

On the Sodium versus Iron Correlation in Late B-Type Stars

TAKEDA, Yoichi, KAWANOMOTO, Satoshi, OHISHI, Naoko
(NAOJ)

It is naturally known that a close abundance correlation exists between Na and Fe in comparatively old FGK stars (cf. [1]) as a result of Galactic chemical evolution. However, the existence of similar relation recently found for A-type stars ([2]) was quite unexpected, since it is hard to understand this tendency based on the present-day diffusion theory intending to explain the diversified chemical peculiarity in late-B through A type stars. In order to check whether this trend in A-type stars persists into the regime of late B-type stars, we determined Na abundances for 30 selected sharp-lined late B-type stars ($10000\text{ K} < T_{\text{eff}} < 14000\text{ K}$) by using the spectrum-fitting technique applied to the Na I 5890/5896 doublet lines, based on the high-dispersion spectra obtained with the 188-cm reflector and HIDES spectrograph at Okayama Astrophysical Observatory. The results are depicted in Figure 1, from which the following conclusions are drawn:

— (1) In the regime of A-type stars ($7000\text{ K} < T_{\text{eff}} < 10000\text{ K}$), the mechanism causing chemical peculiarities (mainly Am anomalies in this case, characterized by overabundance of Fe and underabundance of O) acts nearly equally on both Na and Fe, so that a near-scaling relation between $[\text{Na}/\text{H}]$ and $[\text{Fe}/\text{H}]$ ($[\text{Na}/\text{H}] \sim 0.64[\text{Fe}/\text{H}]$) is realized despite that these two elements have suffered appreciable abundance changes.

— (2) However, as T_{eff} is increased (higher than 10000 K), this relation first becomes appreciably loosened and ambiguous at the transition region ($10000\text{ K} < T_{\text{eff}} < 11000\text{ K}$), then the correlation eventually disappears at $11000\text{ K} < T_{\text{eff}} < 14000\text{ K}$ where $[\text{Na}/\text{H}]$ stabilizes almost at the primordial value, despite both O and Fe still show $v_e \sin i$ -dependent anomalies. This suggests that the physical process causing abundance peculiarities does not work any more on Na at this higher- T_{eff} regime of late B-type stars, though it still operates on both Fe and O (typically exhibited by HgMn stars).

— (3) It is interesting to note that the “transition region” stars at $10000\text{ K} < T_{\text{eff}} < 11000\text{ K}$ are in the mass range of $\sim 2.5\text{--}3 M_{\odot}$, which just corresponds to the region on the HR diagram occupied by both HgMn stars and hot Am stars nearly overlapped. We may state that these two groups of non-magnetic chemically peculiar stars (Am stars and HgMn stars) could be roughly characterized by the existence of Na–Fe correlation (i.e., both elements undergo abundance peculiarities in a similar manner) and the absence of such connection (i.e., Fe suffers anomaly while Na do not), respectively.

This consequence may serve as an important observational constraint for understanding the mechanism

producing abundance peculiarities in upper main-sequence stars. Generally, less attention seems to have been paid to Na in early-type chemically peculiar stars, presumably because published observational data have been insufficient. Above all, diffusion calculations for Na in the envelope of B-type stars with $M \gtrsim 2.5 M_{\odot}$ seem to have been rarely conducted so far. In this respect, new contributions by theoreticians are desirably awaited toward reasonably explaining the observational trend for Na (along with O and Fe) confirmed in this investigation.

The more details of this study are described in [3].

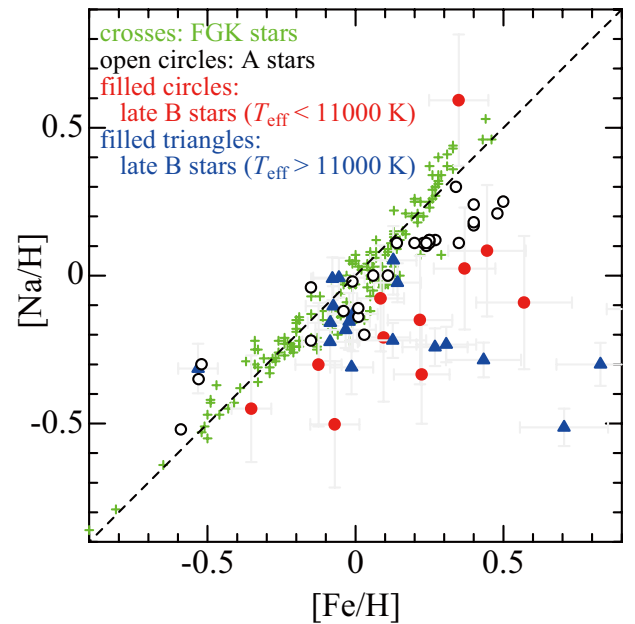


Figure 1: Abundance correlation between Na and Fe. Star groups of different T_{eff} are discriminated by symbols: Crosses...FGK stars ([1]), open circles...sharp-lined A-type stars ([2]), filled circles...late B-type stars with $T_{\text{eff}} < 11000\text{ K}$ (this study), and filled triangles...late B-type stars with $T_{\text{eff}} > 11000\text{ K}$ (this study).

References

- [1] Takeda, Y.: 2007, *PASJ*, **59**, 335.
- [2] Takeda, Y., et al.: 2012, *PASJ*, **64**, 38.
- [3] Takeda, Y., Kawanomoto, S., Ohishi, N.: 2014, *PASJ*, **66**, 23.