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Detailed photospheric abundances of 28 Peg and HD 202240☆

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HIGHLIGHTS

- Detailed spectral analysis is performed on two chemically normal A-type stars.
- The spectra were obtained at Tubitak National Observatory.
- The atmospheric parameters are determined using spectroscopic methods based on LTE model atmospheres.
- The evolutionary status of the stars are estimated.
- The abundances of both stars were compared with members in open clusters.

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ABSTRACT

The atmospheric parameters and chemical abundances of two neglected A-type stars, 28 Peg and HD 202240, were derived using high resolution spectra obtained at the TÜBİTAK National Observatory. We determined the photospheric abundances of 11 elements for 28 Peg and 20 for HD 202240, using equivalent-width measurement and spectral synthesis methods. Their abundance patterns are in good agreement with those of chemically normal A-type stars having similar atmospheric parameters. We pinpoint the position of these stars on the H-R diagram and estimate their masses and ages as; 2.60 ± 0.10 $M_\odot$ and 650 ± 50 Myr for 28 Peg and 4.50 ± 0.09 $M_\odot$ and 150 ± 10 Myr for HD 202240. To compare our abundance determinations with those of stars having similar ages and atmospheric parameters, we select members of open clusters. We notice that our target stars exhibit similar abundance patterns with these members.

1. Introduction

The precise elemental abundances of normal A-type stars provide information about chemical structure of their photospheres and give an idea of their evolutionary status.

The spectral type of 28 Peg (HD 210516, HR 8459, BD+20 5093) was classified as A3III by Cowley et al. (1969). Even though the star has different radial velocity values (7.8 km s^{-1} (Shajn and Albitzky, 1932), and 10.46, 11.38, 12.16 km s^{-1} (Kuenzli and North, 1998)) throughout the literature, Kuenzli and North (1998) noted that the star is non-variable. Abt and Morrell (1995) derived the $v\sin i$ of 28 Peg, using Mg II 4481 Å line, as 40 km s^{-1}. Royer et al. (2002) also reported its $v\sin i$ to be 49 km s^{-1}.

HD 202240 (HR 8120, BD+36 4470) was classified as F0III (Cowley et al., 1969). Its radial velocity values were given as −13.8 km s^{-1} (Harper, 1937) and −12.8 km s^{-1} (Wilson, 1953). Abt and Morrell (1995) calculated the $v\sin i$ of HD 202240, using Mg II 4481 Å line, as 18 km s^{-1}. The rotational velocity of HD 202240 was also given by Royer et al. (2002) as 26 km s^{-1}. The first chemical abundance analysis of HD 202240 was carried out by Kurtz (1976), who used spectra having a dispersion of 8–10 Å mm^{-1}.

The aim of this paper is to perform abundance analysis of two normal A-type stars. The observations are described briefly in Section 2. The details of atmospheric parameters and abundance analysis are given in Section 3 and Section 4. Finally, we present the results and conclusion in Section 5.

2. Observation

The high resolution ($R \sim 40,000$) spectra of 28 Peg and HD 202240 were obtained using the Coudé Echelle Spectrograph attached to the 1.5 m Russian–Turkish Telescope at TÜBİTAK National Observatory. These spectra covering a wavelength range of 3900–7900 Å, were acquired on the 14th of September and the 23rd of December 2010. The observation run and data reduction procedures follow the same

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Table 1
The properties and observation log of 28 Peg and HD 202240.

Star name	RA [h m s]	DEC [° ′ ″]	HJD [day]	Exposure time [s]	v_{helio} [kms^{-1}]	$v\sin i$ [kms^{-1}]	S/N [@5000 Å]
28 Peg	22 10 30.18	+20 58 40.74	2455464.4633	2 × 4500	12.26 ± 2.6	52	260
HD 202240	21 13 26.42	+36 37 59.75	2455555.1703	2 × 4500	−12.4 ± 0.6	17	300

Table 2
The atmospheric parameters of the analyzed stars.

Star name	Photometric		Spectroscopic			
	T_{eff} [K]	log g [dex]	T_{eff} [K]	log g [dex]	ξ [kms^{-1}]	[Fe/H] [dex]
28 Peg	8122	3.38	8300	3.30	3.00	−0.12
HD 202240	8092	2.78	8000	2.50	3.00	0.18

routine as described in Çalışkan et al. (2015). We co-added the two consecutive spectra of each star to achieve a higher signal-to-noise ratio (S/N). The properties and observation log of each target star are listed in Table 1.

3. Atmospheric parameters

We estimated the initial atmospheric parameters (T_{eff} and log g) of 28 Peg from the Strömgren photometric data (Hauck and Mermilliod, 1998) using the calibration of Napiwotzki et al. (1993). As for the initial T_{eff} and log g of HD 202240, we used the Geneva colours of Rufener (1976) with the calibration of Kuenzli et al. (1997). The adopted parameters are listed in Table 2. Using these parameters, we computed the initial model atmospheres for each star with ATLAS9 code (Kurucz, 1993a; 2005; Sbordone et al., 2004).

