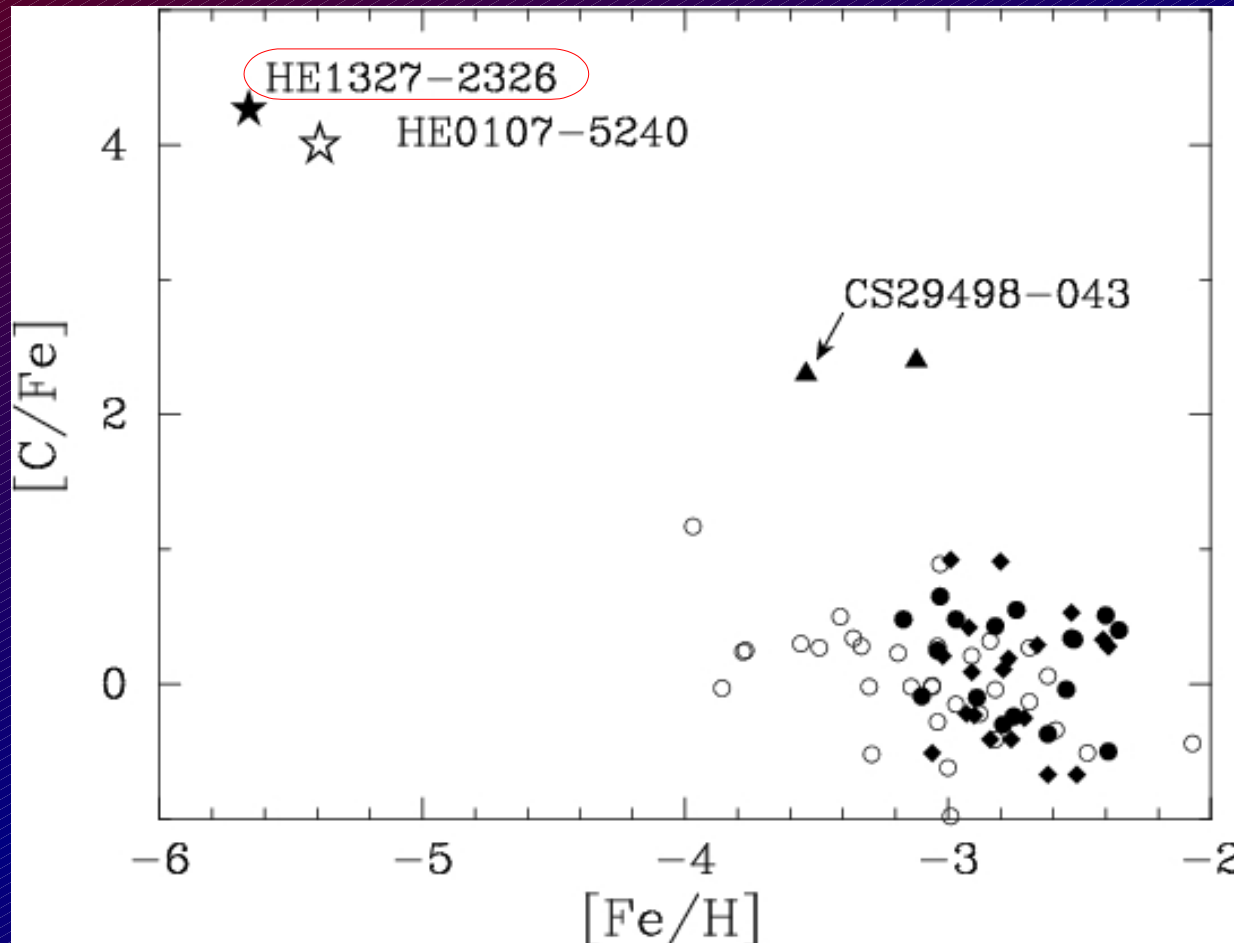
detection of CH molecular bands

→ excess of carbon



2. A large excess of carbon

HE1327 and HE0107 have very high C/Fe ($[C/Fe] \sim +4$)
→ A common origin of the peculiar abundance pattern

