Detection of Low-Level Activities in Solar-Analog Stars from the Emission Strengths of Ca II 3934 Line

TAKEDA, Yoichi, TAJITSU, Akito, KAWANOMOTO, Satoshi, ANDO, Hiroyasu, SAKURAI, Takashi
(NAOJ)

HONDA, Satoshi
(Kyoto University)

There have been several arguments regarding the status of solar activity among similar Sun-like stars. This began with the implication of Baliunas and Jastrow [1] based on their Mt. Wilson HK survey that a considerable portion (~1/3) of solar-type stars have activities significantly lower than the present-day Sun, which they called "Maunder-minimum stars." However, their conclusion could not be confirmed by Hall and Lockwood's follow-up study [2], and Wright [3] criticized the reality of such low-active solar-type stars by pointing out that most of them are not so much dwarfs as evolved subgiants.

Given this controversial situation, we decided to contend with this problem by ourselves based on carefully selected sample of 118 solar-analogs sufficiently similar to each other (which we already investigated their stellar parameters as well as Li/Be abundances in a series of papers; cf. [4,5,6]), with a special attention being paid to reliably evaluating their activities down to a considerably low level.

Practically, we measured the emission strength at the core of Ca II 3933.663 line (K line; cf. Figure 1) on the high-dispersion spectrogram obtained by Subaru/HDS, where we gave effort to correctly evaluating the pure emission component by removing the wing-fitted photospheric profile calculated from the classical solar model atmosphere to obtain $R'_{\rm Kp}$ (ratio of chromospheric core emission flux to the bolometric flux). This enabled us to detect low-level activities down to log $R'_{\rm Kp} \sim -5.5$.

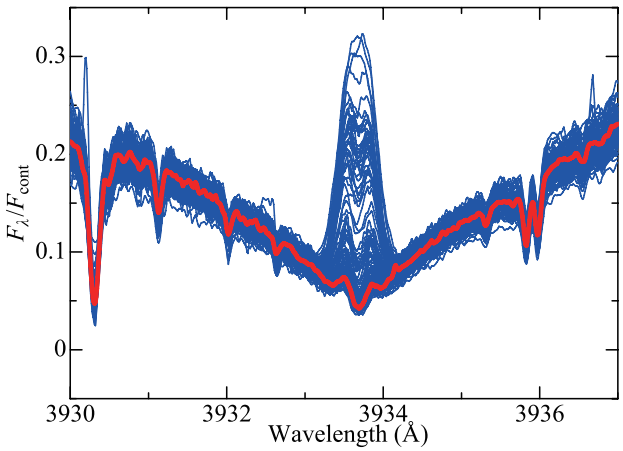

Figure 1: Observed spectra at the Ca II K line core for the 118 program stars (blue) and Vesta/Sun (red).

From the distribution histogram of log $R'_{\rm Kp}$ (Figure 2), we could recognize a clear Vaughan–Preston gap between two peaks at ~−5.3 and ~−4.3. Our result of log $R'_{\rm Kp,\odot}$ = −5.33 manifestly suggests that the Sun belongs to the group of the former peak and has a distinctly low-active nature among solar analogs. Actually, the fraction of stars satisfying the condition of log $R'_{\rm Kp} \leq$ log $R'_{\rm Kp,\odot}$ is only ~10 %. This consequence exclude the possibility for the existence of a considerable portion (e.g., ~1/3) of "Maunder-minimum stars" such that having activities significantly lower than the current solar-minimum level as once suggested by Baliunas and Jastrow ([1]). This consequence also implies that the Sun is a distinctly low-active star even within the group of solar-analog stars. See [7] for more details of this study.

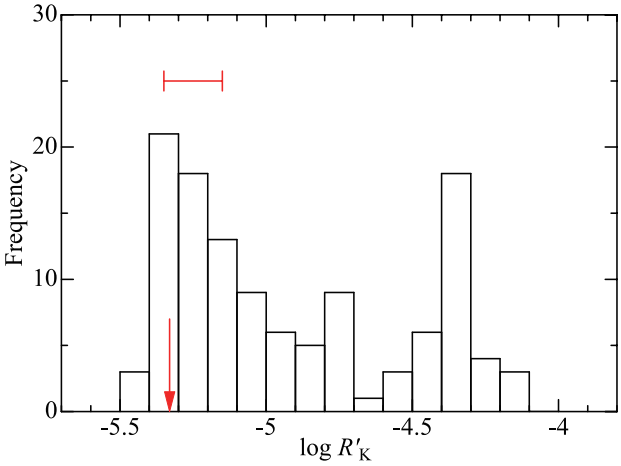

Figure 2: Distributions of log $R'_{\rm Kp}$. The arrow shows the position for the Sun, and its expected minimum–maximum range is also indicated.

References

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