THE ANALYSIS OF THE MGII DOUBLE EMISSIONS NEAR 2800 Å OBSERVED IN THE BINARY SYSTEM β GEM

Amera Abo-Alsoud
College of Science **,** *Babylon University*

Abstract

The paper aims to analyse the spectroscopic observations of the binary system β Gem in the ultraviolet region which obtained by IUE satellite and measured the MgII(h+k) emission line shape parameters, and applied the method of the nonradiative heating of stellar chromospheres by measuring the net radiative losses in the MgII(h+k). The absorption and emission lines which found in the spectrograms of the binary system β Gem in the rang (2950 – 3150) Å had been identifier also.

Introduction

1- The binary system β Gem

The star studied was classified KOIIIb, in the Mk^+ system [2]. And in most subsequence references the abslute flux for β Gem were published by [3]. The well-studied system β Gem shows emission in the CaII H and K lines [4]. [5] measured the characteristic of the CaII(H+K) doublet, and at L_α [6], and a possible coronal feature, OV 1218 Å, has been observed [7]. It has a strong MgII emission lines [8]. The star has solar abundances according to the analysis of [9]. Listed in table (1) the general information about the binary β Gem.

Table (1): The general information about the binary β Gem

Name of star	HD	Equ-J2000 Right Ascension h. m. s.	Equ-J2000 Declination 0 / //	Spectral type	T_{eff} k°	M_v mag	M_{BOL}	B.C	d pc	V	V – R	V – I
β Gem	62509	7 29 48.77	+27 54 58.1	KOIIIb	4800*	+1.1*	0.71**	- 0.30**	10.8***	1.14***	0.75**	+ 1.30**

* [4] ** [10] *** [11]

2- The resonance line of MgII(h+k)

It was appeared in the ultraviolet reigon of spectrum and called ($h = \lambda 2803$ and $k = \lambda 2796$) Å, which appeared in the spectral of the types G – K giants[12], k-type adwarfs [13] and solar plages [14]. It was used a diagnostics of physical properties of the solar chromosphere, and same for the CaII(H+K).

The ionization potential of Mg^+ is 3.2 eV. This means we need a high temperatures in the chromospheres of the star to observe MgII h and k lines. The solar abundance of magnesium is about 15 times that of calcium [15].

The emission profiles of MgII(h+k) resonance lines are characterized by two parameters W_0 and I_k. which defined the full width at half maximum intensity and the intensity of k respectively [5,16].

3- Absolute MgII h and k surface flux

The measurements of the surface flux in erg cm^{-2} s^{-1} is necessary in order to compare the observations with line profiles and line fluxes computed from chromospher models of this star. The stellar surface flux in a specific band pass $F(\Delta\lambda)$ [17] can be measured by the equation (1)

$$\mathscr{F}(\Delta\lambda) = f(\Delta\lambda)\left(\frac{d}{R}\right)^2 = f(\Delta\lambda)(4.125 \times 10^8 / \Phi^-)^2 \qquad \text{………….. (1)}$$

where:

$f(\Delta\lambda)$ = the flux observed at Earth in the same band pass.

d = the stellar distance.

R = the stellar radius.

Φ^- = the stellar angular diameter in milliarcsec

Branes and Evans [18] have shown that the angular diameter of star may be derived from its V – R color and apparent visual brightness.

$$\log \Phi^- = 0.4878 - 0.2V_0 + 0.858\,(V - R) \qquad \text{………….. (2a)}$$

$$\text{for } 0.00 \le V - R \le 1.26$$

$$\log \Phi^- = 0.7674 - 0.2V_0 + 0.640\,(V - R)$$

$$\text{for } 1.2 \le V - R \le 4.2 \qquad \text{………….. (2b)}$$

V_0 = the apparent visual magnitude corrected for interstellar absorption.