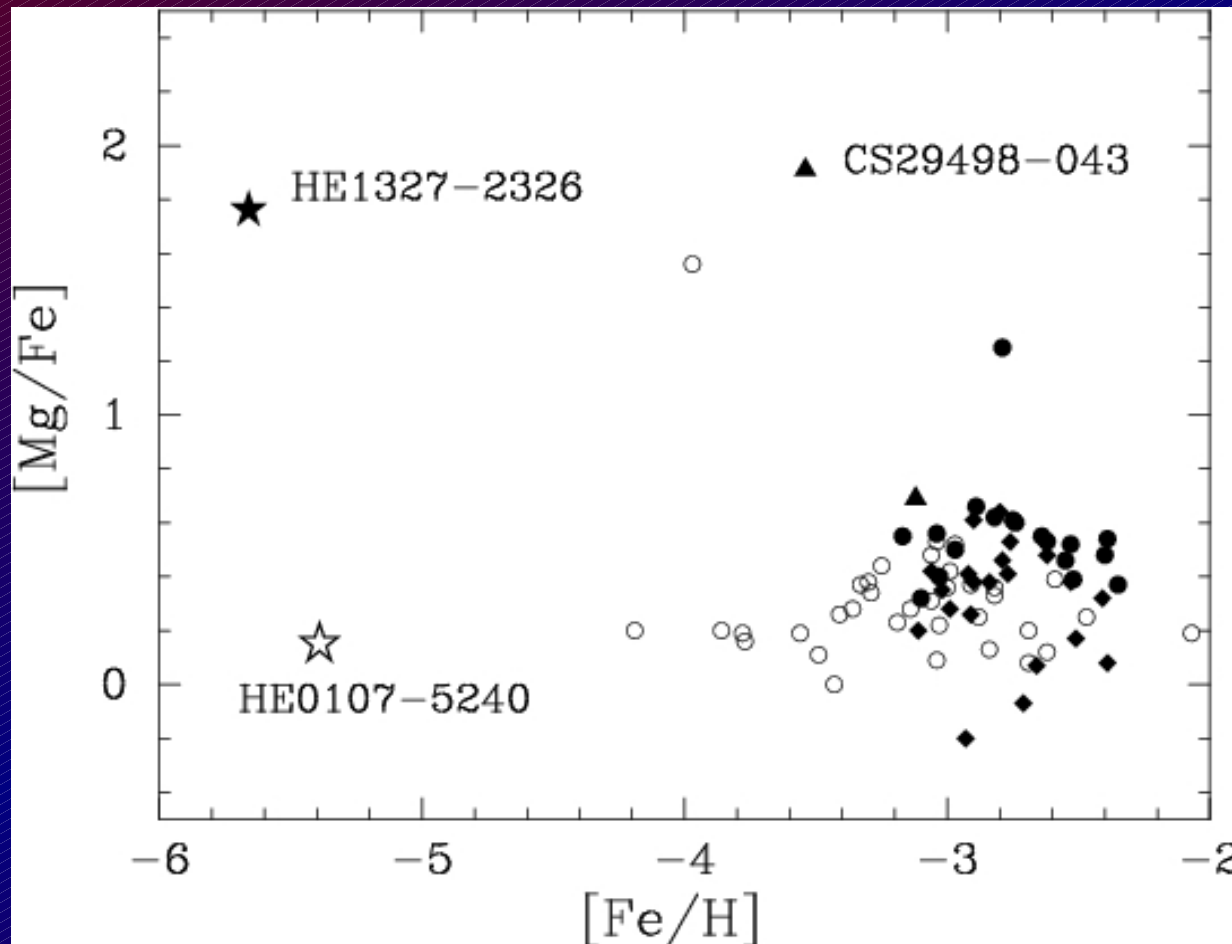


- ★ This work
- Cayrel et al. 2004
- ◆ Honda et al. 2004
- Aoki et al. 2005
- ▲ Aoki et al. 2004

