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HYPERFINE STRUCTURE AND ABUNDANCES OF HEAVY ELEMENTS IN 68 TAURI (HD 27962)

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Abstract. HD 27962, also known as 68 Tauri, is a Chemically Peculiar Am star member of the Hyades Open Cluster in the local arm of the Galaxy. We have modeled the high resolution SOPHIE (R=75000) spectrum of 68 Tauri using updated model atmosphere and spectrum synthesis to derive chemical abundances in its atmosphere. In particular, we have studied the effect of the inclusion of Hyperfine Structure of various Baryum isotopes on the determination of the Baryum abundance in 68 Tauri. We have also derived new abundances using updated accurate atomic parameters retrieved from the NIST database.

Keywords: stars: abundances - stars: individual: 68 Tau - stars: chemically peculiar

1 Introduction

68 Tauri (HD 27962) is the hottest and most massive member of the Hyades open cluster (age about 700 Myrs). Previous abundance analyses of HD 27962 have revealed a distinct underabundance of scandium and overabundances of the iron-peak and heavy elements which prompted to reclassify this early A star as an Am star. The last abundance analysis dates back to 2003 (Pintado & Adelman 2003). It seems therefore justified to redetermine and expand the chemical composition of this interesting object using updated atomic data. In particular we have included the hyperfine structure (Hfs) for several lines. We present here the results for one line of Ba II and discuss the revision of the baryum abundance and other abundances in 68 Tauri.

2 Abundance Determinations

2.1 Model Atmosphere and Spectrum Synthesis

We used the observed Strömgren photometry of 68 Tauri retrieved from SIMBAD and the UVBYBETA code of T.T.Moon (1985) to determine an effective temperature of 9025 ± 200 K and a surface gravity log(g)=3.95 ± 0.25 dex for 68 Tauri. We used these parameters to compute a 72 layers plane parallel model atmosphere with the ATLAS9 code (Kurucz, 1992) assuming Local Thermodynamical Equilibrium, Hydrostatic Equilibrium and Radiative Equilibrium.

We used Hubeny's code SYNSPEC49 (1992) to compute a grid of synthetic spectra to model the observed spectrum of 68 Tauri. We first computed a synthetic spectrum adopting solar abundances as a first iteration and then altered the abundances in order to reproduce the line profiles of selected lines with accurate atomic parameters.

2.2 Baryum Hyperfine Structure

We have replaced the single line λ 5853.675Å of Ba II extracted from the NIST Atomic Spectra Database with the Hfs of the 5 major isotopes of Baryum as calculated by McWilliam(1998). We used a solar isotopic mixture to compute the grid of synthetic spectra. We find a large difference in Baryum abundance when including the full hyperfine structure. For the 5853.675Å line shown Figure 1, the inclusion of Hfs yields a Baryum abundance lower by 0.4 dex than when ignoring Hfs.