The relationship between the stellar flux per angstrom [19] and, $\mathscr{F}$, in the 3925 – 3975 A^o band pass and the V – R color:

$$\log F\,(\Delta\lambda) = 8.264 - 3.076\,(V - R) \qquad \text{………….. (3a)}$$

$$\text{for } \quad V - R < 1.30$$

$$\log F\,(\Delta\lambda) = 5.500 - 0.944\,(V - R) \qquad \text{………….. (3b)}$$

$$\text{for } \quad V - R > 1.30$$

Klans and Francis [20] determined the H and K emission-line fluxes for CaII(H+K) by setting the measured relative fluxes, $f(\Delta\lambda)$ equal to the calibrated flux so that

$$F\,(H_1; K_1) = \frac{50F}{f(\Delta\lambda = 50\,A^o)} f(H, K) \qquad \text{………….. (4)}$$

f (H, k) = the flux above zero-flux level and between the H_{IV} or K_{IV} minima and H_{IR} or K_{IR}

$f(\Delta\lambda = 50\,\mathring{A})$ = the integration boundaries of the $\Delta\lambda = 50\,\mathring{A}$ includes the H and K emission futures

$F\,(\Delta\lambda = 50)$ = It is derived from equation (1) which were selected without much regard to their H and K characteristics.

In this paper we applied the way of [20] for MgII(h+k), and measured the radiative losses in strong MgII with dependent of effective temperature [13, 21, 23, 24] so that:

$$\text{radiative loss} = \frac{F\,(\text{MgII})}{\delta T_{eff}^4} \qquad \text{………….. (5)}$$

δT_{eff}^4 = the total surface luminosity

δ = 5.669 $\times 10^{-5}$ erg cm^{-2} deg^{-4} s^{-1}

T_{eff} = effective temperature of the star which is defined of temperature of a black body that produces the same total energy per unit surface area as does the star.

Analysis of the observations

a. The equivalent width

To calculate the e.w for the profiles of MgII(h+k) which is illustrated in Fig (1) we used [22] the application function. From the spectra of the binary star β Gem in the Fig. (2), for the range (2750 – 2850 $\mathring{A}$).

$$e.w = \sum_{0}^{m} (L_c - L_n)/L_c \times \Delta\lambda \qquad \text{.............. (6)}$$

where

L_c = Depth of the spectra for each separation.

L_n = Depth of the line spectra which studied at any point on the line profile for this separation.

$\Delta\lambda = \frac{(\lambda_2 - \lambda_1)}{m}$ = Deviation in wave length.

m = No. of dividing on the X-axis.

And to determine (the full width at half maximum-W_f), we use [5] the equation

$$\Delta w = w_f - w_0 = 0.03 \qquad \text{.............. (7)}$$

$$w_0 \approx w_f$$

The slope of the emission profile expressed as ($w_1 - w_2 / w_f$).

w_1 = the h,k minimum feature separation.

w_2 = the h,k emission peak separation.

The intensity of I_k reversal which calculated from this equation

$$E = 0.0175\, I_k^2 + 0.06481\, I_k \qquad \text{.............. (8)}$$

where $E = \log \frac{F_2}{F_1}$ .... (9)

The result of e.w and the parameters of MgII emission lines are listed in tables (2) and (3) respectively.

b. The angular diameter and relative fluxes

For the binary star β Gem we use equation (2a) to determined the angular diameter because it's (V – R = +0.77) and to determined the stellar flux per angstrom F we used equation (3a) for the same reason.

Equation (4) and (5) were used to measure relative fluxes and radiative loss respectively . All the results are listed in table (4).

c. The spectral identification of β Gem star

We used the spectrograms of β Gem in the high-resolution mode (0.2 $\mathring{A}$ / mm) which obtained from [1], in the ultraviolet region from (2950 – 3150) A^o. We identify the absorption and emission lines in the observation spectral, by use a standard tables. Fig. (3) shows the spectra of β Gem and table (5) contains the intensity and the name of elements.

Discussion

1. The values of the intensity of I_k was in the range of Wilson's 0 – 5 scale.
2. The values of E are comparable for the values of the stars with same spectral type.
3. The values of w_0 is equal to the values of the stars with same Luminosity where the equivalent width w_0 increases with increasing Luminosity.
4. The longer-period binary giants β Gem show well-separated double emission features with central minima which have about one-half the flux of the emission peaks at a resolution of 0.20 $\mathring{A}$. This star probably do not have circumstellar absorption features which are optically thick in the MgII lines.
5. The observation of β Gem we used show the peak of the emission in the h line at 2795.6 $\mathring{A}$ which is 0.3 $\mathring{A}$ different from the observation of this line made with Buss and 0.2 $\mathring{A}$ for lines of 2802.8 $\mathring{A}$. The deference may be due to Doppler effect.
6. We find the radiative loss rate in MgII is commonly ten times that of the sun. And this means start activity is higher than the sun.
7. In the spectral o f β Gem star we saw abundances of Fe, Mn and Na, and when we compared the spectral of α UMa which have the same spectral types and luminosity classes, which has the same abundances.