3. Abundances of N, Na, Mg and Al

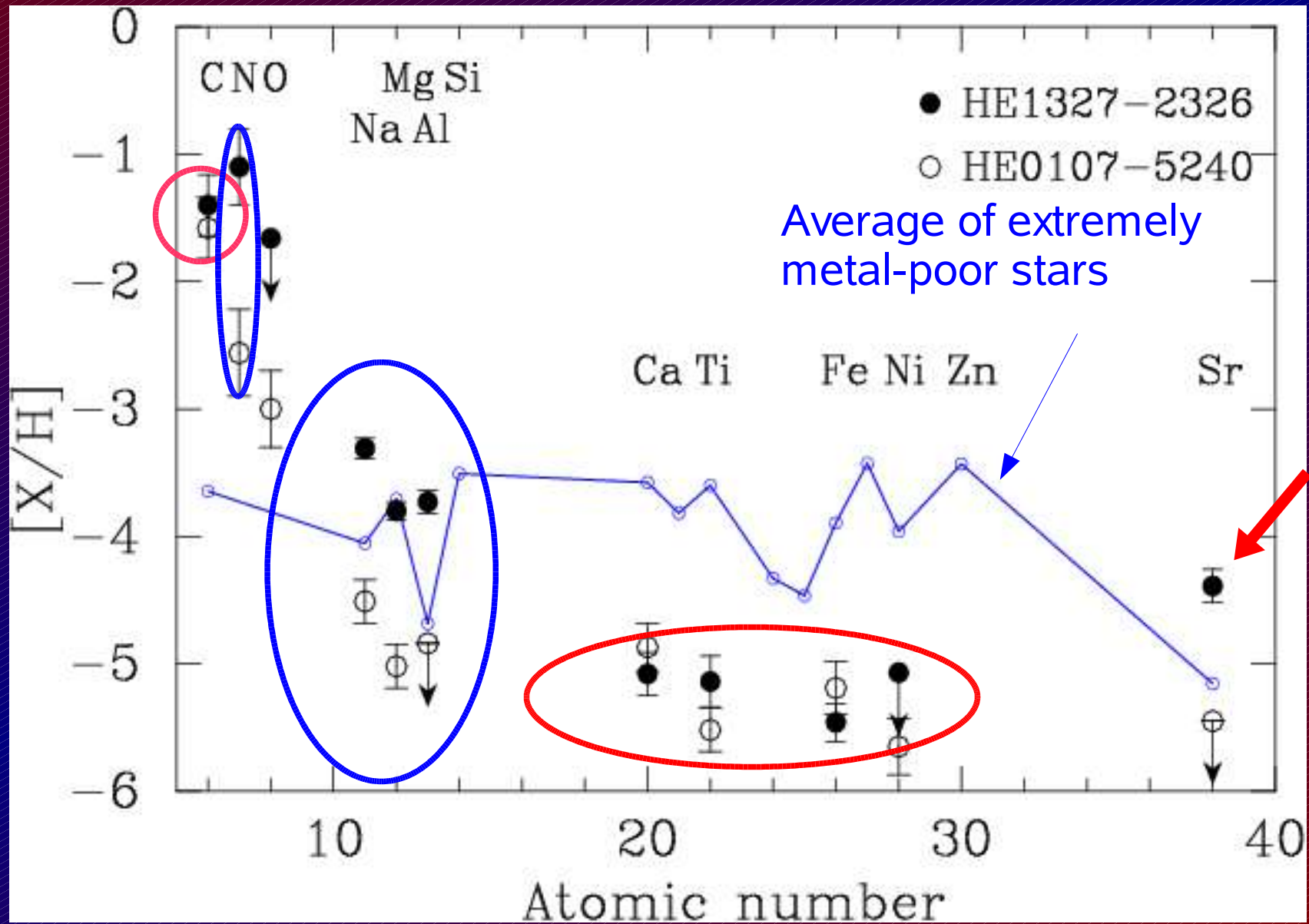
HE1327 show excesses of these elements with respect to HE0107

[Mg/Fe] of HE1327 is ~ 1.5 dex higher than that of HE0107



- ★ This work
- Cayrel et al. 2004
- ◆ Honda et al. 2004
- Aoki et al. 2005
- ▲ Aoki et al. 2004

