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 [Fe/H]<-4 was known, nevertheless large efforts to search for metal-deficient stars.

Chriestlieb et al. (2002, Nature 419, 904) reported a star with [Fe/H]=-5.3 (HE0107-5240). This is a giant with a large excess of carbon ([C/Fe]~+4).

Many models have been proposed to interprete the low iron abundance and the excess of carbon in HE0107-5240. Further search for stars with [Fe/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--6800A
- S/N~100--200@4500A

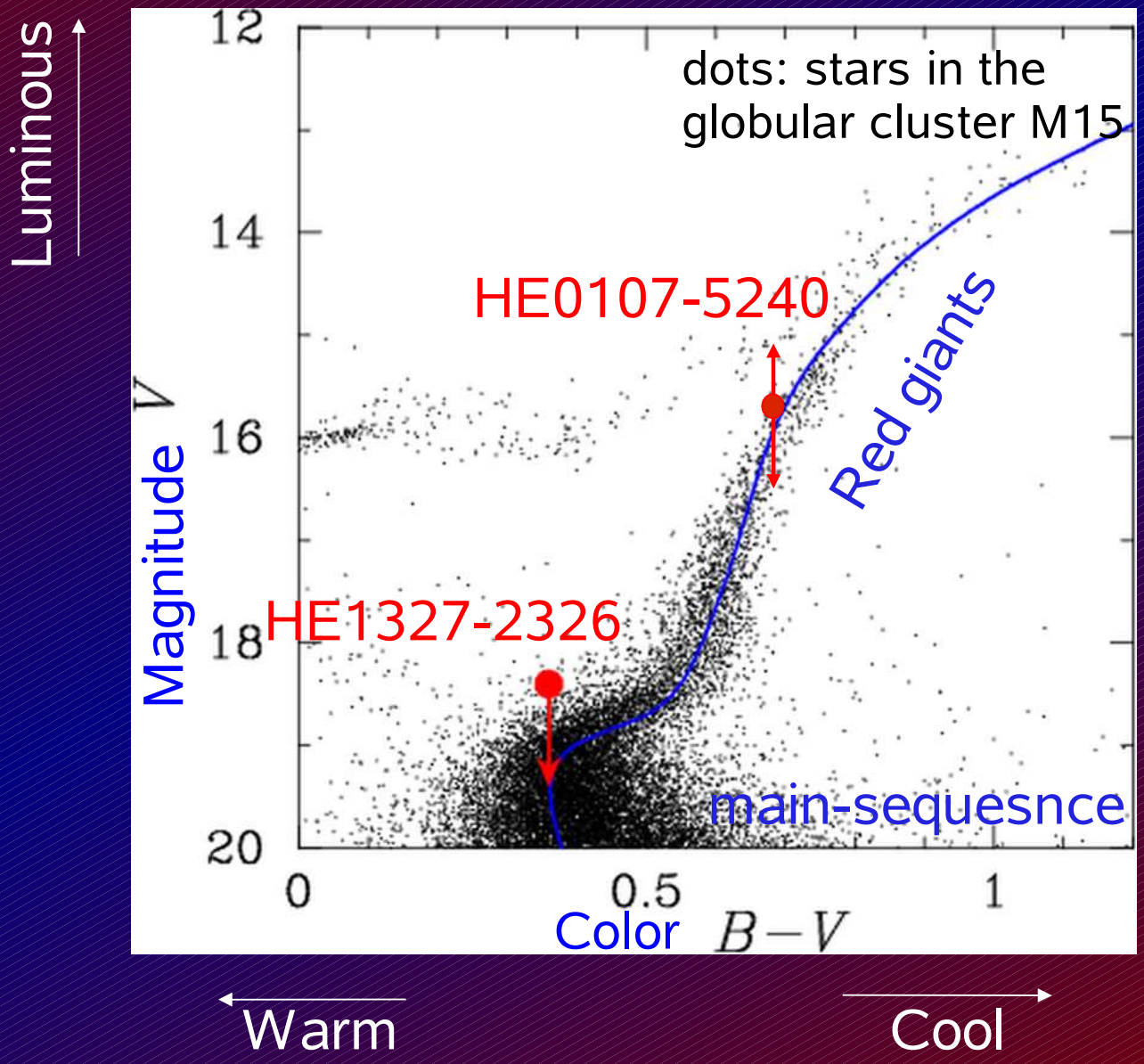
2003 Dec.	2 nights (1 clear night)
2004 May/June	4 nights (3.5 clear nights)
2005 Feb/March	3.5 nights (3 clear nights)
2005 June	5 nights (scheduled)