These photometrically specified atmospheric parameters (T_{eff}, log g) were then derived more precisely using traditional spectroscopic methods (T_{eff} from the excitation equilibrium of Fe I lines and log g from ionisation equilibrium of Fe I/II). We also checked these parameters by generating synthetic H_β profiles with SYNTHE code (Kurucz, 1993b; 2005) and fitting these profiles to the observed ones, as presented in Fig. 1. For the microturbulent velocities (ξ), we used the balance between equivalent-widths (hereafter EQWs) and abundances derived from individual Fe I lines. The atmospheric parameters for each star are given in Table 2.

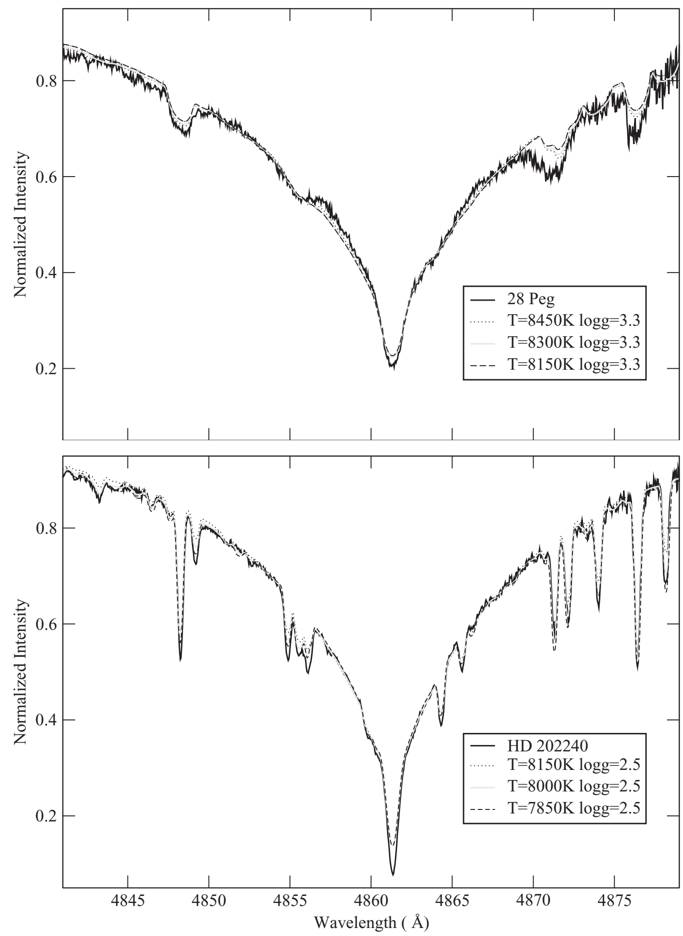

Fig. 1. Comparison between the observed and synthetic H_β line profiles of 28 Peg (top fig.) and HD 202240 (bottom fig.). The gray lines show the determined atmospheric parameters from this study, the dotted (+150 K) and dashed (−150 K) lines represent the uncertainties in T_{eff}.

4. Abundance analysis

In order to identify the absorption lines in the spectra, we used two atomic databases; Kurucz line database[1] and Vienna Atomic Line Database (VALD, Piskunov et al., 1995; Kupka et al., 1999; Ryabchikova et al., 1999). The EQWs were measured by fitting gaussian profiles to the observed lines. The WIDTH9 code (Kurucz, 2005; Sbordone et al., 2004), based on ATLAS9 model atmospheres assuming line formation in LTE, was used to determine the abundances of each atomic species. EQWs greater than 190 mÅ were not used in any calculations.

The atomic data for lines affected by hyperfine splitting (HFS) were also taken from Kurucz line database. We then determined the abundances from these lines using synthetic spectra produced by SYNTHE code. The synthetic spectra were convolved with the broadening effects due to the instrumental profile and the macroturbulent velocity. We justified the abundance value for each line until the observed and synthetic line profiles matched.

All derived elemental abundances within their uncertainties for each star are given in Table 3. The total errors were calculated from the propogation of uncertainties in T_{eff}, log g, and ξ as given in Çalışkan et al. (2015).

5. Results and conclusion

This is the first chemical abundance analysis of 28 Peg and HD 202240 based on high resolution spectra. The results indicate that the ions of both stars are slightly overabundant relative to the Sun, with a few exceptions that can be seen in Fig. 2. These exceptions are; the [Si/H] and [Sr/H] abundances which are as high as 0.38 in the atmosphere of 28 Peg and the abundances of the heavy elements [Ba/H], [La/H], [Zr/H], and [Ce/H] that are about 0.4 for HD 202240. These are typical patterns for normal A-type stars as indicated in Adelman and Unsuree (2007).

The parameters in Table 4 were used to derive the luminosity of each star. We then plotted them on the H-R diagram as given in Fig. 3, along with the evolutionary tracks with solar metallicity from Salasnich et al. (2000), as black solid lines for masses of 2.2 $M_\odot$, 3.0 $M_\odot$, 4.0 $M_\odot$, and 5.0 $M_\odot$. Taking into account these evolutionary

[1] http://kurucz.harvard.edu.tr.