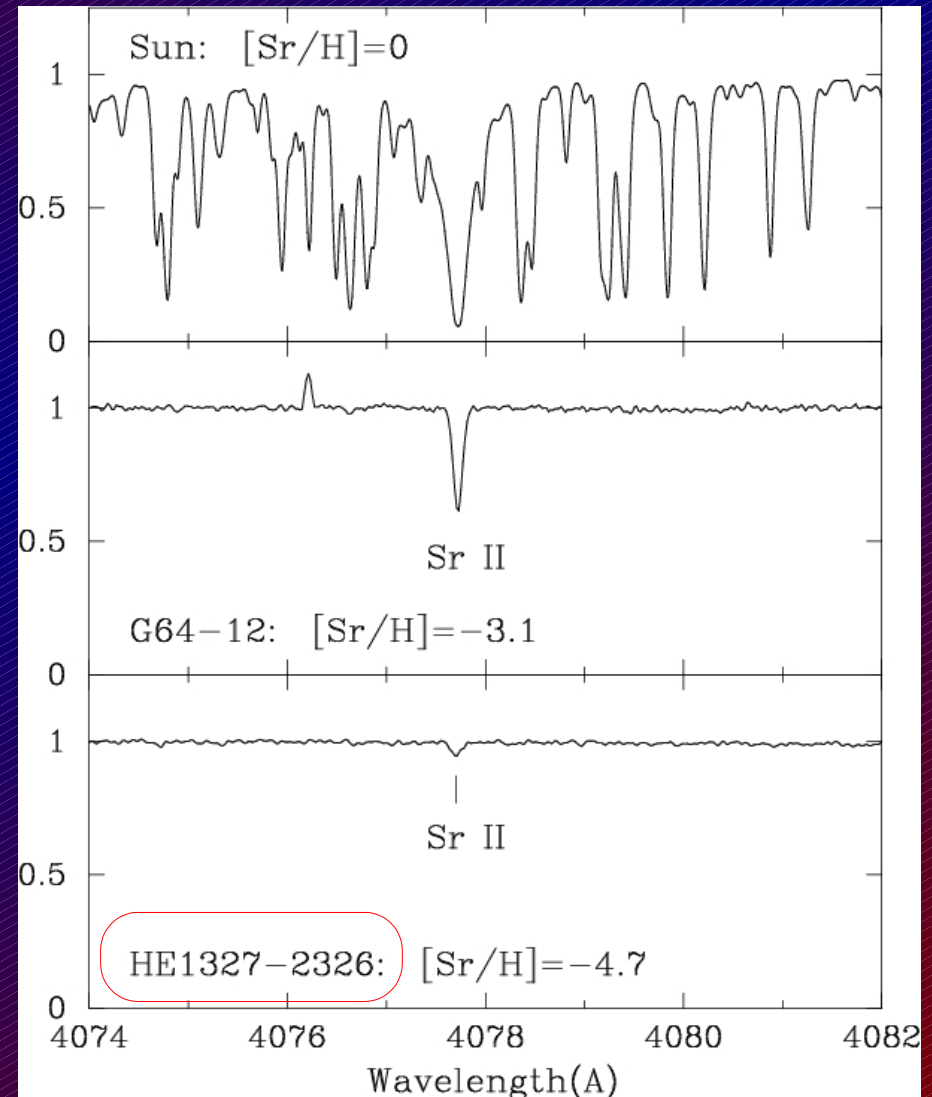
Comparison of the abundance patterns between HE1327 and HE0107