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



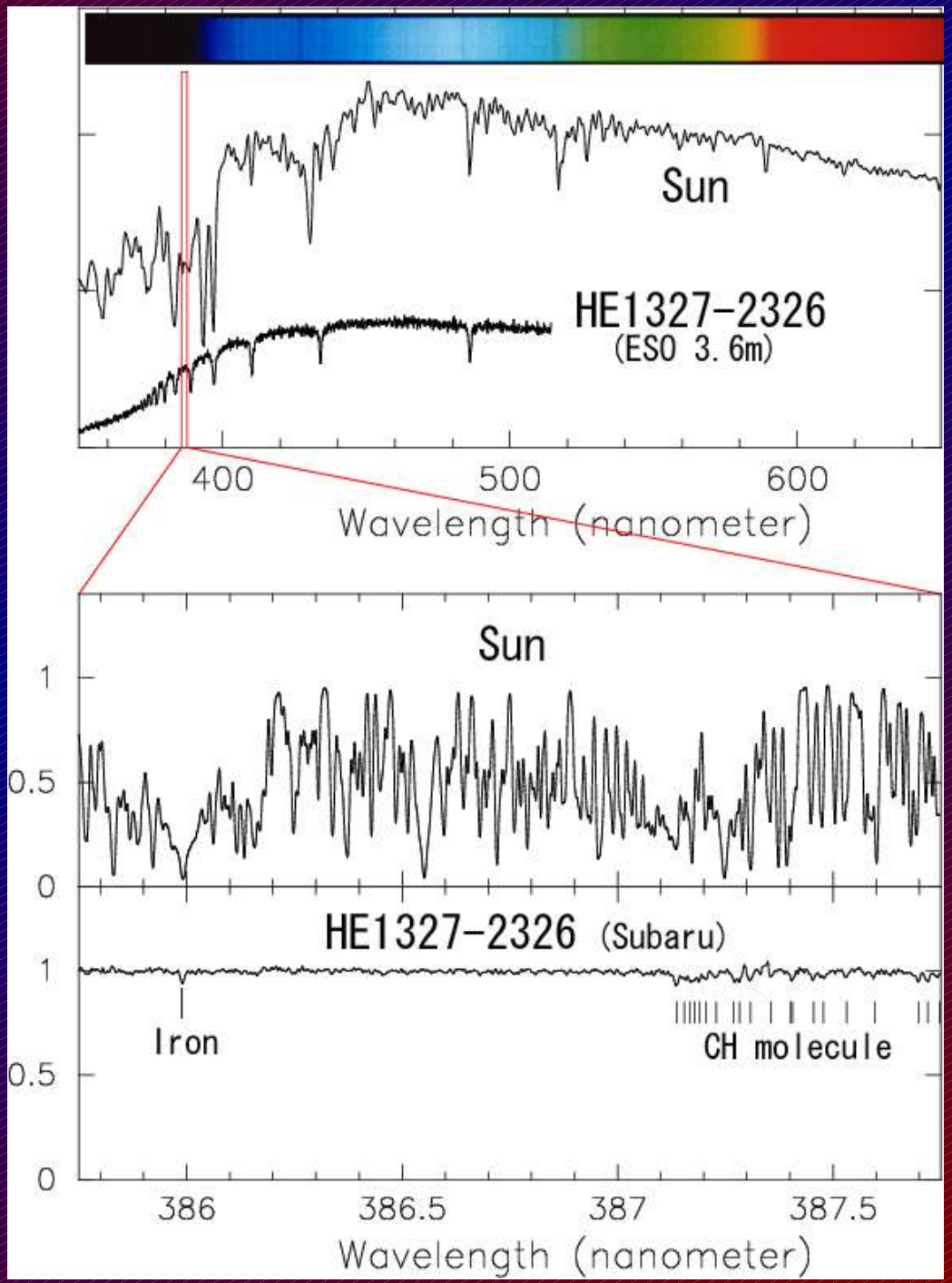
1. Iron abundance

Medium resolution spectra
→

High resolution spectra →

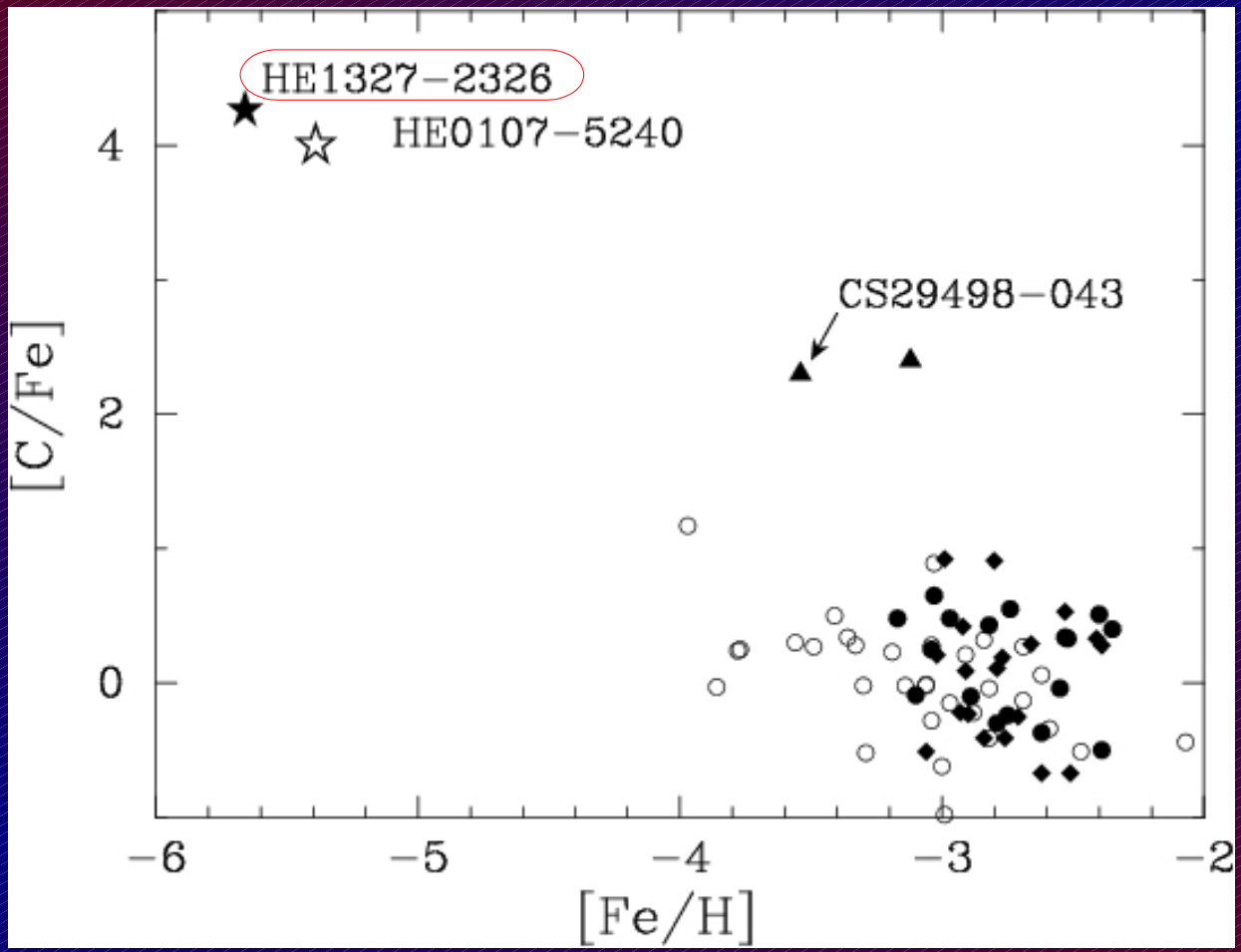
