Lithium Abundances in Stars with Planets: Strong Evidence for Lithium Deficit

Guillermo Gonzalez
Ball State University, Dept. of Physics and Astronomy, Indiana, USA

Introduction

We revisit the question of a possible correlation between the presence of Doppler-detected planets and stellar Li abundance. Several recent studies (Israelian et al. 2009; Gonzalez et al. 2010; Delgado Mena et al. 2014) indicate that stars with planets (SWPs) have lower Li abundances compared to stars without detected planets near the solar temperature. However, other studies (Baumann et al. 2010; Ghezzi et al. 2010; Ramirez et al. 2012) have failed to confirm this pattern. Therefore, despite having received attention for over a decade from several independent research groups, this question remains controversial.

The present work is very similar to our previous study on this topic (Gonzalez 2014), but we have increase the size of the sample of comparison stars with new spectroscopic data and also add additional literature data. In that work we showed that SWPs in the temperature range 5600 < T < 5800 K are deficient in Li by about 0.5 dex relative to comparison stars with similar properties. We presented weaker evidence that SWPs with T > 6100 K are also deficient in Li. However, relatively few comparison stars with T < 5600 K and > 6100 K were employed in that study. We have targeted comparison stars in these ranges in the present work.

The purpose of the present study is to test again the claim that the Li abundances of Sun-like SWPs are different than those of similar stars without known planets.

Observations and Analysis

We observed 30 stars drawn from the Valenti and Fischer (2005) study that do not have detected planets. The temperatures listed by them for these stars range from 5630 to 6274 K, and the average is near 5950 K. We observed our target stars on May 9-12, 2014 using the McDonald Observatory 2.1-m Otto Struve telescope and Sandiford spectrograph, which is a Cassegrain echelle design. A solar spectrum was obtained via reflected light off the Galilean moon Ganymede, and the hot star Regulus was observed in order to correct for telluric features.

Following our procedure in Gonzalez (2014) we reduced the spectra in IRAF and measured the equivalent widths in an automated way using DAOSPEC. The stellar atmospheric parameters and Li abundances were calculated using MOOG. We also used the same linelist and atomic parameters. We list the results of our Fe line analysis in Table 1.

A literature dataset was constructed in a self-consistent way from our latest and previous McDonald data, the data of Delgado Mena et al. (2014), and the large data compilation of Ramirez et al. (2012). It consists of 108 Doppler-detected SWPs and 358 stars not known to host planets. All the stars in this dataset are between late-F and mid-G spectral types and have detected Li.

Results

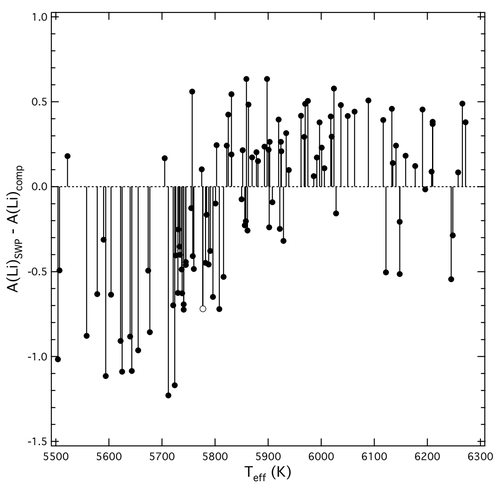

Figure 1: Weighted average Li abundance differences between the SWPs and comparison stars from the literature dataset.

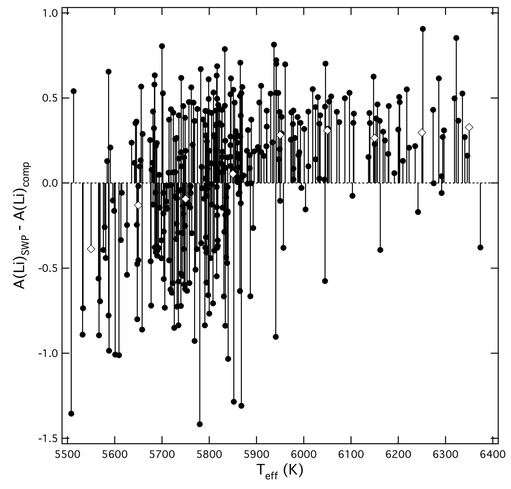

Figure 2: Weighted mean Li abundance differences among the comparison stars from the literature dataset. Calculations were done in the same way as in Figure 1. Open diamonds are the means of the Li abundance differences in 100 K wide bins.

The Li abundance differences shown in Figures 1-3 were calculated using a weighting factor based on the difference in effective temperature, [Fe/H], log g, and log age between an SWP and a comparison star. Stars that are most similar in these four properties, receive the greatest weight.

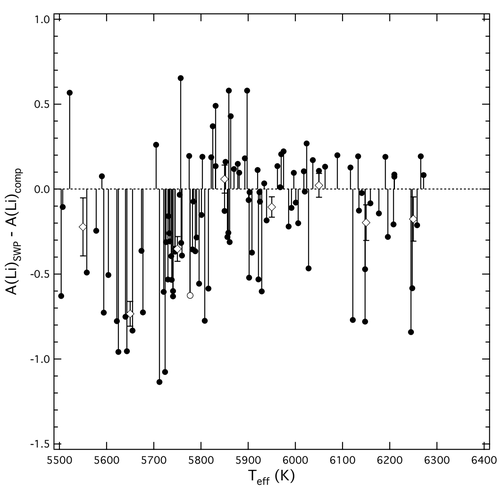

Figure 3: Data from Figure 1 corrected for bias using the means from Figure 2.

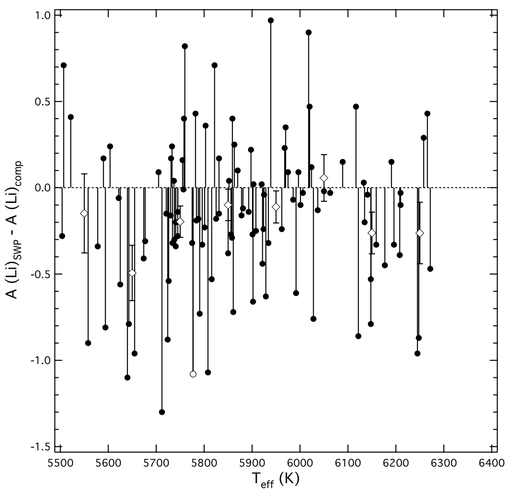

Figure 4: Li abundance differences between SWPs and most similar comparison star. Means in 100 K bins are shown.

Conclusions

When we combine our new data with a large homogeneous sample of similar stars with Li abundance determinations from the literature, we were able to confirm that the Li abundances of SWPs with T ~ 5700 K are significantly smaller than those of stars without detected planets; there is weaker evidence that Li is also deficient among SWPs with T ~ 6200 K. Lithium is deficient among all the SWPs in our literature dataset by 4 to 5-sigma, depending on how the samples are compared. Our results generally confirm other recent independent studies of Li abundances in SWPs.

Like Delgado Mena et al. (2014), we have noted a number of SWP-non-SWP pairs with very similar properties, yet with very different Li abundances. These cases are very unlikely to be explained by observational error. They deserve additional detailed study.

References

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