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Variation of the Si II features in the chemically peculiar star – HD 115735

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Abstract. The chemically peculiar star HD 115735 (= HR 5023 = 21 CVn) was observed with the 2.34 meter Vainu Bappu Telescope at Kavalur during the period of January 1999 to April 2000. A total of 47 spectrograms were obtained in the wavelength region of 3900 Å to 4400 Å at a resolution of 0.65 Å per pixel. The equivalent widths of Si II features at 4077, 4128, 4131 Å have been found to be varying with a period of 0.88 ± 0.02 day, the amplitudes being about 0.1Å. This is the first report of spectroscopic variations of these features in this star.

Keywords : Ap Stars, Spectral features, Equivalent width, Variation Period

1. Introduction

The study of spectral feature variations in the Ap stars (also known as chemically peculiar or CP stars) derives a greater importance in view of the concept of heterogeneous surface of these stars with concentration of different elements in various patches on the stellar surface.

Based on such a point of view, the ambiguously classified A0VSi star HD 115735 (= HR 5023 = 21 Cvn; R.A.2000 = 13h 18m 14.5s; Dec 2000 = $+49^0\ 40'\ 55''$), which was recently found to be a variable (Zverko, 1984), was chosen and spectroscopic observations were obtained. In this paper, we present the first results of the spectroscopic variations of the features of Si II in this star.

2. Observations

The chemically peculiar star HD 115735 was spectroscopically observed on 12 nights using the OMR spectrograph, mounted at the Cassegrain focus of the 2.34 meter Vainu Bappu Telescope at Kavalur during the period January 1999 to April 2000. The wavelength region of 3900 Åto 4400 Å was covered with a 1200 lines / mm grating in the 2^{nd} order, which gives a resolution of 0.65 Å per pixel on a 1K x 1K CCD. A total of 47 spectrograms were obtained and the IRAF packages were employed for the reduction and analysis of the data. From these spectrograms, the equivalent widths of three spectral features of Si II (4077, 4128 and 4131 Å) were measured by using the Gaussian fit package available on IRAF.

These measurements of the equivalent widths along with their corresponding Julian Dates were subjected to period determination algorithm (Raveendran, 2002). All the three features were found to be varying with a period of 0.88 ± 0.02 day, with amplitudes of the order of 0.10Åor more as shown in Fig.1. The initial epoch has been taken as JD 2451208.1264 and the values of equivalent widths are listed in Table 1, 2 and 3.

3. Discussion

In 1969, Cowley et.al. classified this star as A0V- Si type and Bertaud & Floquet (1974) catalogued it among the Ap stars with an uncertain classification. The effective magnetic field of this star has recently been found to be of the order of 10G (Bychkov et al., 2003) adding certain amount of credence to its Ap star status. It may be noted here that though earlier works have shown this star to be exhibiting no variability up to amplitude of 0.008 mag in the k-line of Calcium (Henry, 1969; Henry and Hesser, 1971), Zverko (1984) obtained a photometric period of this star as 0.767 day with a variability amplitude of 0.04. However, it is indicated as an uncertain value in the list given by North (1998).

In the present study, it is evident that the features at Si II (4077) and Si II (4128) are slightly out of phase with each other, while the feature at Si II (4131) is almost 180 degrees out of phase with respect to the other two. This variation could be either due to rotation of the star or due to diffusion of the elements on the stellar surface. If we assume that the anti-correlation of the spectral features to be due to stellar rotation, then it would suggest that each Si patch on the stellar surface would give rise to only one of the spectral features at a given time. This indicates that the patch responsible for 4131Å would exist on a diametrically opposite side to the patches giving rise to the other two features, which seems to be a highly improbable situation. On the other hand, if diffusion of Si on the stellar surface is considered as the cause for the observed variations, then several other factors like surface distribution of magnetic field, transition probability and temperature gradients etc. will have to be taken into account, the detailed treatment of which is beyond the scope of the present work.

Table 1. Equivalent width of the Si II(4131) feature corresponding to the Julian Day (J.D) and phase.

