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^{6}Li: A Clue for Planet Accretion in Stars

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Abstract

Using high quality (S/N $\geq$ 350) and very high resolution spectra ($R\approx$ 125,000) we have searched for ^{6}Li in stars hosting planets. For this study we have chosen a sample of 15 stars out of which 9 are known to have planets, one is a binary, and 5 are not known to have planets. From detailed profile-fitting analysis of Li resonance line at 6700 Å we find no significant amount of ^{6}Li relative to ^{7}Li in any of the planet hosting stars (^{6}Li/^{7}Li $\leq$ 0.03).

1.1 Introduction

To date there are around 90 stars with planets (SWPs). One of the interesting properties of SWPs is that their photospheres are metal-rich compared to stars without planets (Santos et al. 2001). Gonzalez (1997) based on limited data suggested a link between higher metallicity and the smaller orbital periods implying self-pollution of photospheres by rocky material devoid of hydrogen. However, the expected relation between orbital parameters of planets and the metallicity of SWPs is not evident based on much larger data (Santos et al. 2001). This may imply that SWPs higher metallicity is primordial i.e., SWPs formed in metal-rich environment.

Recently, Israelian et al. (2001) reported a large amount of ^{6}Li relative to ^{7}Li (^{6}Li/^{7}Li = 0.126 $\pm$0.014) in HD 82943, a SWP, suggesting that the stellar photosphere was polluted by planetary material. Since lithium ^{6}Li and ^{7}Li would presumably have been preserved in the planets, the ingestion of planets added ^{6}Li (and ^{7}Li) to the star's atmosphere cleansed of ^{6}Li in the pre-main-sequence phase. Here, we briefly discuss lithium isotopic results published by Reddy et al. (2002) for a sample of stars with and without planets, and they are of similar atmospheric parameters and metallicity.

1.2 Analysis and Results

Examination of high-quality and ultra-high resolution spectra of the Sun and the 16 Cyg B suggest weak unidentified features near the ^{6}Li wavelength (Figure 1). The wavelengths of unidentified features in the solar spectrum are measured by Brault & Müller (1975) and they are at 6708.025 and 6708.110 Å. King et al. (1997) noted the effect of these lines on solar ^{6}/^{7}Li ratio. By treating these as ^{6}Li lines they obtain a large value of ^{6}Li/^{7}Li = 0.10 for the Sun. This high value of ^{6} in the Sun's atmosphere is very unlikely as ^{6}Li is expected to be depleted completely in a cool star (Sun) of around 5 Gyrs old.

Thus, the unidentified lines were assumed to be neutral Ti lines (Reddy et al. 2002) with lower excitation potential of around 1.88eV. The gf-values were derived by inverting the

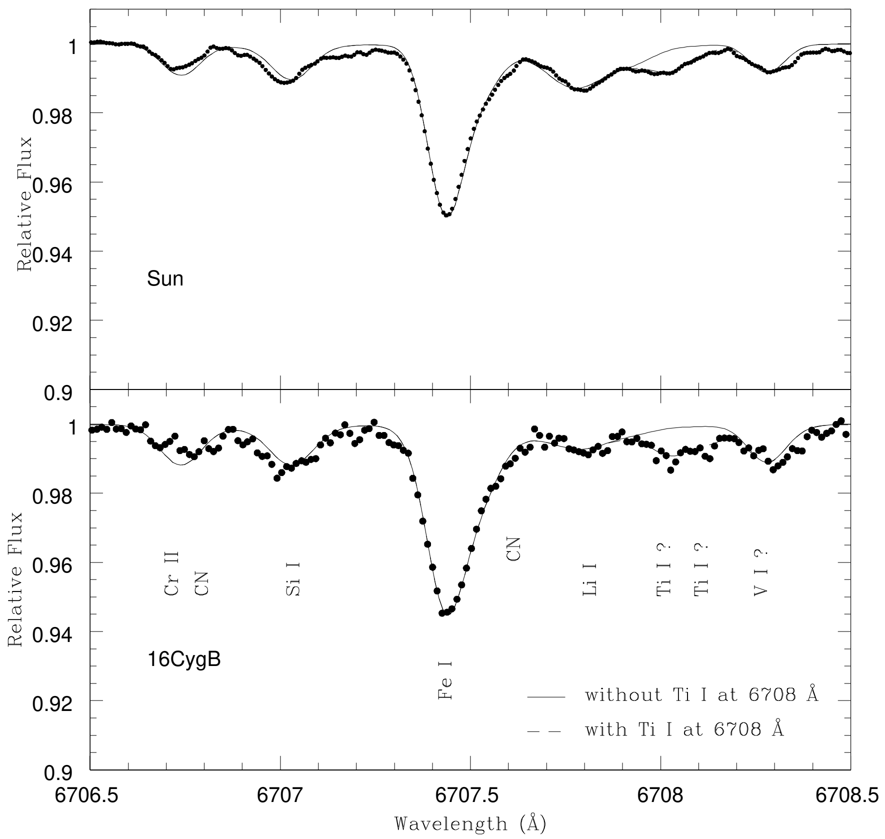

Fig. 1.1. Observed and synthetic spectra around the Li I 6707 Å feature for the Sun and 16 Cyg B. The contribution of the unidentified lines near the weaker ^{6}Li line is given by the difference between the dashed and solid lines between 6707.9 Å and 6708.2 Å.

solar spectrum. The assumed Ti I lines with the derived atomic data from the Sun nicely fit (Figure 1) with the relatively cooler spectra of 16 Cyg B suggesting the unidentified lines are not ^{6}Li but may be some neutral atomic transitions. 16 Cyg B is deficient in Li (log ϵ(Li) = 0.6) compared to the Sun (log ϵ = 1.0).