Table (2): The result of the equivalent width of MgII(h+k)

e.w. $\mathring{A}$			
h_p	h_s	k_p	k_s
1.836	1.230	2.147	2.275

p: primary star, s: secondary star.

Table (3): MgII emission line shape parameters

w_0 $\mathring{A}$				E				I_k		w_1 $\mathring{A}$				$\frac{w_1 - w_2}{w_f}$			
h_p	h_s	k_p	k_s	h_p	h_s	k_p	k_s	P	S	h_p	h_s	k_p	k_s	h_p	h_s	k_p	k_s
0.500	0.454	0.636	0.272	1.0479	0.875	1.852	0.7201	1.700	4.820	0.803	0.590	0.954	0.500	1.726	1.299	1.5	1.838

Table (4): MgII h and k fluxes

Φ^- arcsec	f ergs cm^{-2} s^{-1}	f(h)	f(k)	$\mathcal{F}$ (h)	$\mathcal{F}$ (k)	$\mathcal{F}$ (MgII)	$\frac{\mathcal{F}\text{ (MgII)}}{\delta T_{eff}^4}$
8.49(-3)	7.86(5)	51.9	54	1.7(5)	1.768(5)	3.46(5)	1.23(-5)

Table (5): Identification of the spectral lines of βGem

Line	Element	Wavelength Å	Lab. Intensity $erg.cm^{-2}.sec^{-1}$ Å^{-1}		Line	Element	Wavelength Å	Lab. Intensity $erg.cm^{-2}.sec^{-1}$ Å^{-1}
	Ne I	2974.714	300		16	Na II	3053.664	6
1	Xe II	2979.32	300		17	F II	3059.96	8
2	Ne I+ CII	2982.663+2982.106	300+8		18	Cℓ IV + Cu I	3063.13+3063.411	5+2500
3	O III+Na II	2983.79+2984.183	9+7		19	O IV	3071.66	5
4	Ca II	2988.61	7		20	Aℓ I	3082.1529	24
5	C II	2992.618	18		21	Si III	3086.236	25
6	Cu I	2997.364	2000		22	Ti II	3088.027	75
7	N II	3006.830	7		23	Na II	3092.729	10
8	Fe III	3007.275	20		24	Si III	3093.424	20
9	Cu I	3010.838	2000		25	Xe II	3104.40	70
10	Fe III	3013.167	20		26	Ca III	3119.66	8
11	Xe II	3017.43	100		27	Fe III	3120.847	20
12	Fe I	3021.0743	150		28	Kr III	3129.368	6
13	Kr III	3024.45	80		29	O II	3134.82	10
14	F III	3042.808	10		30	O II	3138.44	8
15	O III	3047.13	8		31	Si IV	3149.561	7

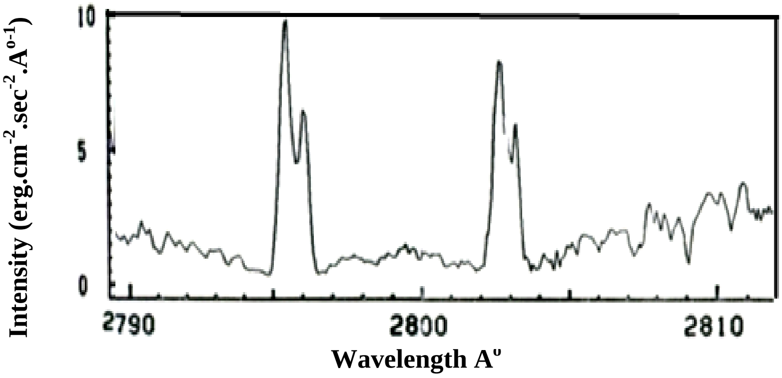

Fig. (1) The MgII(h+k) doublet for the binary βGem [1]

