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International Journal of Current Research
Vol. 7, Issue, 03, pp.13831-13835, March, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

REVIEW ARTICLE

ON ATMOSPHERIC PARAMETERS AND CHEMICAL COMPOSITION OF GIANT HD 206731 (G8II)

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ARTICLE INFO

Article History:
Received 14th December, 2014
Received in revised form
06th January, 2015
Accepted 18th February, 2015
Published online 31st March, 2015

Key words:

Giant stars,
Fundamental parameters,
Evolutionary parameters,
Chemical composition.

ABSTRACT

By comparing observed and model characteristics of atmosphere, we determined fundamental and evolutionary parameters and chemical composition of giant HD 206731. Spectral class of stars G8 and luminosity class II. Spectral materials are obtained by CCD camera mounted on Cassegrain focus at Shamakha Astrophysical Observatory of NAS of Azerbaijan. It is found that T_{eff}=5000±200 K, logg = 2.1±0.2, $M = 5.37M_{\odot}$, $R = 34R_{\odot}$, $L = 660L_{\odot}$. By selected non-blended lines of Fe I, we determined the microturbulence velocity in stellar atmosphere which was found to be ξ_t=4km/h. The content of some chemical elements in the atmosphere of the studied star is determined. The results are compared with solar ones. Spectra processing is performed by program DECH 20. Equivalent widths of lines are averaged by the results of 4th series of observations. The error in determining equivalent widths makes about 5%.

INTRODUCTION

For construction and analysis of stellar atmosphere models effective temperature T_{eff} and surface gravity g are required. By these parameters we can determine evolutionary parameters of the star – radius R, luminosity L, mass M, age t and chemical composition of stellar atmosphere. In the present work fundamental (T_{eff}, lgg) and evolutionary parameters (M, R, L, t) of giant star HD 206731 (G8II) are determined by comparing observed and theoretical model values of spectral and photometric quantities. Further the composition of series of chemical elements in stellar atmosphere is determined by model method. The obtained data are compared with the Sun. Spectra processing is conducted by program DECH 20. Equivalent widths of lines are averaged by results of 4th series of observations. The error in determining equivalent widths makes about 5%.

Observational materials

Observational materials were obtained in 2009 with the help of CCD mounted on Cassegrain focus in 2-meter telescope at Shamakha Astrophysical Observatory. Spectral resolution is found to be about 0.3Å, but linear dispersion is 10Å/mm. Excitation potential of the lower level of the used lines varies from ε = 0.02eV to ε = 5.59eV. Spectra processing is conducted by program DECH 20 (Galazutdinov, 1992). Equivalent widths of lines are averaged by results of 4th series of observations. The error in determining equivalent widths makes about 5%. Atomic characteristics and observed equivalent widths of the used spectral lines are given in the Table 1, where in 1, 4, 7 columns we show wavelengths in Å, in 2, 5 and 8 columns excitation potentials of the lower levels are ε eV, and in 3, 6 and 9 columns – equivalent widths of lines are shown in m Å.

Determination of effective temperature and surface gravity

Effective temperature of the star HD 206731 (G8II) and surface gravity are determined by comparing photometric and spectral indexes. As photometric indexes we used the following indexes

$[c_1] = c_1 - 0.2(b-y)$ and $Q = (U-B) - 0.72(B-V)$;

As spectral indexes we used equivalent widths of the first two lines of Balmer series of hydrogen H_α and H_β.

Observed values of photometric and spectral indexes are: (c_1) = 0.2142, Q = 0.04 (Hauck, 1998), $W_{H_\alpha} = 1{,}8\,\AA$, $W_{H_\beta} = 1{,}2\,\AA$.

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Table 1. The main characteristics of the spectral lines