	4131 Å				4131 Å	
Phase	Eq. Wdt.	J.D		Phase	Eq. Wdt.	J.D
0	0.197	2451208.1264		1	0.197	2451208.1562
0.021	0.193	2451208.1743		1.021	0.193	2451208.1743
0.039	0.103	2451271.9785		1.039	0.203	2451271.9785
0.06	0.196	2451271.9965		1.06	0.196	2451271.9965
0.077	0.199	2451272.0011		1.077	0.199	2451272.0011
0.169	0.178	2451241.0583		1.169	0.178	2451241.0583
0.181	0.163	2451209.1743		1.181	0.163	2451209.1743
0.206	0.165	2451241.0903		1.206	0.165	2451241.0903
0.21	0.157	2451209.1993		1.21	0.157	2451209.1993
0.239	0.156	2451241.1188		1.239	0.156	2451241.1188
0.24	0.163	2451209.2250		1.24	0.163	2451209.2250
0.269	0.144	2451241.1444		1.269	0.144	2451241.1444
0.328	0.113	2451642.8931		1.328	0.113	2451642.8931
0.338	0.14	2451210.1715		1.338	0.14	2451210.1715
0.361	0.114	2451642.9215		1.361	0.114	2451642.9215
0.367	0.098	2451210.1965		1.367	0.098	2451210.1965
0.393	0.111	2451210.2194		1.393	0.111	2451210.2194
0.42	0.101	2451210.2424		1.42	0.101	2451210.2424
0.429	0.121	2451642.9799		1.429	0.121	2451642.9799
0.465	0.12	2451643.0111		1.465	0.12	2451643.0111
0.491	0.102	2451643.0333		1.491	0.102	2451643.0333
0.519	0.082	2451643.0576		1.519	0.082	2451643.0576
0.546	0.081	2451643.0806				
0.604	0.047	2451643.1306				
0.63	0.082	2451643.1535				
0.668	0.118	2451631.9799				
0.669	0.113	2451643.1868				
0.696	0.106	2451632.0035				
0.728	0.098	2451632.0313				
0.754	0.127	2451632.0535				
0.786	0.133	2451632.0813				
0.818	0.107	2451632.1090				
0.833	0.121	2451213.1840				
0.861	0.139	2451213.2083				
0.889	0.12	2451213.2326				
0.899	0.108	2451632.1792				
0.915	0.122	2451213.2549				
0.929	0.137	2451632.2049				

Table 2. Equivalent width of the Si II(4128) feature corresponding to the Julian Day (J.D) and phase.

	4128Å				4128Å	
Phase	Eq.Wdt.	J.D		Phase	Eq.Wdt.	J.D
0	0.247	2451208.1264		1	0.247	2451208.1264
0.017	0.243	2451643.1868		1.017	0.243	2451643.1868
0.036	0.273	2451208.1562		1.036	0.273	2451208.1562
0.057	0.272	2451213.1840		1.057	0.272	2451213.1840
0.057	0.264	2451208.1743		1.057	0.264	2451208.1743
0.086	0.274	2451213.2083		1.086	0.274	2451213.2083
0.115	0.262	2451213.2326		1.115	0.262	2451213.2326
0.142	0.267	2451213.2549		1.142	0.267	2451213.2549
0.285	0.299	2451209.1993		1.285	0.299	2451209.1993
0.316	0.303	2451209.2250		1.316	0.303	2451209.2250
0.417	0.336	2451327.8826		1.417	0.336	2451327.8826
0.438	0.339	2451241.0583		1.438	0.339	2451241.0583
0.445	0.338	2451327.9062		1.445	0.338	2451327.9062
0.449	0.317	2451210.1715		1.449	0.317	2451210.1715
0.468	0.335	2451271.9785		1.468	0.335	2451271.9785
0.474	0.307	2451327.9299		1.474	0.307	2451327.9299
0.477	0.316	2451241.0903		1.477	0.316	2451241.0903
0.489	0.319	2451271.9965		1.489	0.319	2451271.9965
0.507	0.302	2451210.2194		1.507	0.302	2451210.2194
0.507	0.339	2451272.0111				
0.511	0.336	2451241.1188				
0.534	0.315	2451210.2424				
0.542	0.314	2451241.1444				
0.624	0.332	2451632.0035				
0.658	0.311	2451632.0313				
0.665	0.291	2451642.8931				
0.699	0.281	2451642.9215				
0.718	0.276	2451632.0813				
0.729	0.3	2451328.9785				
0.751	0.271	2451632.1090				
0.757	0.29	2451329.0014				
0.807	0.267	2451643.0111				
0.809	0.252	2451329.0451				
0.833	0.254	2451643.0333				
0.835	0.242	2451632.1792				
0.862	0.231	2451643.0576				
0.866	0.242	2451632.2049				
0.89	0.244	2451643.0806				
0.95	0.236	2451643.1306				
0.977	0.263	2451643.1535				

Table 3. Equivalent width of the Si II(4077) feature corresponding to the Julian Day (J.D) and phase.

