Oxygen Abundance Determination of B-type Stars with O I 7771–5 Å Lines

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It is known that anomalous abundances are observed in specific light elements (e.g., C or N) in B-type main-sequence stars, which are interpreted as due to mixing caused by rotation-induced meridional circulation. However, the appreciable He enrichment in B-type stars once reported by [1] can not be explained within the framework of the canonical theory of stellar evolution. If this is real, it would require a special non-canonical deep mixing extending to the core where transformation of H→He takes place. Yet, given that He abundance determination from strong He lines is difficult (which critically depends on a choice of microturbulent velocity) and the conclusion of [1] may not necessarily be reliable. In this context, oxygen abundances play a key role, since an appreciable He-enrichment should accompany a significant O-deficit due to dredge-up of ON-cycle product from the deep core region. So, the necessity/existence of non-canonical mixing may be judged by examining the surface oxygen abundances of B stars, where the standard calculation predicts negligibly small O-anomaly ([2]).

Motivated by this consideration, we decided to conduct an O-abundance analysis for a well-defined sample of B-type stars, while employing the O I 7771–5 Å triplet lines. The observations for selected 34 targets (where Be stars and B supergiants are not included) in a wide range of $v_e \sin i$ ($\sim$ 0–250 km s^{-1}) as well as $T_{\rm eff}$ ($\sim$ 10000–28000 K) were carried out mostly in 2015 September by using the MALLS spectrograph attached to the 2 m NAYUTA telescope at Nishi-Harima Astronomical Observatory of Hyogo University. The resolving power and typical signal-to-noise ratio of the spectra are $R \sim 12000$ and S/N $\sim$ 200–300, respectively. By using the atmospheric parameters determined from *uvbyβ* colors, we derived the oxygen abundances by applying the spectrum-fitting technique to the O I triplet lines while taking into account the non-LTE effect. The following conclusions were obtained:

— The strength of O I 7771–5 Å lines decreases with an increase in $T_{\rm eff}$, while the non-LTE effect is considerably large for both late-B as well as early-B stars (non-LTE abundance correcton is on the order of ~ -1 dex) and thus has to be taken into account by all means.

— The resulting oxygen abundances of our sample stars distribute around the solar abundance and do not show any systematic dependence upon $v_e \sin i$ as well as $T_{\rm eff}$, which means that any meaningful oxygen abundance anomaly is not observed.

— Since this doe not contradict the prediction from the standard stellar evolution calculations (e.g., [2]), the appreciable enrichment of surface He abundance suggested by [1] may be questionable and worth reinvestigation.

See [3] for more details of this study.

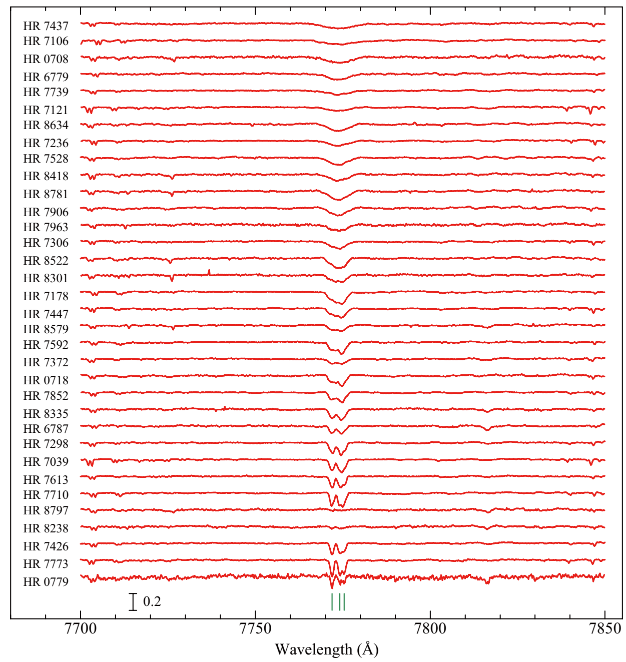

Figure 1: Spectra of our 34 target stars in the 7700–7850 Å region, which are arranged in the descending order of $v_e \sin i$.

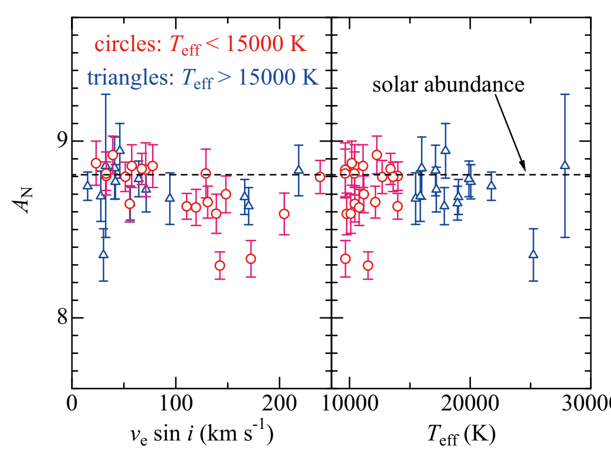

Figure 2: The resulting $A_{\rm N}$ (non-LTE oxygen abundance) plotted against $v_e \sin i$ as well as $T_{\rm eff}$.

References

[1] Lyubimkov, J. S., et al.: 2004, *MNRAS*, **351**, 745.
[2] Georgy, C., et al.: 2013, *A&A*, **553**, 24.
[3] Takeda, Y., Honda, S.: 2016, *PASJ*, **68**, 32.