λ, Å	ε,eV	W,mÅ	λ, Å	ε,eV	W, mÅ	λ, Å	ε, eV	W, mÅ
1	2	3	4	5	6	7	8	9
N a l			5953,16	1,88	180	4946,39	3,35	153
5682,62	2,09	193	5965,83	1,87	24	4950,11	3,40	76
5688,22	2,10	243	5978,55	1,87	25	4957,61	2,84	626
6154,23	2,09	38	6126,22	1,06	61	4973,11	3,94	13
Si I			6258,11	1,44	184	4994,13	0,91	207
5665,56	4,90	49	6336,11	1,44	102	5007,28	3,93	258
5690,47	4,91	66	6554,24	1,44	96	5012,07	0,86	236
5793,13	4,91	61	6556,08	1,45	96	5031,90	4,35	143
5948,55	5,06	56	6599,11	0,90	36	5049,82	2,27	114
6142,49	5,59	118	Ti II			5074,76	4,20	112
6145,02	5,59	10	4865,62	1,11	106	5104,21	4,16	111
Ca I			5336,8	1,57	137	5123,72	1,01	336
5260,38	2,51	55	5418,8	1,57	82	5127,68	0,05	250
5512,98	2,92	250	VI			5168,90	0,05	282
5581,97	2,51	125	5727,06	1,08	163	5202,27	4,24	209
5588,76	2,51	164	6039,74	1,06	48	5217,40	3,20	86
5857,55	2,92	194	6081,45	1,05	85	5223,12	3,62	10
6102,73	1,87	377	6216,36	0,27	40	5226,86	3,03	374
6122,23	1,88	197	6224,5	0,29	14	5229,86	3,27	179
6162,18	1,89	298	6256,91	0,27	155	5232,95	2,93	229
6166,44	2,51	36	6285,16	0,27	26	5242,50	3,62	178
6169,04	2,51	162	C r I			5243,80	4,24	141
6169,56	2,51	256	5238,96	2,70	45	5253,48	3,27	132
6471,67	2,51	104	5296,69	0,98	104	5280,36	3,63	190
6499,65	2,51	201	5409,79	1,03	225	5293,97	4,12	72
Sc II			5783,93	3,31	28	5294,60	3,62	20
5526,81	1,76	110	5787,99	3,31	81	5315,07	4,35	76
5552,25	1,45	60	Cr II			5321,11	4,42	57
5640,99	1,49	104	5308,44	4,05	38	5322,05	2,27	14
5684,19	1,50	150	5310,7	4,05	15	5324,18	3,20	244
6245,62	1,50	90	5508,6	4,14	34	5328,04	0,91	732
T i l			Mn I			5364,88	4,43	181
4820,41	1,50	49	5413,68	3,84	18	5379,58	3,68	37
5219,7	0,02	89	6013,5	3,06	122	5393,17	3,23	169
5460,5	0,05	25	6021,8	3,06	105	5429,52	4,17	450
5662,16	2,31	154	Fe I			5441,32	4,29	41
5866,45	1,06	115	4808,16	3,24	58	5445,05	4,37	141
5880,31	1,05	95	4838,52	3,40	119	5476,57	4,09	318
5903,32	1,06	22	4920,51	2,82	318	5481,25	4,09	565
5922,11	1,04	98	4930,33	3,94	169	5487,75	4,12	290

λ, Å	ε,eV	W,mÅ	λ, Å	ε,eV	W,mÅ	λ, Å	ε,eV	W,mÅ
1	2	3	4	5	6	7	8	9
5491,80	4,17	60	6007,96	4,63	82	5316,71	3,21	240
5522,46	4,19	45	6020,17	4,59	152	5325,56	3,21	206
5532,75	3,56	140	6024,07	4,53	143	5414,09	3,21	122
5543,94	4,20	24	6027,06	4,06	102	5991,38	3,14	28
5546,51	4,35	185	6056,01	4,71	106	6147,74	3,87	113
5549,94	3,68	55	6065,49	2,60	188	6149,62	3,87	30
5560,23	4,42	60	6078,50	4,79	150	6247,56	3,87	61
5567,40	2,60	119	6079,02	4,63	90	6432,65	2,88	18
5569,63	3,40	283	6096,67	3,97	79			
5572,84	3,38	323	6157,73	4,06	125			
5576,10	3,42	119	6165,36	4,12	49			
5586,76	3,35	229	6173,34	2,21	140			
5598,31	4,63	253	6180,21	2,72	78			
5602,95	3,42	376	6188,00	3,93	30			
5679,02	4,63	122	6191,56	2,42	364			
5701,55	2,55	229	6200,32	2,60	94			
5705,47	4,28	68	6213,43	2,21	118			
5731,77	4,24	174	6219,29	2,19	213			
5741,86	4,24	38	6240,65	2,21	170			
5752,04	4,53	78	6246,32	3,59	204			
5775,09	4,20	97	6246,33	3,59	246			
5778,48	2,58	50	6252,56	2,39	199			
5793,93	4,20	64	6265,14	2,17	192			

Continue……..