	4077 Å				4077 Å	
Phase	Eq. Wdt.	J.D		Phase	Eq. Wdt.	J.D
0	0.345	2451208.1264		1	0.345	2451208.1264
0.033	0.346	2451208.1562		1.033	0.346	2451208.1562
0.044	0.348	2451327.9062		1.044	0.348	2451327.9062
0.054	0.321	2451208.1743		1.054	0.321	2451208.1743
0.201	0.356	2451209.1993		1.201	0.356	2451209.1993
0.229	0.358	2451209.2250		1.229	0.358	2451209.2250
0.289	0.443	2451210.1715		1.289	0.443	2451210.1715
0.244	0.381	2451328.9785		1.244	0.381	2451328.9785
0.27	0.423	2451329.0014		1.27	0.423	2451329.0014
0.317	0.443	2451210.1965		1.317	0.443	2451210.1965
0.329	0.442	2451631.9799		1.329	0.442	2451631.9799
0.342	0.49	2451210.2194		1.342	0.49	2451210.2194
0.355	0.411	2451632.0035		1.355	0.411	2451632.0035
0.368	0.454	2451210.2424		1.368	0.454	2451210.2424
0.387	0.51	2451632.0313		1.387	0.51	2451632.0313
0.411	0.472	2451632.0535		1.411	0.472	2451632.0535
0.456	0.502	2451271.9785		1.456	0.502	2451271.9785
0.493	0.524	2451272.0111		1.493	0.524	2451272.0111
0.574	0.523	2451647.9215		1.574	0.523	2451647.9215
0.66	0.495	2451213.1840				
0.674	0.468	2451643.0111				
0.687	0.499	2451213.2083				
0.714	0.494	2451213.2326				
0.726	0.487	2451643.0576				
0.739	0.457	2451213.2549				
0.752	0.48	2451643.0806				
0.854	0.49	2451241.0583				
0.871	0.424	2451643.1868				

4. Conclusion

The high-resolution spectroscopy of the chemically peculiar A0V-Si star, HD 115735, has revealed an additional characteristic showing periodic spectral feature variations. It is seen in this work that the features at Si II (4077) and Si II (4128) are slightly out of phase with each other, while the feature at Si II (4131) is almost 180 degrees out of phase with respect to the other two. This is the first report of such a variation in this star. This variation of the spectral features with a period of 0.88 day is very unlikely to be

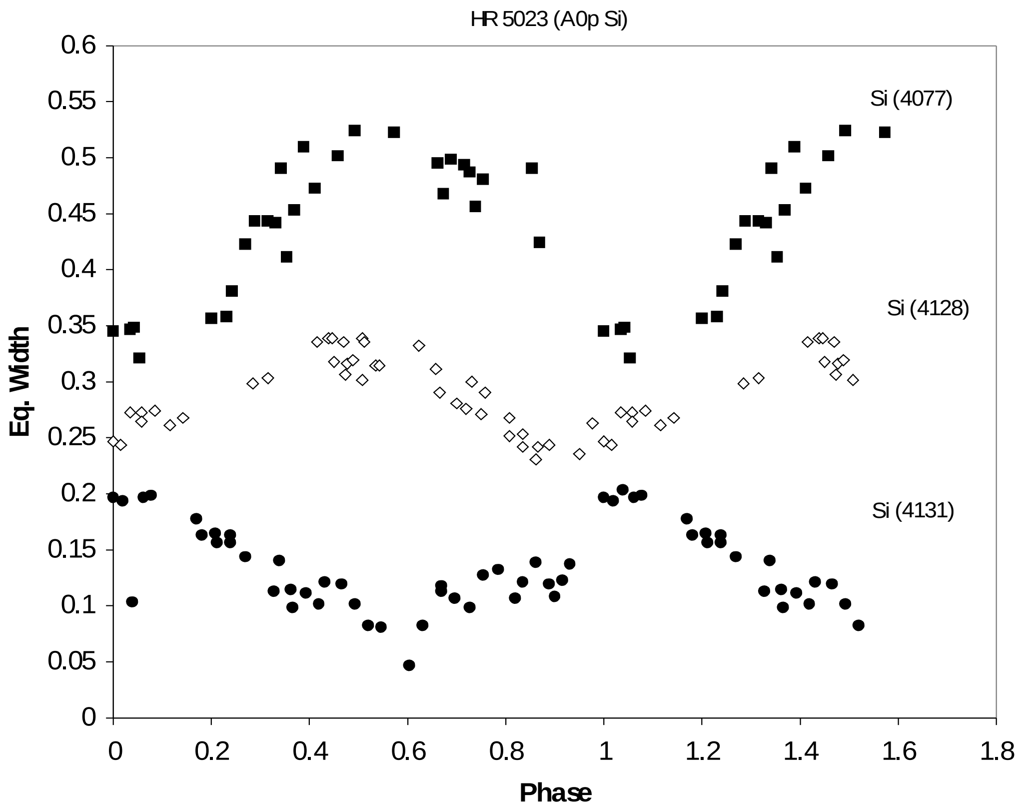

Figure 1. Variations in the spectral lines of Si (4077), Si(4128) and Si(4131) in the Ap star HD 115735 (= HR 5023). The phase is based on the period of 0.88 day and the scale for the equivalent width (in Angstroms) is arbitrary.

due to rotation of the star, but could be caused by the diffusion of the elements on the stellar surface. Further, more accurate measurements of the rotational velocity and the magnetic field of this star would lead to a better understanding of the cause of these variations.

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