Beryllium Abundances of Solar-Analog Stars

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The surface Li abundances ($A_{\rm Li}$) in solar-analog stars (i,e., early G-type main-sequence stars like our Sun) show a remarkably large diversity amounting to more than ~2 dex. Why such a large difference is produced for stars with similar parameter values? We previously found in statistical study on 118 selected solar-analogs based on the OAO/HIDES spectra that $A_{\rm Li}$ depends upon the rotational velocity (see [1]). This finding was further corroborated from the viewpoint of stellar activity (controlled by rotation via a dynamo) estimated from the core flux of the Ca II 8542 line [2].

Then, why slow rotation leads to an efficient Li depletion? Interestingly, according to Bouvier's recent theoretical simulation [3], slow rotators develop a high degree of differential rotation between the radiative core and the convective envelope, which eventually promotes lithium depletion by enhanced mixing, while such core–envelope decoupling does not evolve in faster rotators. Then, the key to understanding the mixing process lies in "the bottom of the convection zone" (i.e., "tachocline"), where the condition may be probed by examining the abundance of Be along with Li (each having different burning temperatures). (See Figure 1 showing the structure of the solar envelope model taken from [4].)

Accordingly, we conducted an extensive beryllium abundance analysis for the same sample of 118 solar analogs (based on the high-dispersion UV spectra obtained with Subaru/HDS in 2009–2010) by applying the spectrum synthesis technique to the near-UV region comprising the Be II line at 3131.066 Å, in an attempt to investigate how and whether Be suffers any depletion such as the case of Li showing a large diversity.

Our findings are as follows (cf. Figure 2):

—In marked contrast to Li, most (~96%) of the solar analogs are superficially similar in terms of their $A_{\rm Be}$.

—However, 4 out of 118 stars turned out strikingly Be-deficient (by >~2 dex) and these 4 stars have the lowest $v_{\rm e} \sin i$, the lowest stellar activity, and depleted $A_{\rm Li}$.

—Moreover, even for the other majority showing an apparent similarity in Be, we can recognize a tendency that A(Be) gradually increases with an increase in $v_{\rm e} \sin i$.

These results suggest that any solar analog star (including the Sun) generally suffers some kind of rotation-dependent Be depletion, for which we suspect two kinds of mechanisms may operate: The "strong" process should work only in limited cases under special conditions but depletes surface Be very efficiently once triggered, whereas the "weak" process acts on most stars and slowly reduce Be in the outer envelope. Contributions of theoreticians are awaited toward developing a reasonable model accounting for these observational facts.

See [5] for more details of this study.

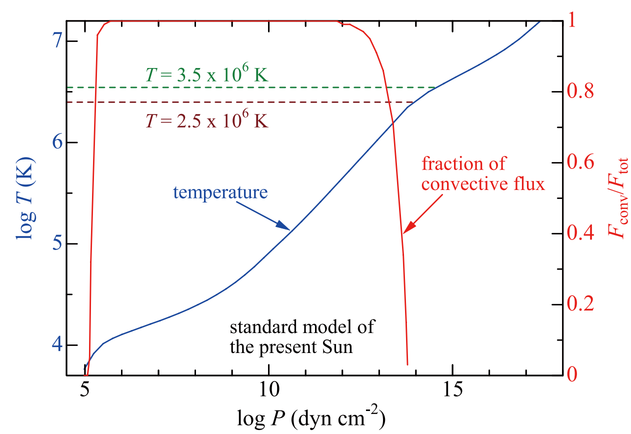

Figure 1: Physical structure of the envelope of the Sun.

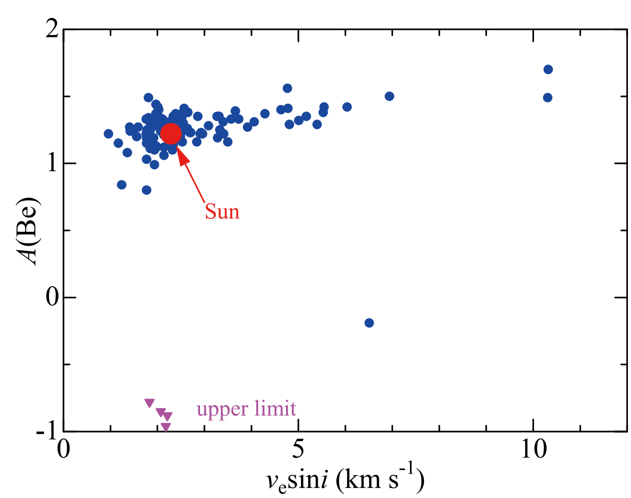

Figure 2: Be abundances plotted against the projected rotational velocity.

References

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