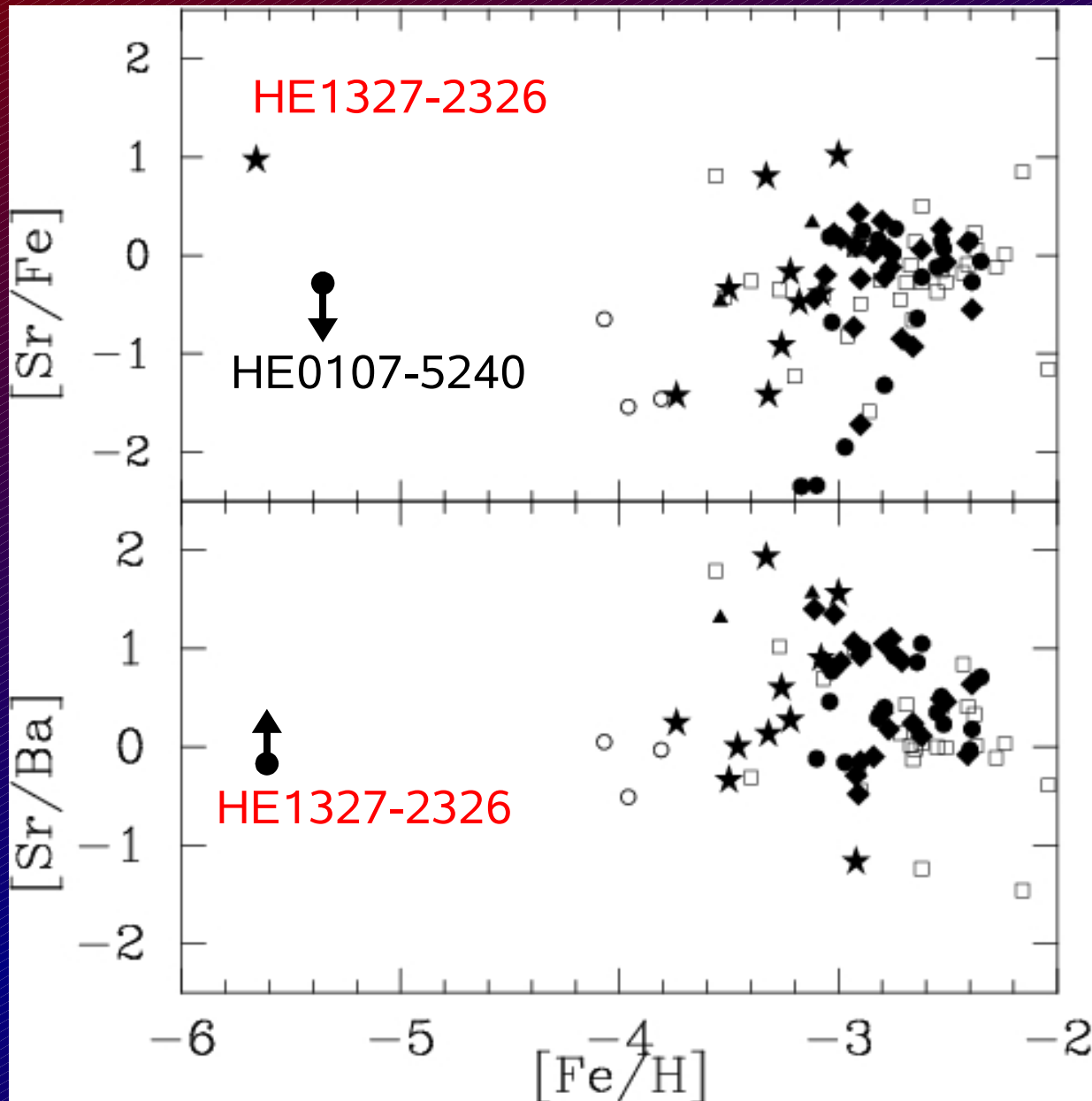
4. The light Neutron-capture element Sr

The two Sr resonance lines are detected only in HE1327-2326, while no Ba line is seen.