very weak Fe lines
→[Fe/H]=-5.4

detection of CH molecular bands
→excess of carbon



2. A large excess of carbon

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

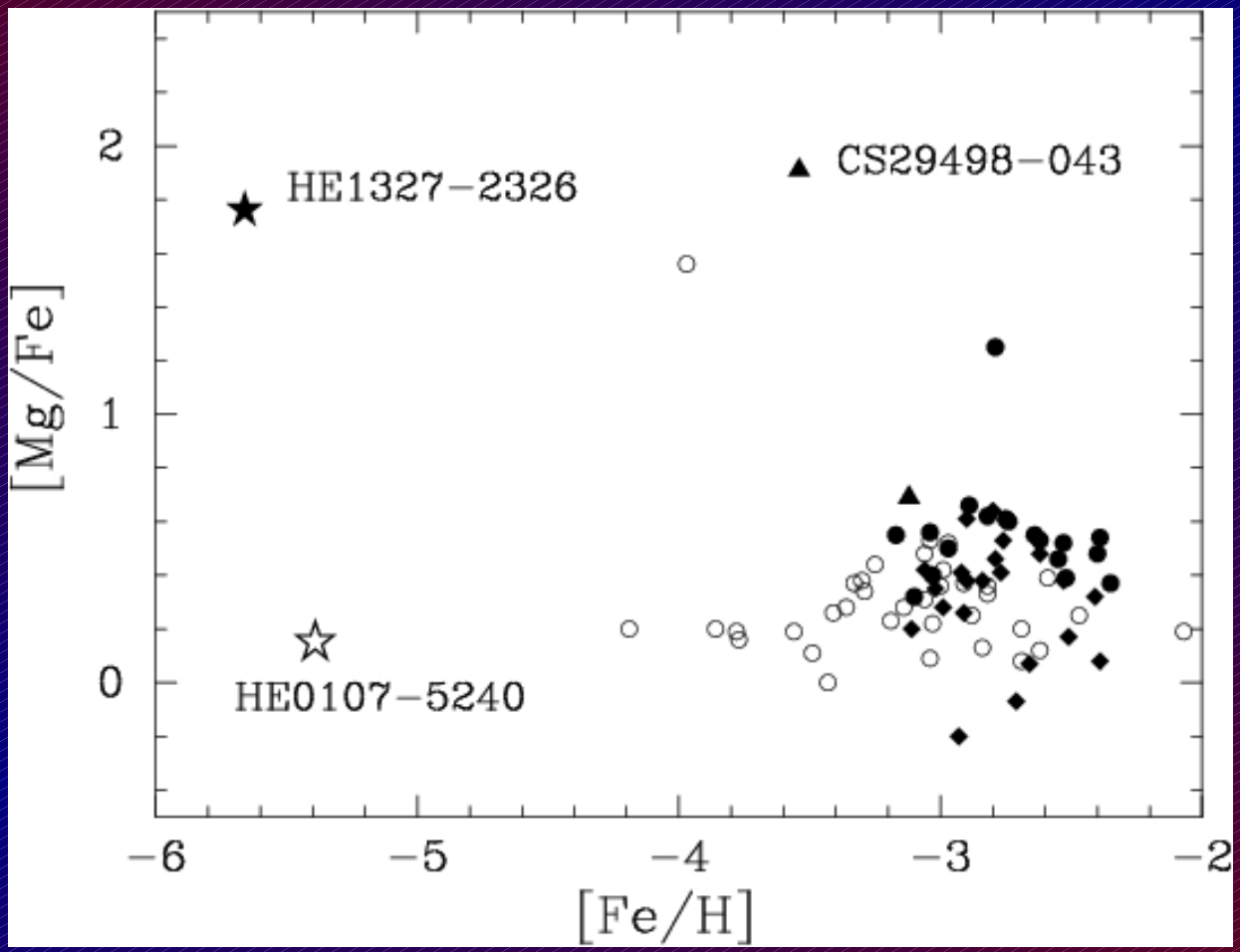


★This work
○ Cayrel et al. 2004
♦ Honda et al. 2004
● Aoki et al. 2005
▲ Aoki et al. 2004

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