5809,24	3,87	92	6297,80	2,21	105
5827,89	3,27	35	6335,34	2,19	183
5838,42	3,93	120	6355,04	2,83	180
5859,61	4,53	96	6358,69	0,86	164
5862,36	4,53	100	6380,75	4,17	64
5877,77	4,16	47	6400,01	3,59	314
5905,68	4,63	82	6411,66	3,64	172
5914,16	4,59	172	6421,36	2,27	187
5916,25	3,97	138	6421,36	2,27	217
5929,70	4,53	226	6430,86	2,17	247
5930,17	4,63	202	6469,12	2,39	105
5934,65	4,53	159	6574,25	0,99	121
5952,75	3,97	120	6593,88	2,42	125
5976,80	3,93	219	Fe II		
5983,69	4,53	80	4923,92	2,88	317
5987,06	4,77	109	5234,62	3,21	70
6003,03	3,86	110	5264,8	3,22	289

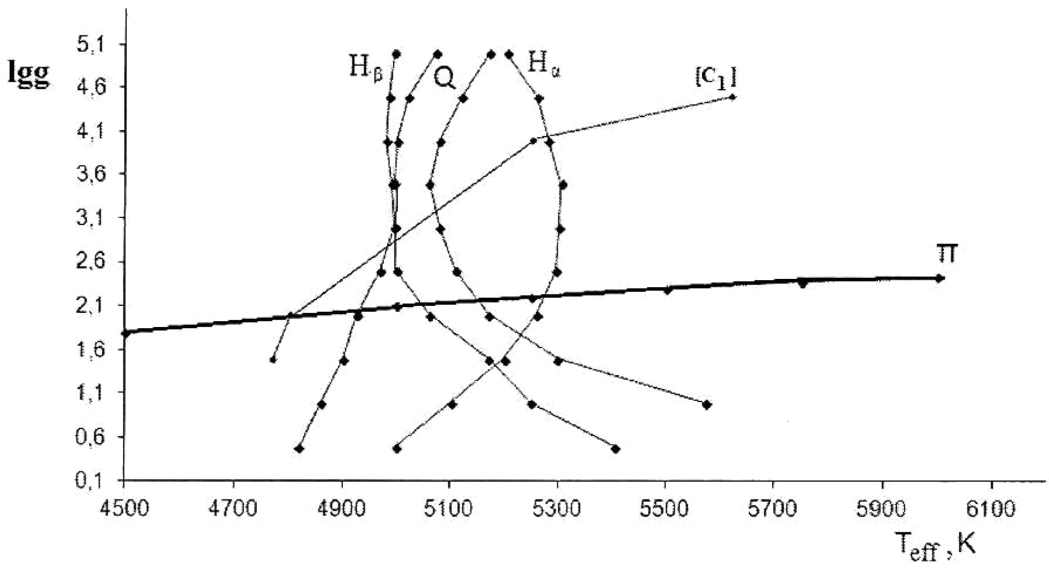

Fig.1. T_{eff} – lgg diagram

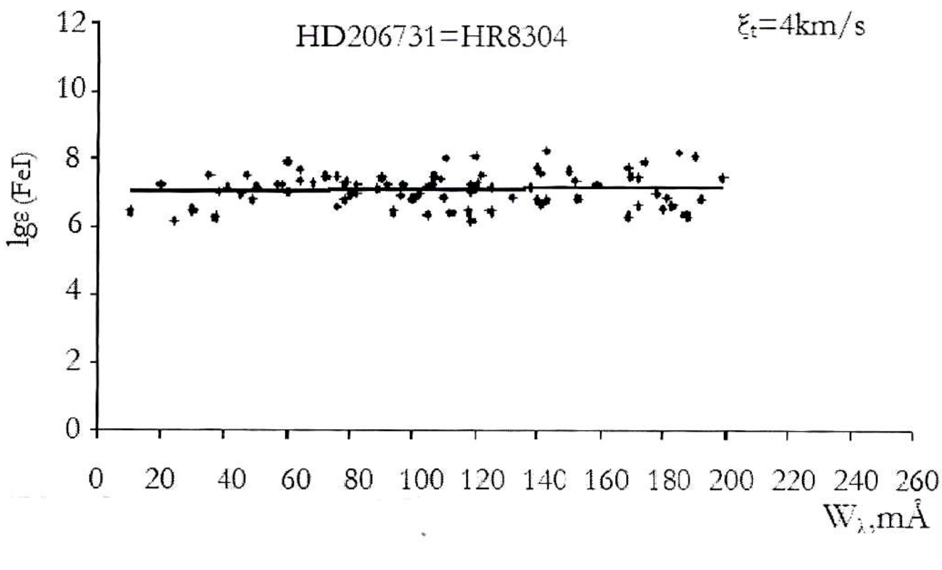

Fig.2. Comparison of the chemical composition of the star HD206731 with the chemical composition of the Sun

Theoretical values of these indexes are borrowed from Kurucz model (Kurucz, 2004). Number of parameters of T_{eff} and lgg are determined by comparing observed and theoretically calculated indexes (c_1), Q, W_{H_α}, W_{H_β}. By using stellar parallax the determination accuracy of T_{eff} and lgg increases significantly. As is known, stellar distance is determined by empiric formula

$$\lg d = -5.25 + 0.5 \lg M/M_\odot + 2 \lg T_{eff} - 0.5 \lg g + 0.2 m_v - 0.2 A_v + 0.2 BC,$$

where $M/M_\odot$ - stellar mass in units of Sun's mass, m_v – visible magnitude of a star, A_v – interstellar absorption and BC – bolometric correction.