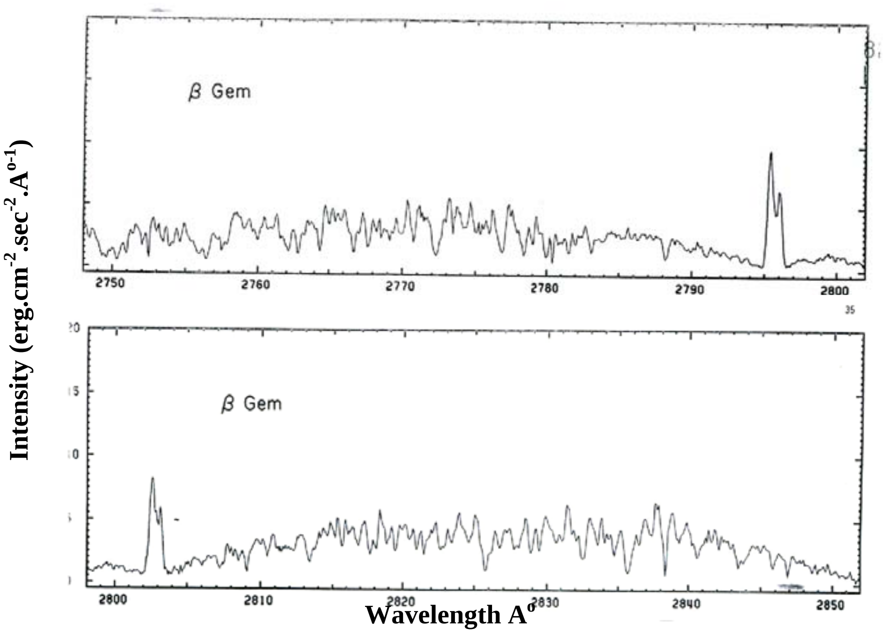

Fig (2) The spectra of βGem with high resolution in the region (2750 – 2800) Å (1)