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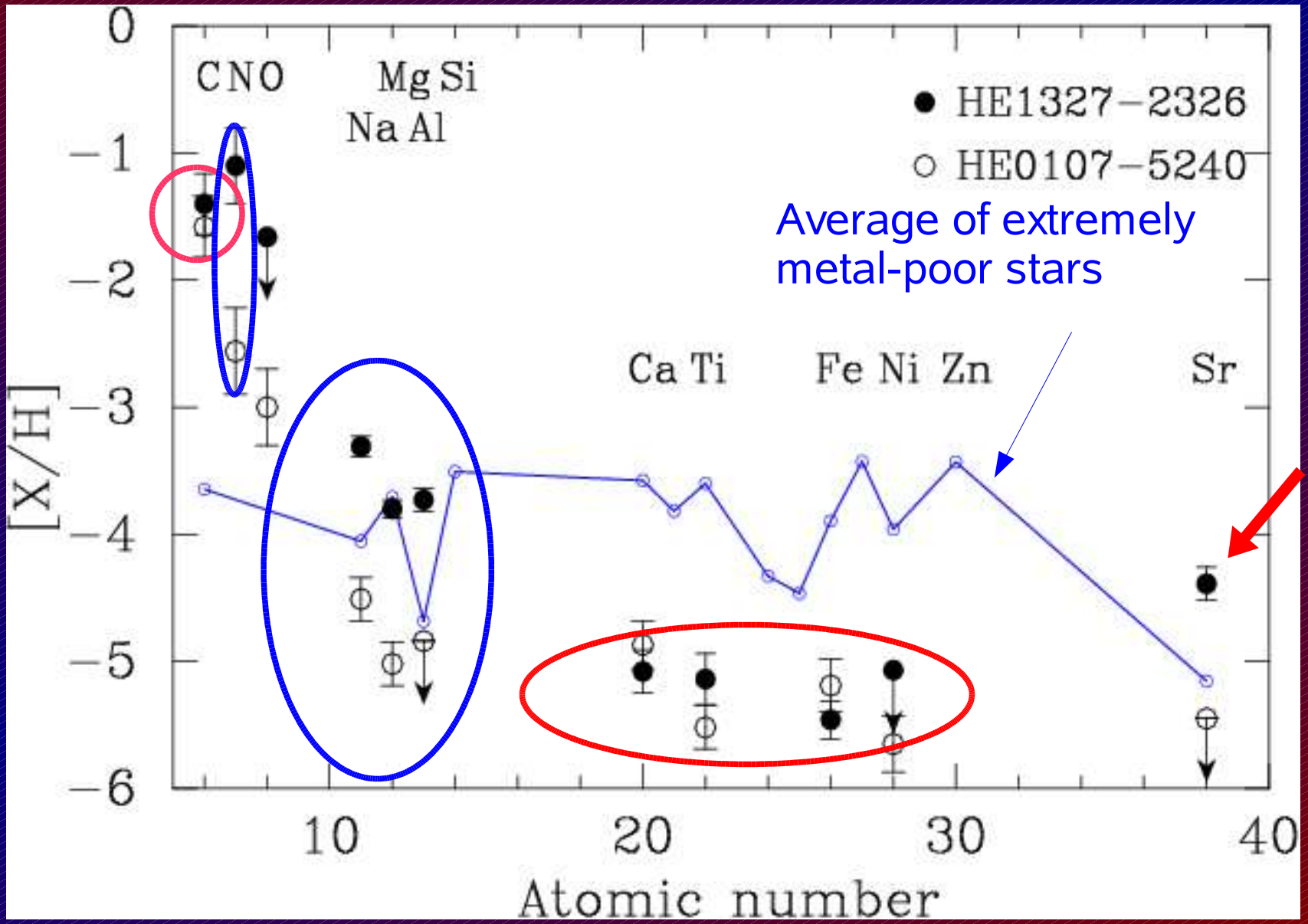
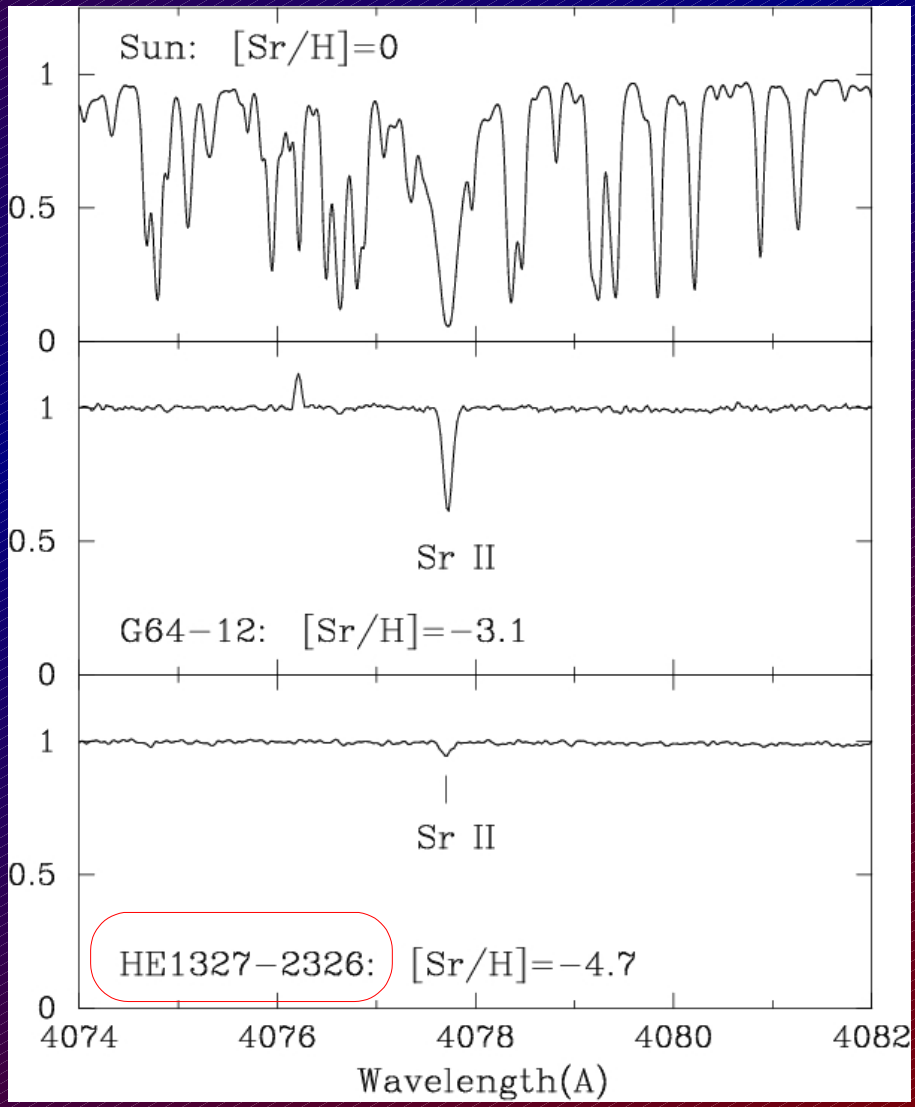
○ Cayrel et al. 2004
♦ Honda et al. 2004
● Aoki et al. 2005
▲ Aoki et al. 2004