→ excess of *light* neutron-capture elements

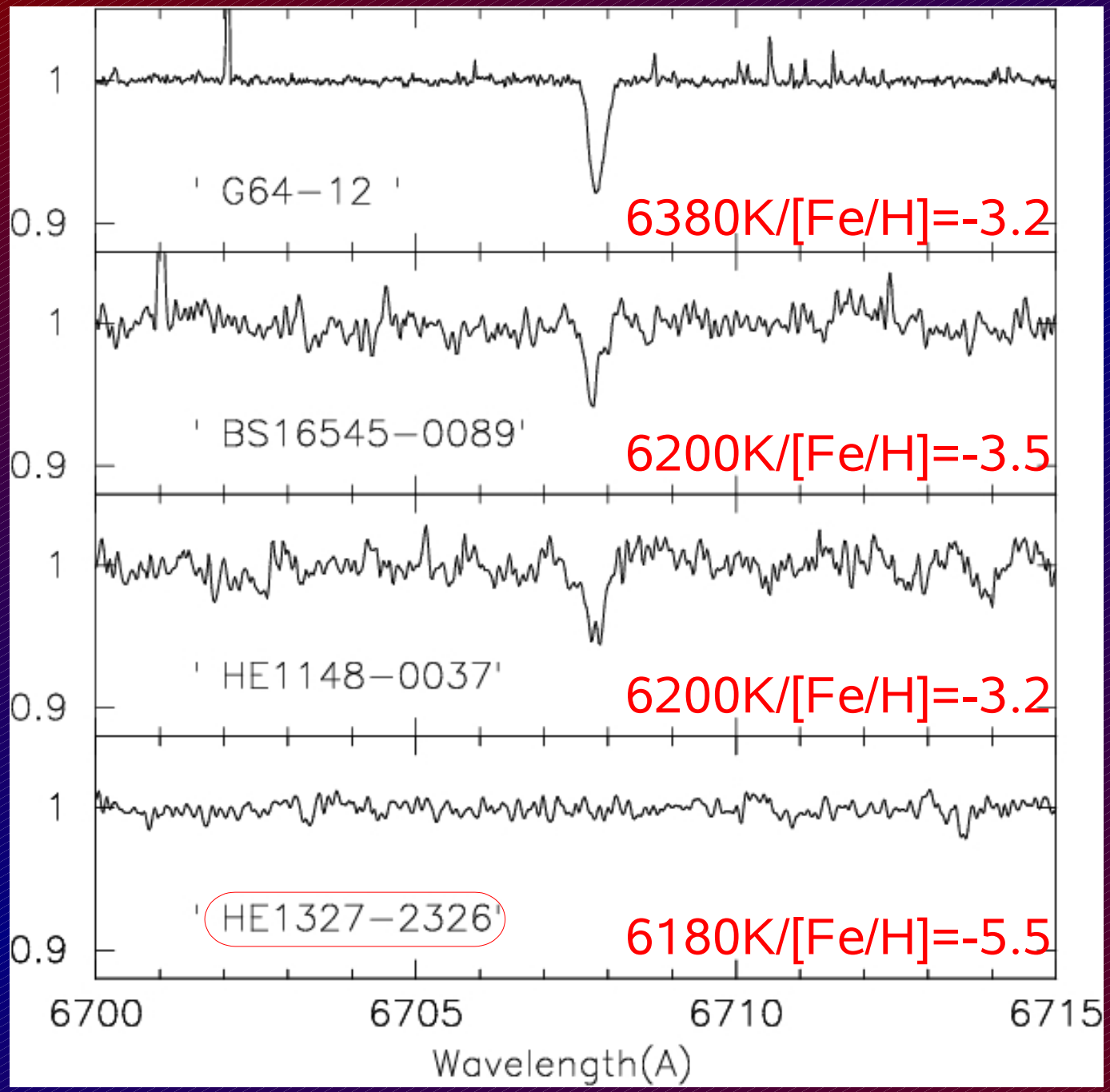


4. The light Neutron-capture element Sr

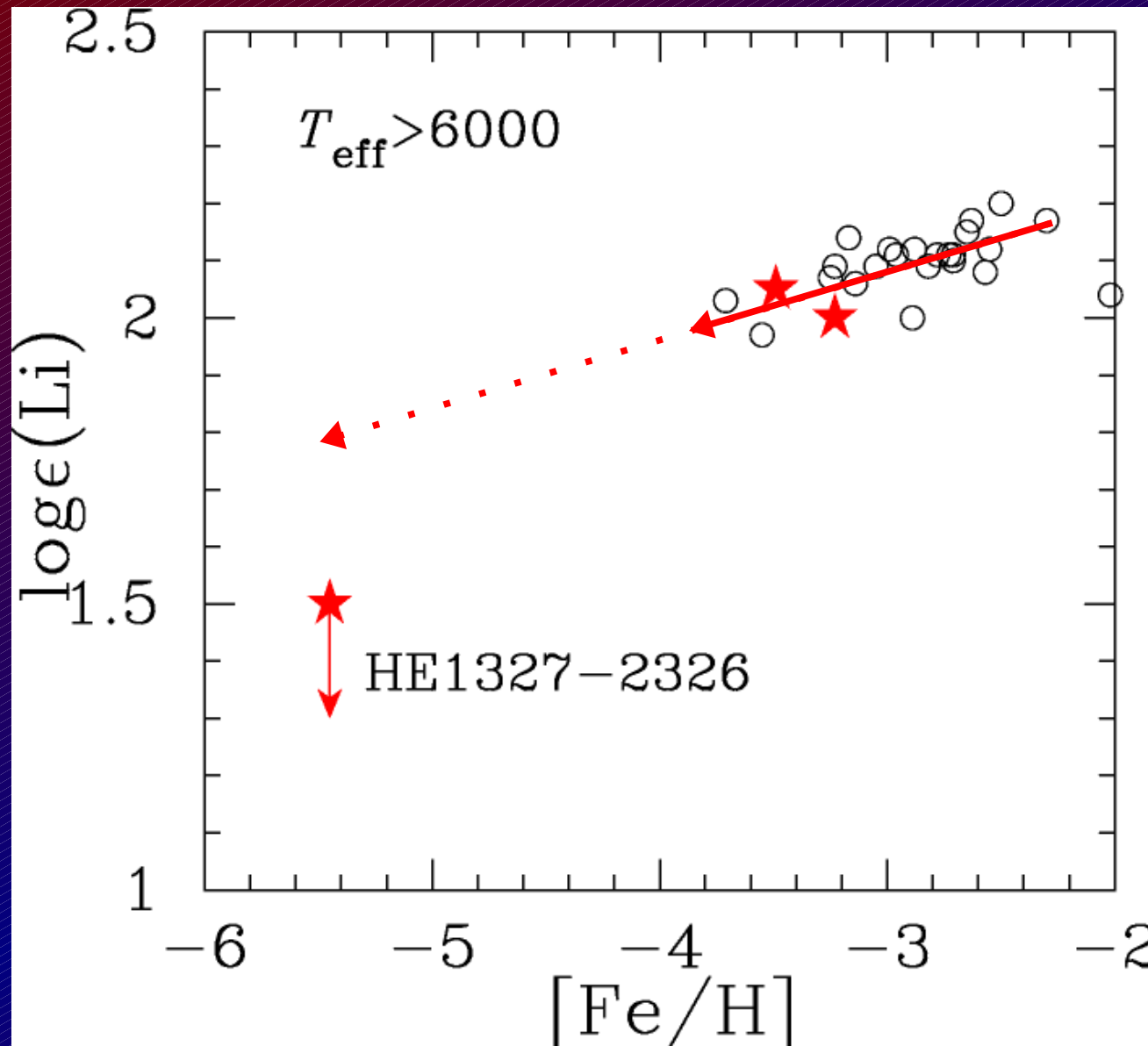


- ★ This work
- Francois et al. 2003
- Cohen et al. 2004
Carretta et al. 2002
- ◆ Honda et al. 2004
- Aoki et al. 2005
- ▲ Aoki et al. 2004

5. Upper-limit of Lithium Abundance



5. Upper-limit of Lithium abundance



- ★ This work
- Ryan et al. 1999
Norris et al. 2000

Summary: the chemical abundance pattern of the unevolved star HE1327-2326

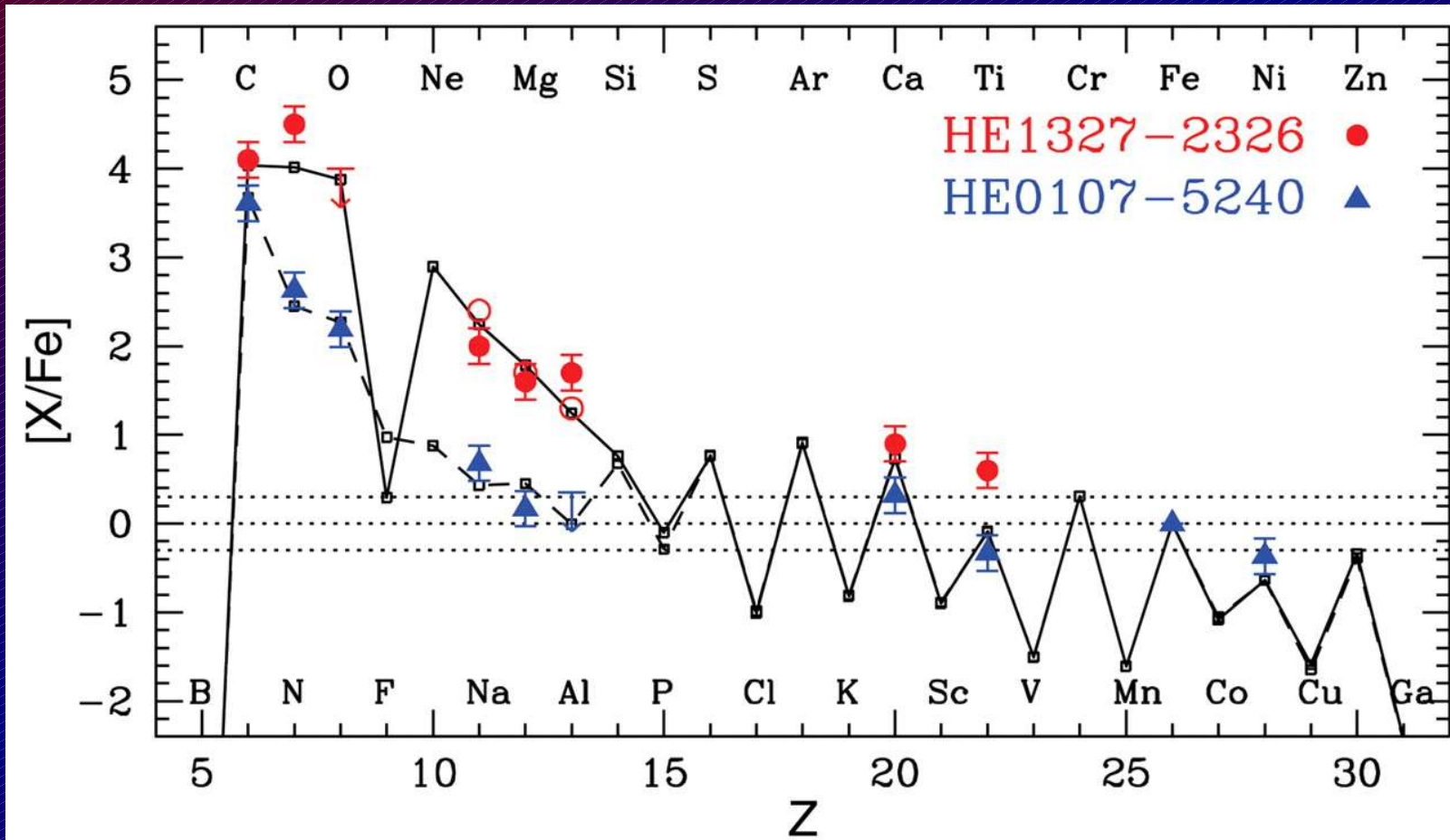
1. The **iron abundance** ($[\text{Fe}/\text{H}] = -5.4$) is lowest in halo stars known to date. No star has been found in $-5 < [\text{Fe}/\text{H}] < -4$.
2. The **excess of carbon** is significant ($[\text{C}/\text{Fe}] = +4$), as found in HE0107-5240. → These two stars have similar enrichment history.
3. The **excesses of N, Na, Mg and Al** is significant in HE1327-2326.
4. The **excess of Sr** is found in HE1327-2326.
5. The **Li** abundance of HE1327-2326 is significantly lower than the values found in halo unevolved stars.