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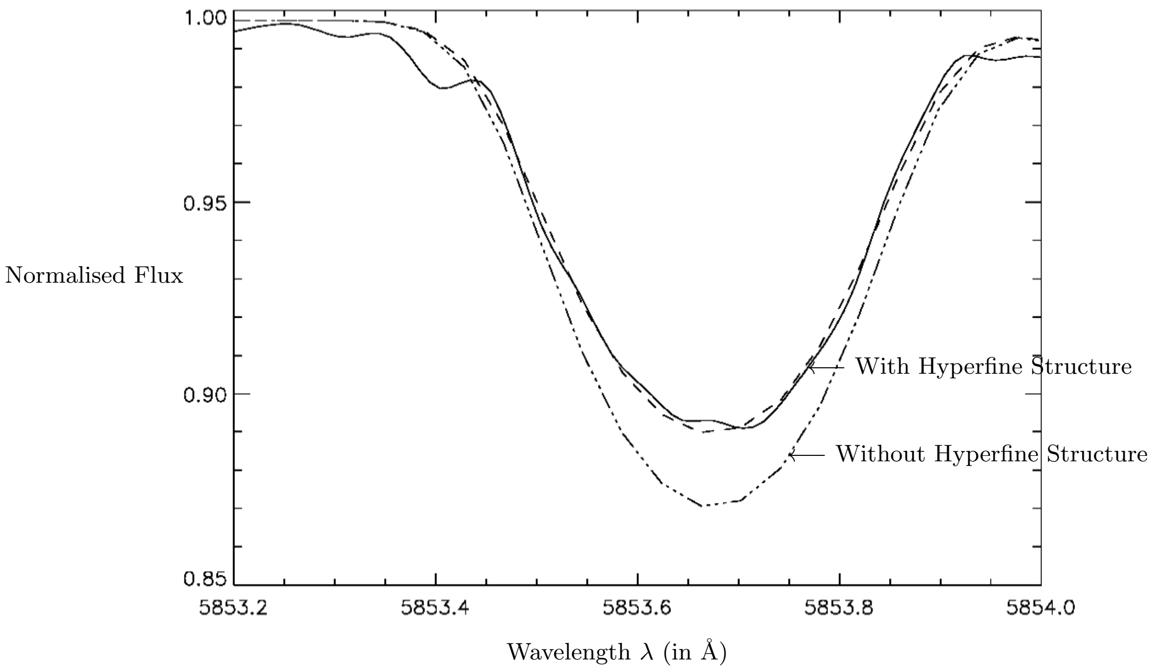

Fig. 1: The effect of including hyperfine structure on the line profile of the 5853.675 Å line of Ba II. *(observed: solid line, synthetic spectra: dashed lines).*

2.3 Abundances in the Atmosphere of 68 Tauri

For iron, we have determined abundances for each lines of Fe II and then computed a weighted mean according to the quality grades assigned to each transition in NIST.

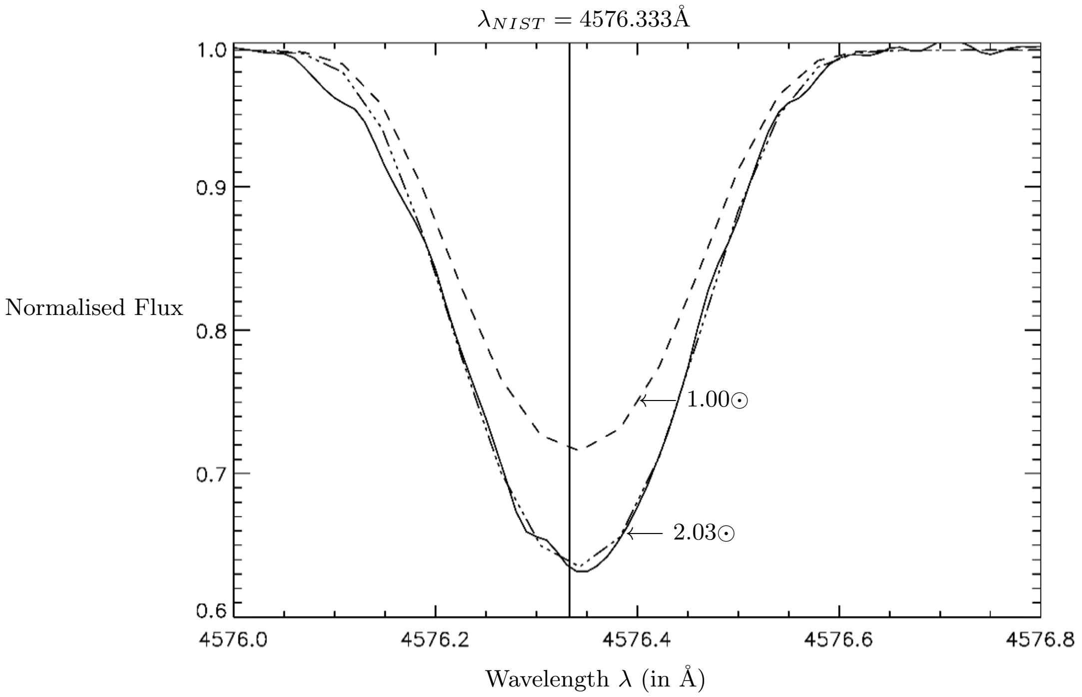

Fig. 2: Determination of Iron abundance for the 4576.33Å Fe II line *(observed: solid line, synthetic spectra: dashed lines)*