We can rewrite the abovementioned expression as

$$\lg g - \lg M/M_\odot - 0.4\,BC - 4 \lg T_{eff} = -10.50 + 2 \lg \pi'' + 0.4\, m_v - 0.4\, A_v$$

where π'' - stellar parallax.

Considering that π'', m_v and A_v (van Leuwen, 2007; Kulikovskiy, 2008) are defined from observations, the right side of this expression is the known constant. Different values of T_{eff} and lgg are given and $M/M_\odot$ (Claret, 2004) are defined by these pairs from evolution curves, but BC is defined from atmospheric model.

Further pair of T_{eff} and lgg values given in Figure T_{eff} – lgg (Fig. 1) are determined from the balance calculated by the left and known right sides of the previous expression

As a result of comparing observed and theoretically calculated indexes (c_1), Q, W_{H_α}, W_{H_β} in view of parallax on the intersection centers, we find T_{eff} = 5000 ±200K, lgg = 2.1 ± 0.2 taken as desired velocity of microturbulent motions in stellar atmosphere. Figure 2 shows dependence of chemical composition on equivalent widths of lines. By this way we find that in atmosphere of HD 206731 (G8II) ξ_t = 4 km/h.

Determination of evolution parameters

By T_{eff} and lgg we can define mass M, radius R and luminosity L of the star. By calculations from Kurucz model (Hauck and Mermilliod, 1998) for the studied star we find $M/M_\odot = 5.37$. After that by empiric formula we find:

$$\lg R/R_\odot = 2.22 + 0.5 \lg \frac{M}{M_\odot} - 0.5 \lg g = 1.54$$

$$\lg \frac{L}{L_\odot} = -15.045 + 2 \lg \frac{R}{R_\odot} + 4\, lgT_{eff} = 2.82$$

Determination of chemical composition

By defined T_{eff} = 5000K, lgg = 2.1 and ξ_t = 4km/h from Kurucz model we calculate theoretical equivalent widths of lines, equivalent widths of which are defined by us from the observations (Table 1). From comparison of observed and calculated equivalent widths we determined the composition of series of chemical elements in stellar atmosphere HD 206731 (G8II). Results are given in Table 2.

For comparison in the Table 2 we also give the composition of relevant chemical elements in atmosphere of the Sun.

Table 2. Comparison of the chemical composition of the star HD206731 and sun

Chemical element	Number of lines	$lg\varepsilon_*$	$lg\varepsilon_\odot$	$\Delta lg\varepsilon = lg\varepsilon_* - lg\varepsilon_\odot$
NaI	2	6,17	6,28	-0,11
SiI	4	7,34	7,65	-0,31
CaI	10	5,91	6,36	-0,45
ScII	4	2,87	3,00	-0,13
TiI	17	4,70	4,86	-0,16
TiII	3	4,20	4,86	-0,66
VI	4	3,61	4,04	-0,43
CrI	5	4,79	5,61	-0,82
CrII	3	5,01	5,50	-0,49
MnI	3	4,74	5,35	-0,61
FeI	111	7,25	7,60	-0,35
Fe II	8	7,25	7,60	-0,35
CoI	2	4,37	4,55	-0,18
NiI	16	5,71	6,08	-0,37
YII	3	1,67	2,24	-0,57

Determination of velocity of turbulent motions

Velocity of micro turbulent motions is defined by the lines FeI. For most of lines with weak and average intensity the observed equivalent widths of lines are compared with theoretical model widths. Further the chemical composition is defined on various lines by giving different values of velocity of turbulent motions. The value of turbulent velocity at which chemical composition does not depend on equivalent widths of lines, is

In the Table 2 the composition of chemical elements are given by logarithmic scale

$$\lg \varepsilon = \lg \frac{N(El)}{N(H)} + 12,$$

where lg ε(H) = 12.

As the Table 2 shows, in atmosphere of giant star HD206731(G8II) the systematic low content of elements are observed than in atmosphere of the Sun. This is especially strong for Ca, Mn, V, Cr and Y.

In conclusion we express our gratitude to L.S.Lyuimkov, employee of Crimean Astrophysical Observatory for placing complex calculation program and model atmosphere by Kurucz at our disposal.

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