Spectral changes in the stable shell star 1 Del

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Abstract. We present results of our long-term observations of a stable shell star 1 Del. We found small scale variations in the profiles of hydrogen Hα and Hβ lines.
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Introduction

The star 1 Del (HD 195325, HR 7836, WDS J20303+1054AB, ADS 13920, HIP 101160) was first mentioned as a Be star by Merrill & Burwell (1949) in their Supplement to the Mount Wilson Catalogue of stars of classes B and A with bright hydrogen lines. Already in the first research paper devoted to shell stars (Merrill, (1953)), 1 Del is regarded as a shell star. Merrill specially noted that the shell spectrum features of the star are stable "for a long term of years, perhaps indefinitely". Thus he opposed 1 Del as well as other 2 shell stars (HD 54858 and HD 193182) to the majority of other shell stars that are known to be variable.

1. 1 Del as visual multiple system

1 Del was established as triple visual system. It was reported that this star is a hardly observable visual binary by Burnham (1873a). His measurements were published in Burnham (1873b) and there 1 Del was designated as a star No.63. Later he found a faint more distant companion to this binary (star No.297) Burnham (1874).

Speckle interferometric measurements of 1 Del yield the separation of A and B components $0.919'' \pm 0.007''$(Scardia et al., (2006)). Other results from speckle interferometry were reported by Hartkopf et al. (2000), Douglass et al. (2000) and Docobo et al. (2004). All these measurements of separation ρ and positional angle θ for the visual components A and B of 1 Del practically coincided with mean value of ρ=0.914″and θ=349.4°.

Douglass et al. (2000) estimated V magnitudes of the A and B components as 6.0 and 7.9, respectively. Data about the components of the visual system, their coordinates and magnitudes are summarized in Table 1. Most of the data were extracted using the facilities of the International Virtual Observatory project, the other were taken from the quoted references.

Micrometric measurements of 1 Del were reported by Prêtre (1951), van den Bos (1957) and Alzner (1998). They are in good agreement with the speckle interferometric measurements in the limits of achieved accuracy. They also prove that the separation ρ and positional angle θ are constant for a period of more than 50 years.

Table 1. Components of 1 Del visual system

Component	star name	V [mag.]	distance from A ["]	RA(2000)	DE(2000)
A	TYC 1091-1875-1	6.0	0	20 30 17.96	+10 53 45.32
B	TYC 1091-1875-2	7.9	0.914	20 30 17.95	+10 53 46.22
C	BD+10 4303C	14.1	17.26	20 30 17.57	+10 54 01.60

As can be seen from Table 1 (see also Fig.1), the visual component C found by Burnham is relatively distant from the A and B components and with expected little contribution in the visual region.

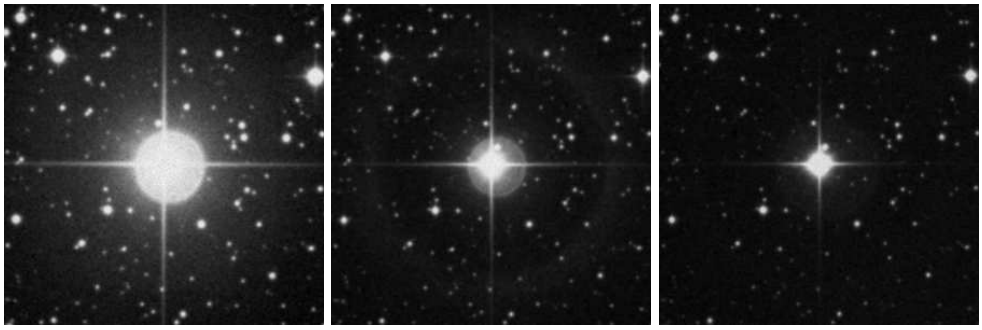

Fig. 1. The field image of 1 Del in blue (upper panel), red (left panel), and infrared (right panel). Images are taken from the STScI Digitized Sky Survey.