We then applied this method to determine the abundances of 21 elements. Our determinations are displayed in Figure 3 with error bars, and we compare our results to the abundances previously found by Pintado & Adelman (2003) who used the same effective temperature and surface gravity. Indeed, the parameters chosen by Pintado & Adelman differ as $\Delta T_{eff} = \pm 250$K and $\Delta \log(g) = \pm 0.25$ from our parameters. Furthermore, we used in our model atmosphere a microturbulence velocity up to $\xi_T = 2.64 \pm 0.66$ km/s while Pintado & Adelman used $\xi_T = 2.3$ km/s.

Our abundance analysis yields a pronounced underabundance of Sc and slight underabundances in C, O, Mg, Si and Ca, mild overabundances of the iron-peak elements and large overabundances of the rare-earth elements. We find abundances which are consistent with the determinations of Pintado & Adelman (2003) except for Scandium. Our results differ from 0.01 dex up to 0.4 dex as we adopted new atomic data. All these new abundance determinations confirm the Am status for 68 Tauri.

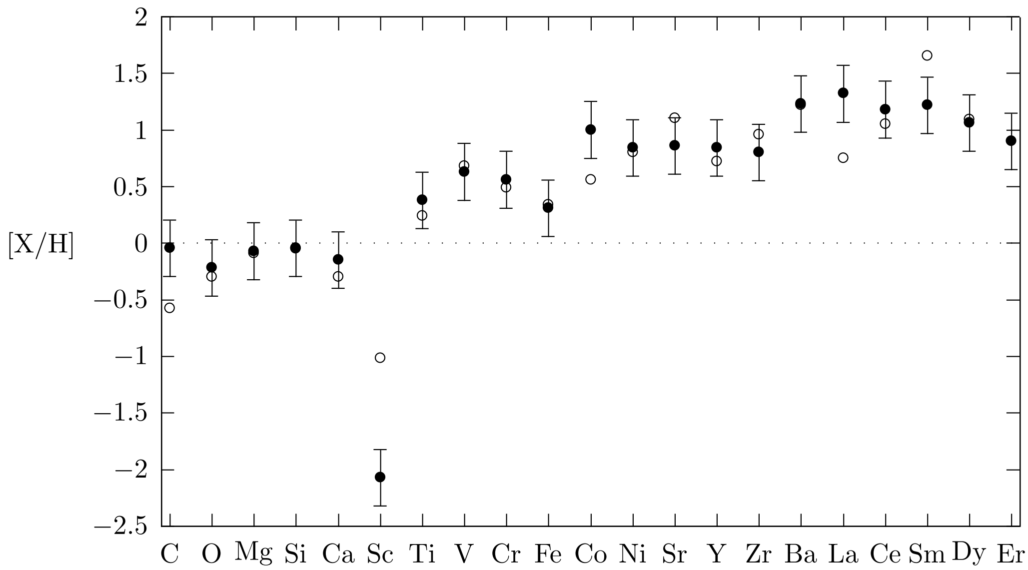

Fig. 3: The abundance pattern determined for 68 Tauri: *circles (Pintado & Adelman 2003), dots (this work).* As usual, the script [X/H] means $log(X/H)_* - log(X/H)_\odot$; the solar abundances are adapted from Grevesse and Sauval (1998).

3 Conclusions

Our abundance analysis yields a pronounced underabundance of Sc and slight underabundances in C, O, Mg, Si and Ca, mild overabundances of the iron-peak elements and large overabundances of the rare-earth elements. All these new abundance determinations confirm the Am status for 68 Tauri. Thanks to the improvement of atomic data, we have enlarged and improved the elemental abundances of 68 Tauri. The new results on the rare-earth group confirm the Am peculiarity of 68 Tauri. The inclusion of the hyperfine structure of the various isotopes of Ba II leads us to decrease the baryum abundance in 68 Tauri. We stress the importance of taking into account the Hyperfine Structure for all isotopes when available in order to derive accurate abundances.

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