Comparison of the abundance patterns between HE1327 and HE0107

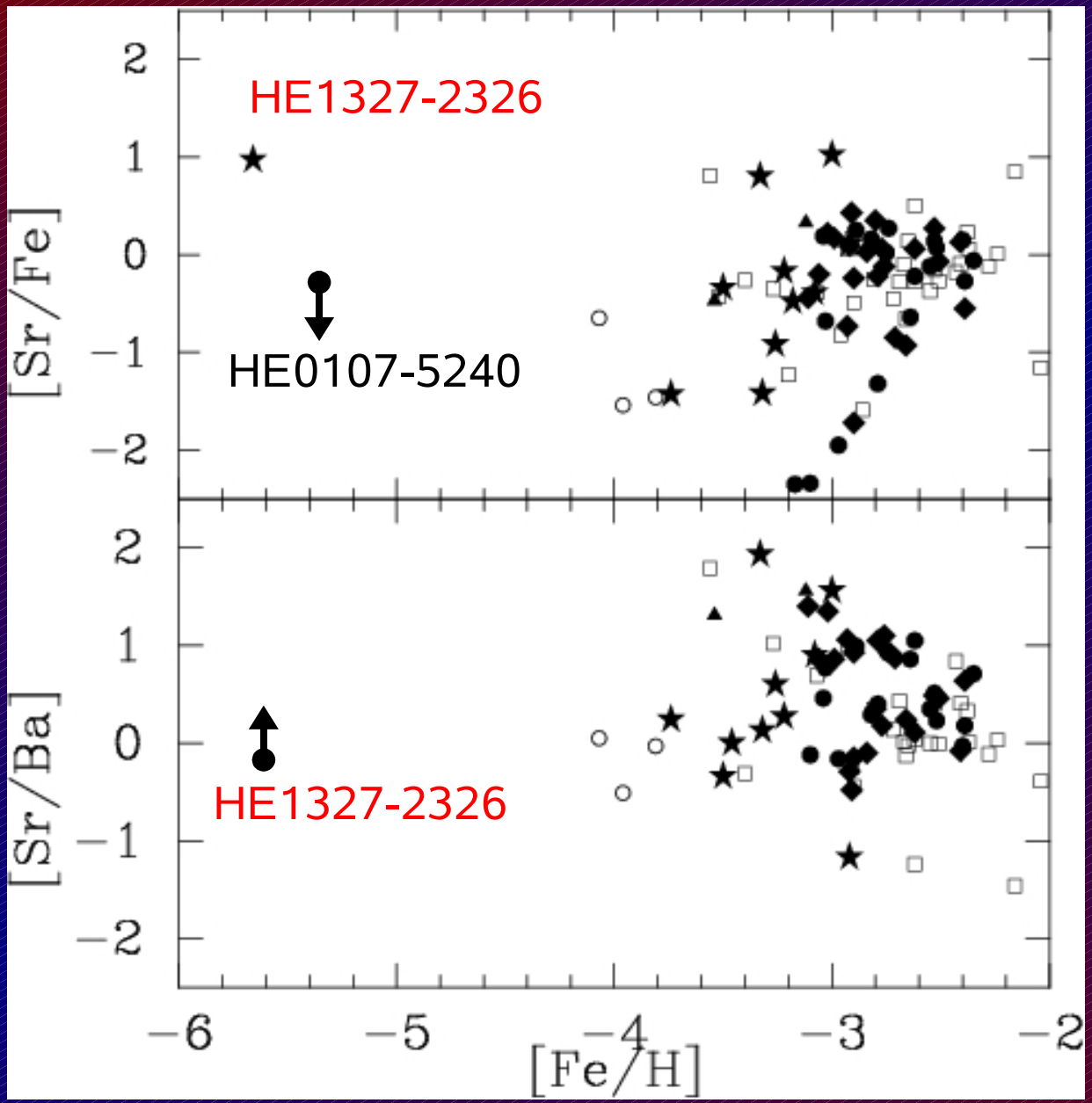


4. The light Neutron-capture element Sr

The two Sr resonance lines are detected only in HE1327-2326, while no Ba line is seen.
→excess of *light* neutron-capture elements