2.Previous indications of variability

1 Del has been considered to be a stable shell star. Shell spectrum of 1 Del was first detected on 9-th of August, 1919 at the Dominion Astrophysical Observatory (see Bidelman (1988)).

Gulliver (1981) inspected its spectrograms obtained at Mount Wilson, David Dunlop, and Dominion Astrophysical Observatories, and did not find any changes in the spectra of 1 Del between 1953 and 1980. However, Slettebak (1982) reports Hα as an absorption line with rather weak emission shoulders on a scan from 11-th of April, 1981 (using the 1.8-m telescope of the Lowell Observatory). Gray & Marlborough (1974) present similar line profile of this line on 26/27-th of June (no year is given) in their Table 3 (observed with the 1.2-m telescope of the University of Western Ontario). Jones et al. (2011) found variability in the equivalent width of Hα in 1 Del but in lesser scale compared with the majority of Be and shell stars. However no details about variations of the structure of the emission lines were reported up to the present moment.

Possible photometric variability of 1 Del was indicated by Alvarez & Schuster (1981).

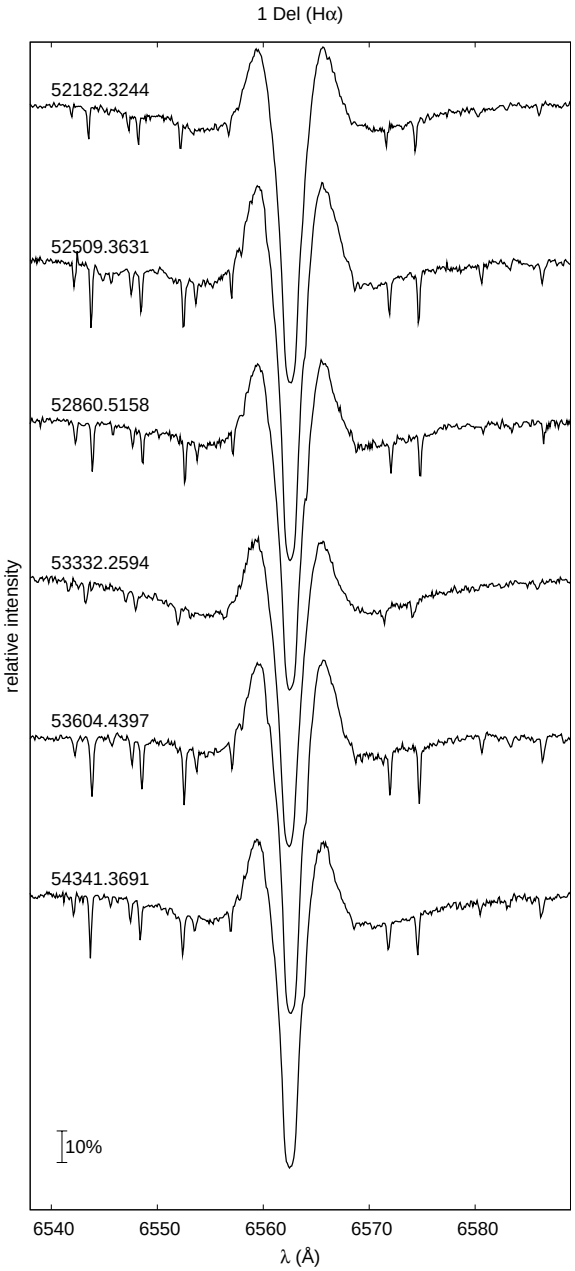

Fig. 2. Selected Hα profiles of 1 Del illustrate the observed small scale variability.

3. Observations

All observations were done using the coudé-spectrographs of the Rozhen 2-m telescope and the Perek 2-m telescope at the Ondřejov Observatory in the frames of a coordinated observational program. Details of the observing conditions and spectrographs configurations could be found in, e.g., Iliev et al. (2012).