Using the refined line list near the Li-region and the LTE model atmospheres we derived both the Li abundance and the isotopic ratios for all of the stars in our sample (Reddy et al. 2002). Line broadening parameters like macroturbulence and the rotational broadening are estimated using the well defined Fe I lines around the Li-region. The χ^2-test analysis of Li-profiles yields no significant amount of ^{6} Li in any of the stars in our sample. Li-profile fitting for the presence of ^{6} in HD 82943 is shown shown in Figure 2.

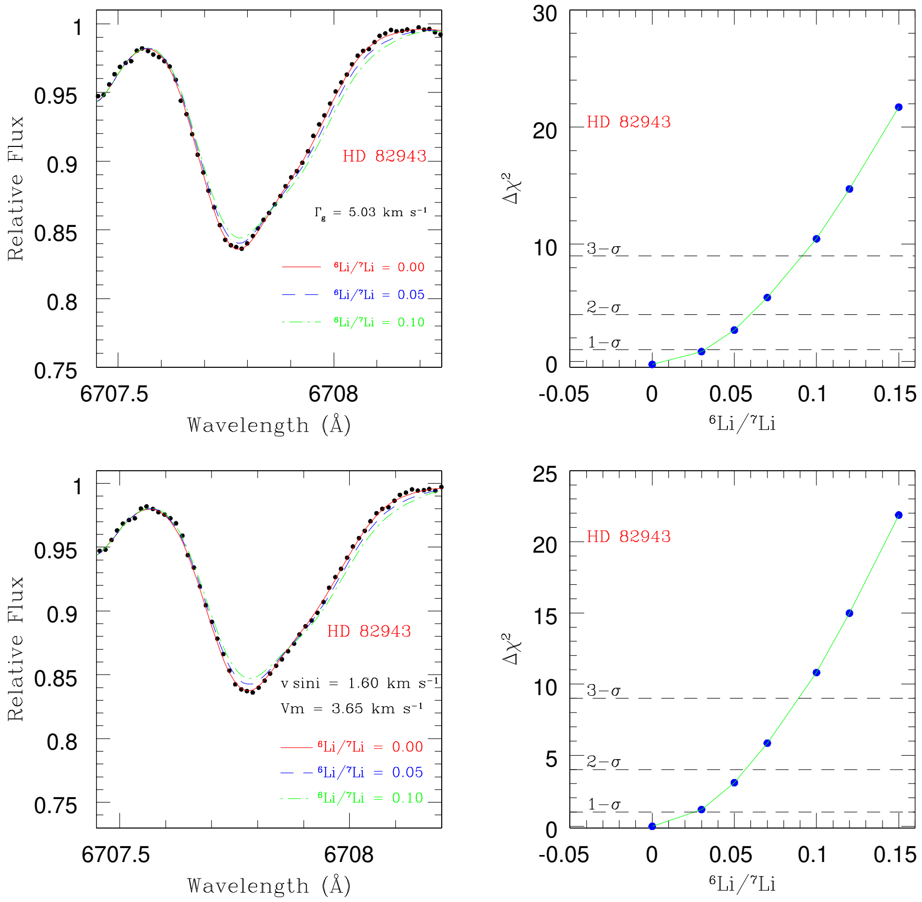

Fig. 1.2. Computed synthetic profiles for different ^{6}Li/^{7}Li ratios are compared with the observed Li profile. Computed profiles are broadened with the broadening parameter Γ_g (top panel) and with the separated radial-tangential macroturbulence, rotational velocity, and the instrumental profile (bottom panel). The χ^2-variance $\Delta\chi^2$ versus the Li isotopic ratio is shown for both the cases.

1.3 Conclusions

Our search for ^{6}Li is planet-hosting stars proved unsuccessful, including HD 82943. Significant difference between our current analysis and the Israelian et al. (2001) is the inclusion of two unidentified lines near ^{6}Li wavelength. It would appear Israelian et al. did not include these lines and therefore arrived at larger ^{6}Li/^{7}Li ratio. We are continuing the search for ^{6}Li in more SWPs. Positive detection is the clear evidence of planet accretion by SWP. Our failure to detect ^{6}Li has 3 possibilities: a) the star did not accrete planets, b) accretion occurred, but ^{6}Li is below the detection limits, c) accretion occurred but ^{6}Li was subsequently destroyed below the detection limit.

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