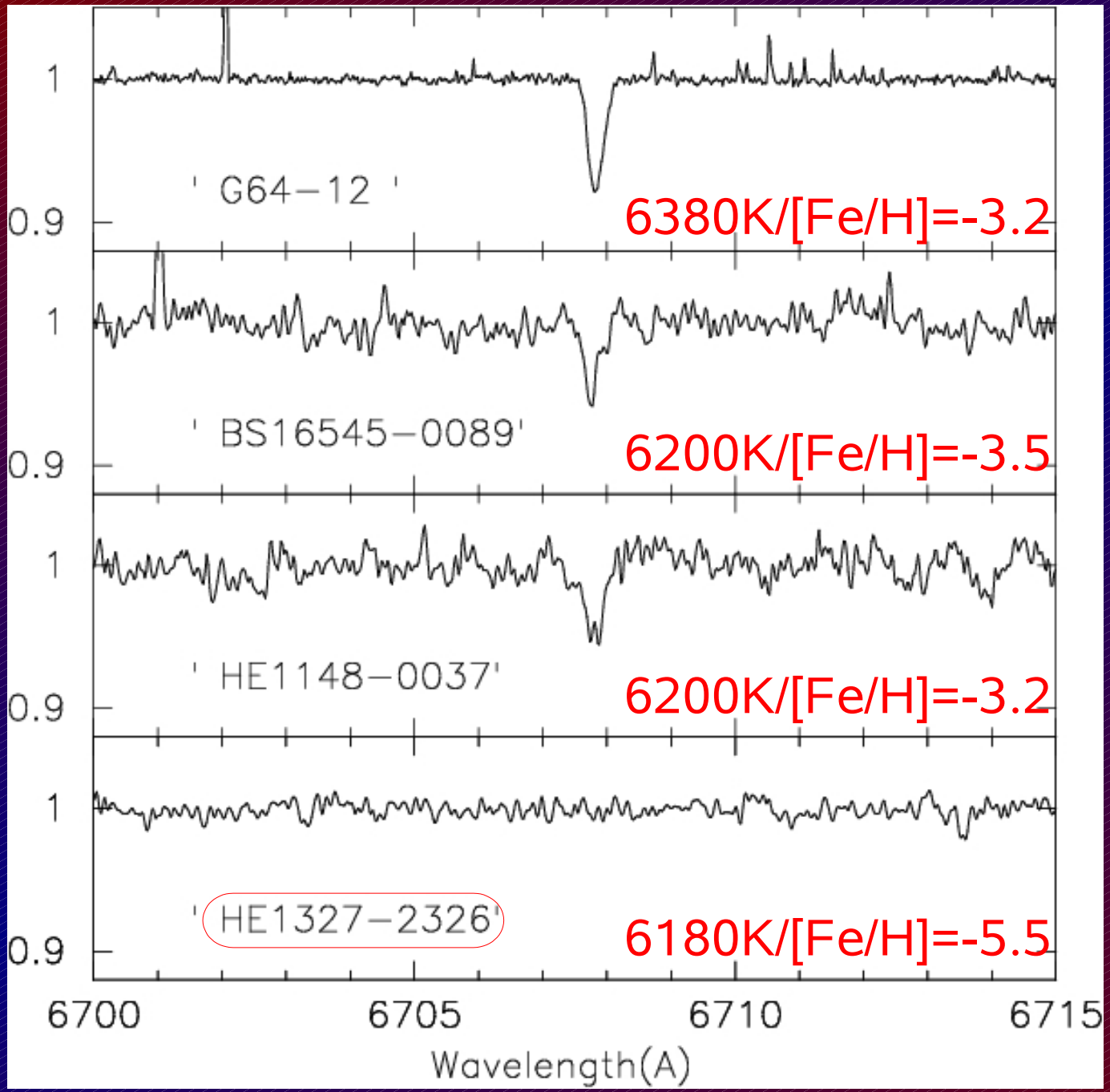


4. The light Neutron-capture element Sr



★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



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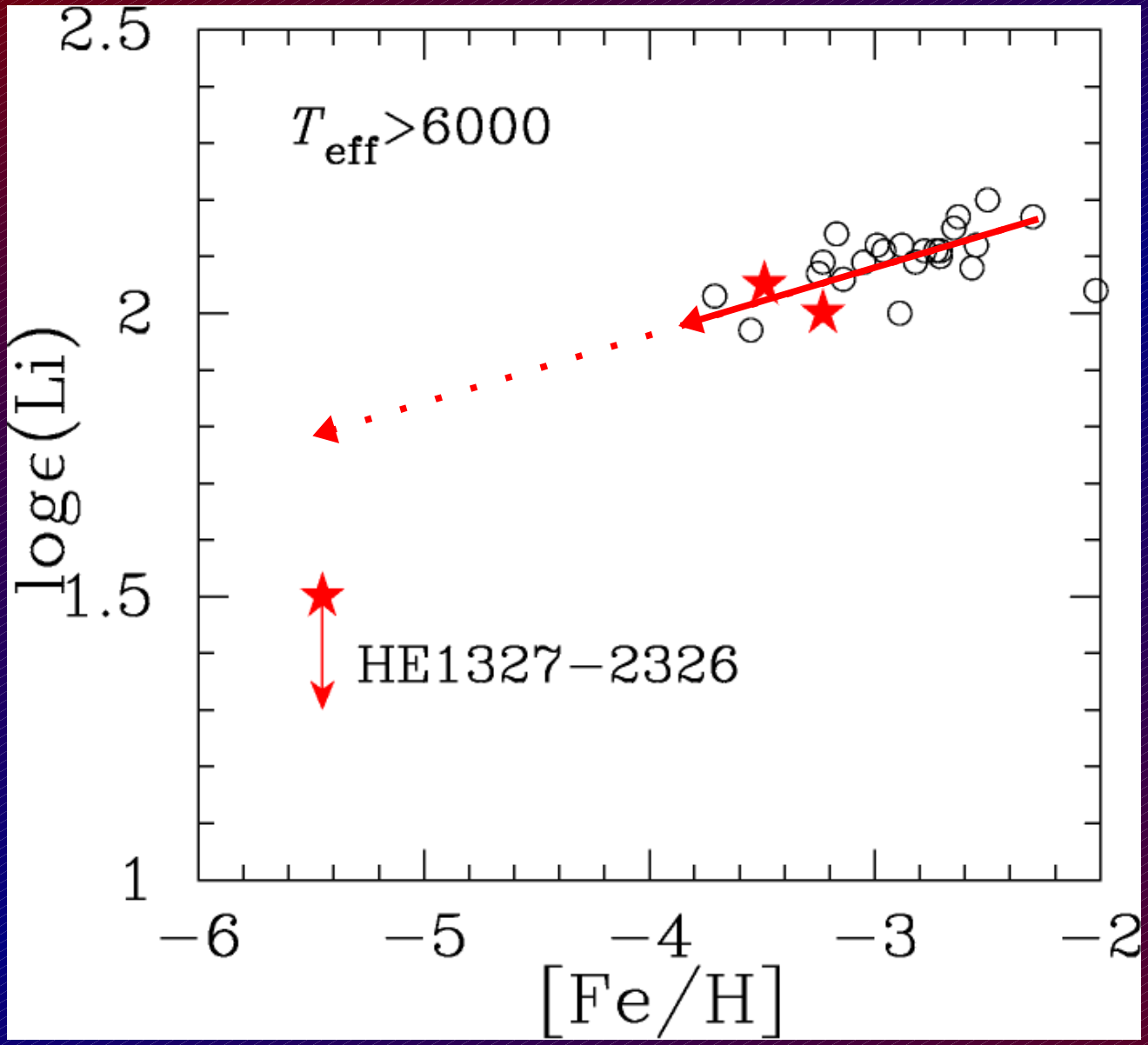