Possible interpretations

- **Population III (=1st generation star) scenario:**
HE1327 (as well as HE0107) formed from primordial (metal-free) clouds, but polluted by interstellar medium (Fe etc.) and AGB stars (C etc.).
cf. Suda et al. 2004
- **Population II (>2nd generation star) scenario:**
HE1327 (as well as HE0107) formed from clouds polluted by 1st generation massive stars, that have provided C-rich material.
 - “Faint supernova”: Umeda & Nomoto 2003,
Iwamoto et al. 2005
 - Rotating massive star: Meynet et al. 2006

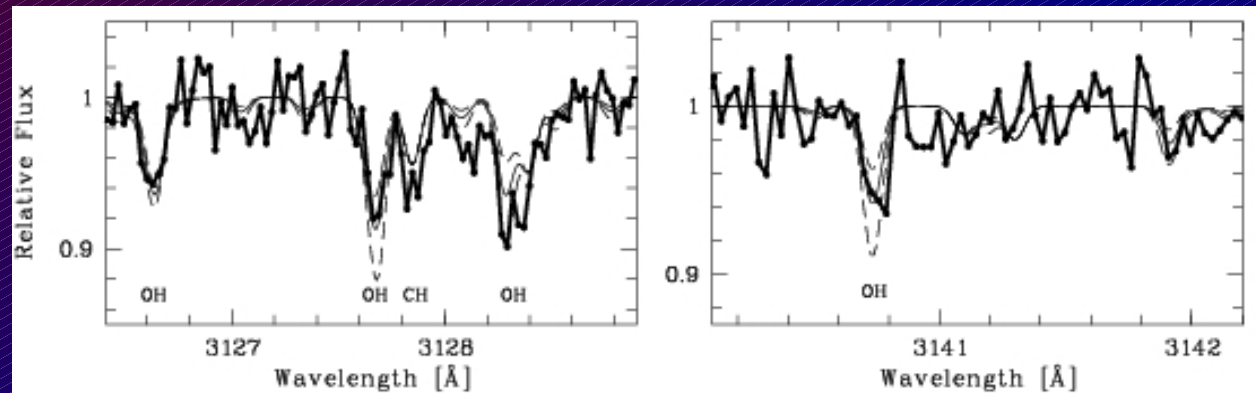
Comparison with the calculation of “faint supernova” model

Iwamoto et al. 2005



Ongoing & future work

Further observing for HE1327-2326 ... was made with VLT.
→ detection of OH molecular lines.



Frebel et al. 2006 (submitted to ApJL)

Further survey & spectroscopy:
-Hamburg/ESO survey + VLT
-SDSS-SEGUE + Subaru