4. Spectral variability of 1 Del

As can be seen from Fig. 2, our observations prove that the intensity of emission in the Hα spectral line varies in the range 1.14 – 1.27 of the continuum level. During the period of our observations emission was strongest in 2002 and it was weakest in 2004 seasons.

The ratio of the violet-peak intensity to the red-peak intensity (V/R) changed from less than 1 (red component stronger) to more than 1 (red component weaker) and vice versa. In August 2002 and in August 2005 the red component was stronger with V/R = 0.9903 and 0.9909, respectively, while in November 2004 blue component was stronger with V/R = 1.013.

The depth of the central absorption core of Hα also varied during the period of our observations. It was strongest in August 2002 reaching 0.06 in a rectified to 1 continuum level scale. The weakest absorption core strength was observed in November 2004 at the level of about 0.2. It should be noted that stronger overall emission in the Hα profile of 1 Del coincides with greater absorption core depth and vice versa. On the average, all measured variations exceed about 5 times the estimated accuracy of a single measurement. Peak separation of V and R components of Hα line did not show any significant changes during the period. This could be regarded as evidence of stability of the dimensions of the circumstellar shell around 1 Del. More detailed analysis of the spectral variability of 1 Del will be presented in forthcoming papers.

From Fig. 3 we can see some small scale variations observed in the Hβ line. Although the emission in the Hβ line was generally very weak compared with that in the Hα line, the blue component was stronger than the red one. During our period of observations the Hβ line has shown minor changes, the emission being fainter in 2007. The central absorption component showed some variations, it was strongest in 2001. It should be noted that on some of the frames of Hβ region wide photospheric spectral lines could be seen, as in the frame from 2002 observing season.

Conclusions

We found small changes in the spectral line profiles of 1 Del. During the period covered by our observations small variations in emission components strength as well as in the absorption core were detected. Because of this we can conclude that 1 Del is in fact small scale spectral variable star.

For another star from the group of stable shell stars established by Gulliver (1981), namely HD 179343, similar small scale spectral variations were already reported by Iliev & Kubat (2010). However, the question of the origin of observed variations is still opened as well as the question about the spectral

characteristics and contribution of each of the visual components. Further high S/N spectral observations are necessary.

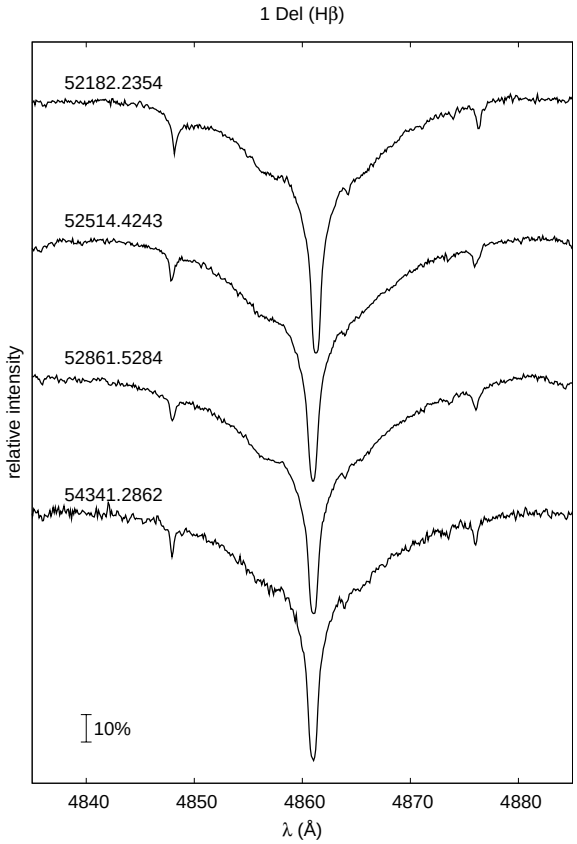

Fig. 3. Set of selected H β profiles of 1 Del

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