★This work
○ Ryan et al. 1999
Norris et al. 2000

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

1. The iron abundance ([Fe/H]=-5.4) is lowest in halo stars known to date. No star has been found in -5<[Fe/H]<-4.

2. The excess of carbon is significant ([C/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.

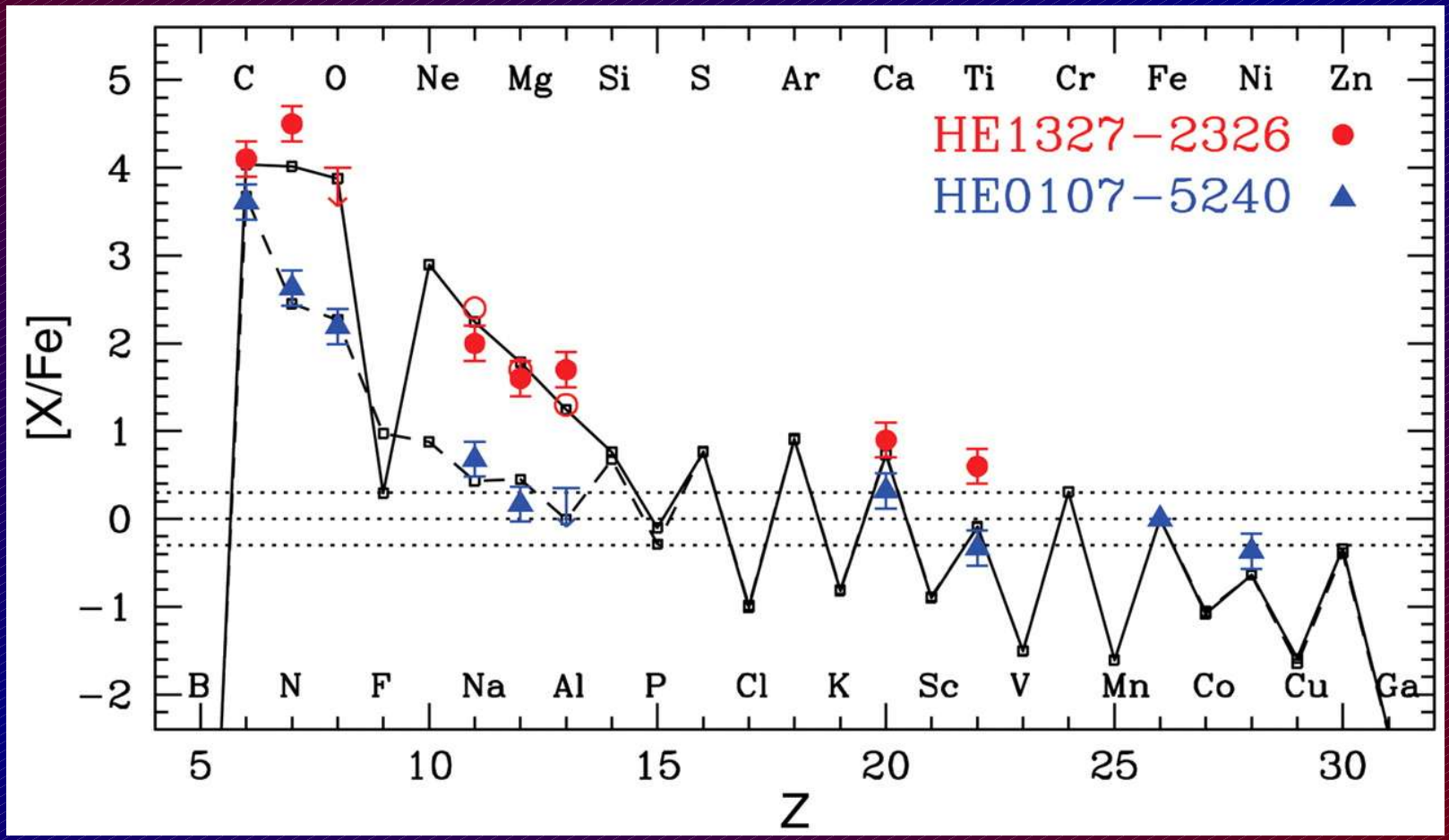
Possible interpretations

- 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

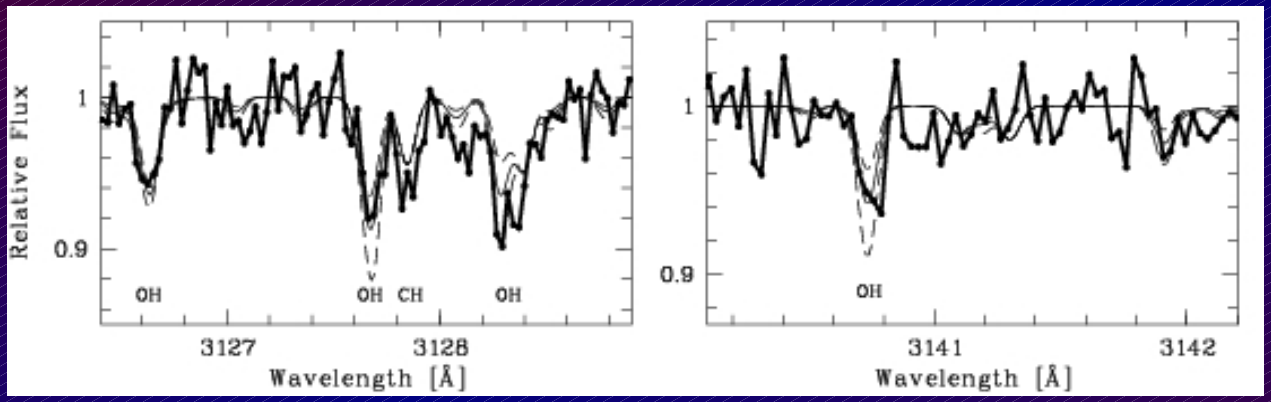
Comparison with the calculation of “faint supernova” model

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