# Search for the $^3$He isotope in the atmospheres of HgMn stars

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## 1. Introduction

For the last twenty years it has been established that the $^3$He isotope is present in the spectra of some peculiar stars, which ocupy a narrow range of effective temperatures. An explanation of these results has been attempted in the framework of the diffusion theory (Michaud et al., 1979). On the other hand, the He I lines used for detecting the $^3$He isotope are burdened with blends, which were unknown at the times of the first studies of $^3$He; therefore, careful reanalysis of the $^3$He isotope is needed before making comparisons with the predictions of helium diffusion .

Three of the stars studied here were checked for the presence of $^3$He by Hartoog & Cowley(1979). They searched for $^3$He on photographic spectra by accurately measuring the isotopic shifts of the He I lines. We performed our work as a continuation of a systematic study of the $^3$He isotope in stellar atmospheres, on the basis of high dispersion, high S/N spectra and using the spectral synthesis technique.

## 2. Observations and results

We carried out observations of HD 58661, HD 172044, HD 185330 and HD 186122 (46 Aql) at the Bulgarian National Astronomical Observatory (BNAO) - Rozhen with the CCD camera attached to the Coudé-spectrograph of the 2m telescope. The CCD spectra were centred on three regions around He I lines ($\lambda\lambda$ 4921, 5875, 6678). The spectral resolving power was about 30 000 and the signal-to-noise ratio (S/N) was 150-200.

Atmosphere parameters $T_{\rm eff}$ and $\log g$ were derived using photometric data in Geneva and Strömgren photometric systems. The microturbulences were taken from Smith & Dworetsky(1993). For HD 185330 we assumed $\xi$=0 km s$^{-1}$.

We used the spectral synthesis technique for checking the presence of the $^3$He isotope (SYNTH code written by Piskunov 1992). The parameters of the atomic lines were extracted from the VALD database (Piskunov et al. 1995). In order to determine accurately the abundance of the $^3$He isotope, we had to take into

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**Table 1.** Model atmosphere parameters, helium abundances and isotopic ratios

| star | $T_{eff}$ [K] | $\log g$ [dex cm s$^{-2}$] | $\xi$ [km/s] | $v_e \sin i$ [km/s] | log He/H | $^3$He/$^4$He |
|---|---|---|---|---|---|---|
| HD 58661 | 13 500 | 4.0 | 0.5 | 30 | -1.70 | 0.56 |
| HD 172044 | 14 500 | 3.9 | 1.5 | 34 | -1.85 | |
| HD 185330 | 16 500 | 3.7 | 0.0 | 8 | -2.20 | 0.96 |
| 46 Aql | 13 000 | 3.7 | 0.0 | 15 | -2.55 | 0.1 |

account the possible blends. All He I lines used are weak and the contribution of blends could be significant. The He I $\lambda$ 4921.93 Å line is blended only with Fe II $\lambda$ 4922.19 Å, while He I $\lambda$ 6678.15 Å may be blended with Ne I $\lambda$ 6678.28 Å, Si II $\lambda$ 6678.66 Å, Si II $\lambda$ 6678.73 Å, Fe II $\lambda$ 6678.84 Å.

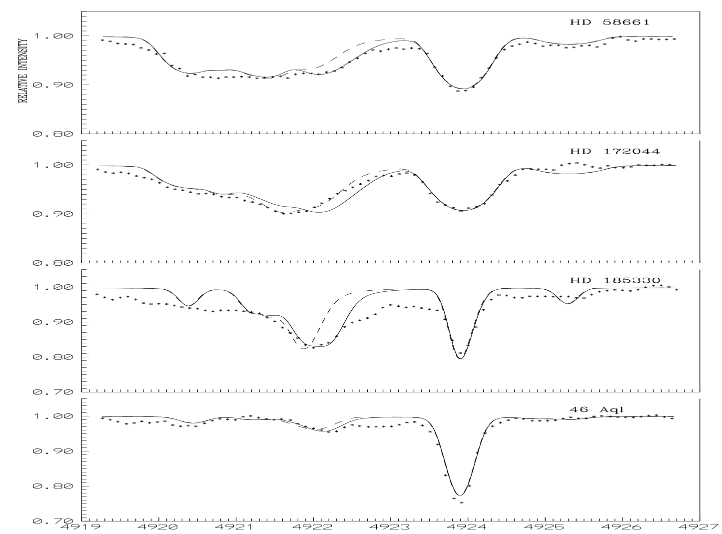


**Figure 1.** Comparison of the observed (asteriks) and synthesized with the presence of $^3$He isotope (full line) and without it (dashed line) spectra for the region of $\lambda$ 4921

<u>HD 58661.</u> We detected the presence of the $^3$He isotope in the atmosphere of HD 58661. He I $\lambda$ 4921 is blended with Fe II $\lambda$ 4922.19 Å, which position nearly coincides with those of $^3$He I $\lambda$ 4922.26 Å. Because of the underabundance of Fe, this line could not produce a significant amount of absorption (Figs 1, 2).

<u>HD 172044.</u> The line profiles of He I $\lambda$ 4921 and $\lambda$ 6678 were synthesized successfully without any contribution of $^3$He. Our results confirmed the conclusion of Hartoog & Cowley(1979) that HD 172044 is not a $^3$He star.

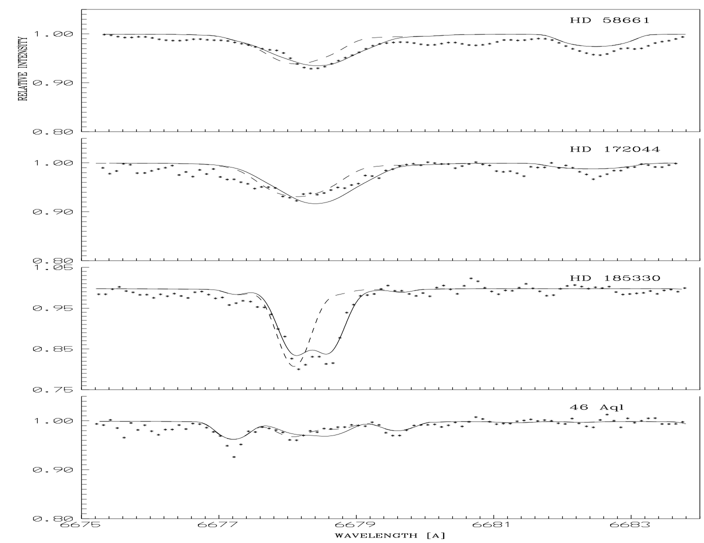


**Figure 2.** The same as in Fig.1 but for the region of λ 6678

HD 185330. The presence of the $^3$He isotope in the atmosphere of HD 185330 was confirmed as it was reported for the first time by Hartoog & Cowley(1979). The isotope ratio $^3$He/$^4$He=0.96 derived by us does not differ very much from that given by Hartoog & Cowley, which was $^3$He/$^4$He= 1.3.

46 Aql. The $^3$He isotope was detected in the profile of λ 4921 (Fig. 1) based on three spectra. But λ 6678 was synthesized more successfully without any presence of $^3$He isotope based on one spectrum (Fig. 2). The reason for this discrepancy may be found in the weakness of this line; moreover the helium abundance is extremely low: log(He/H)=-2.55. 46 Aql is a possible $^3$He star.

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