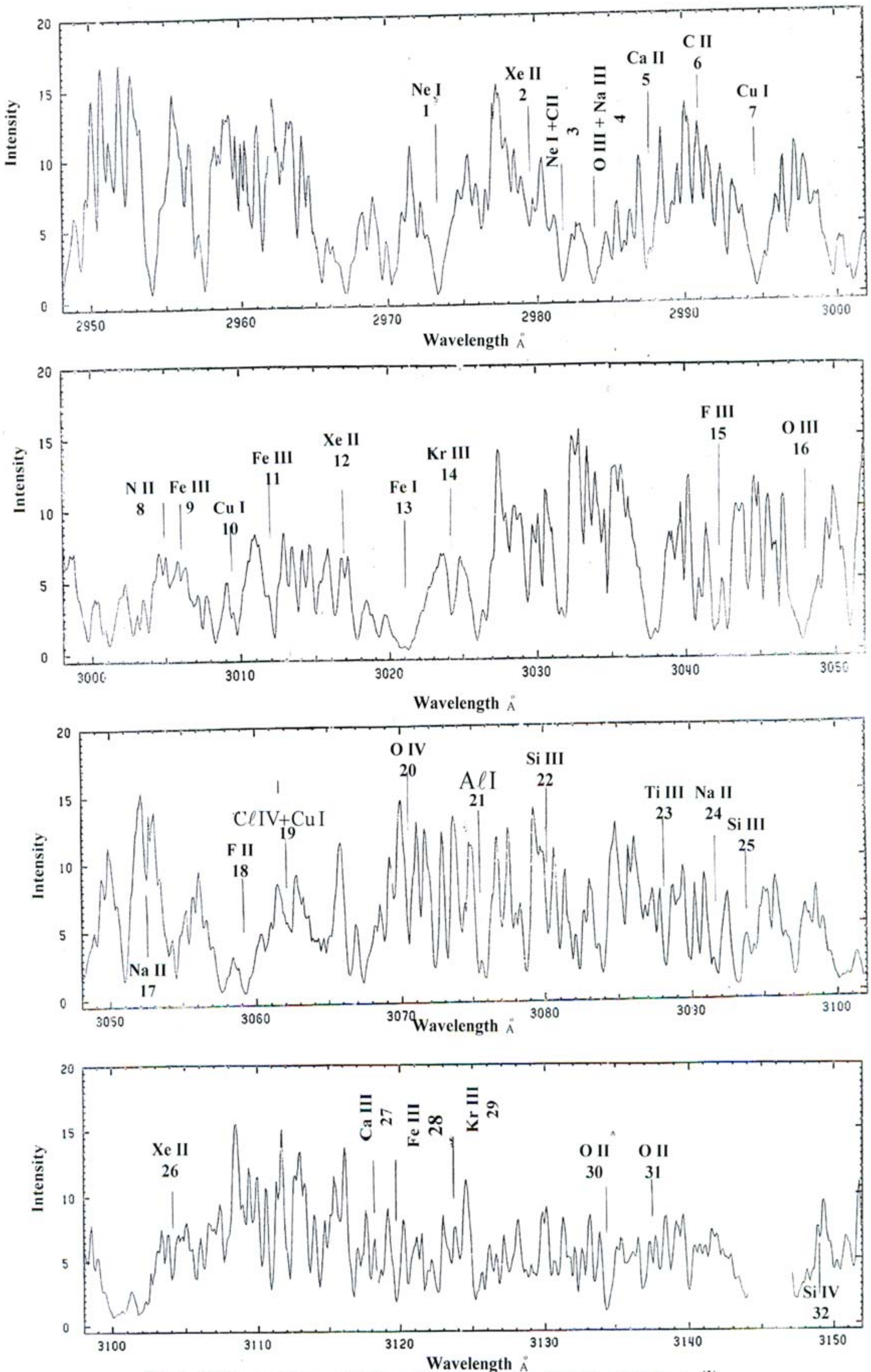

Fig (3) The spectra of βGem in the region (2950 – 3150) Å [(1)]

References

1. Robert, F.W., Keneth, G.C. and Glenn, M.W., 1983. Atlas of high resolution, No. 1. (the Ohio state University: Perkins obsetvatory).
2. Kondo, Y., Morgan, T.H., and Modisette, J.L. 1975a., Ap. J. 207, 167.
3. Kondo, Y., Duval, J.E. , Modisette, J.L. and Morgan, T.H. 1976b, Ap. J. 210, 713.
4. Wilson, O.C. and Bappu, M.K.V. 1957, Ap. J. 125, 661.
5. Glebocki, R., Stawikowski, A., Acta. Astro., Vol. 3o, (1980), No. 3.
6. Mc Clintock, W., Henry,R.C., Moos, H.W. and Linsky, J.L. 1975, Ap. J. 202, 733.
7. Gerola, H., Linsky, J.L., Shine, R., Mc Clintock, W., Henry, R.C., and Moos, H.W. 1974, Ap. J. (Letters), 193, L107.
8. Kondo, Y. and Wells, C.W. 1973, Telescope systems for Ballon-borne Research (NASA TMX-62, 397), P. 107.
9. Griffin, R. 1976, Mon. Not. Astron. Soc. 175, 225.
10. Jonson, H.L. 1966. An.. Rev. Astr. Ap., 4, 193.
11. Edward, J., J.W. and William, R.O., 1979, Ap. Js, 39: 537-547.
12. Garadini, D., 2003, Astro., 408, 337.
13. Kelch, W.L. 1978, Ap. J., 222, 931.
14. Kelch, W.L., Linsky, J.L., and Worden, S.P., 1979, Ap. J., 229, 700.
15. Gibor, S., Jeffrey, L. 1979. Ap. J., 234, 1023 B.
16. Cassatella, A., Altamore, A. and Badial, M., 2001, Astro., 374, 1085.
17. Linsky, J.L., Worden, S.P., Mc Clintock, W. and Robertson, R.M. 1979b, Ap. J. Suppl., 41, 47.
18. Barnes, T.G., Evans, D.S. and parsons, S.B. 1976. M.N.R.A.S., 174, 503.
19. Bopp. B.W., Strassmeier, G.K. and Dempsy, R.D.,1990, Ap. J. Suppl., 72, 191-230.
20. Al-Ugaily, A.A. (1997). M. Sc. Thesis, University of Babylon.
21. Cardini, D., 2005. Astro., 430, 303.
22. Konda, Y., Morgan, T.H., 1976, 207, 167-173.
23. Kelch, W.L., Linsky, J.L., Basri, G.S. and Shiu, H.Y., 1978, Ap. J., 220, 962.
24. Kelch, W.L., Linsky, J.L., and Worden, S.P. 1979, Ap. J., 229, 700.

الخلاصة

يهدف البحث إلى تحليل الإرصاد الطيفي للثنائي β Gem في المنطقة فوق البنفسجية من الطيف الذي تم الحصول عليه بوساطة القمر الصناعي IUE، إذ تم حساب معالم المزدوج الثنائي للمغنيسيوم MgII(h+k). كذلك حساب محصلة فقدان إشعاع مزدوج المغنيسوم إضافة إلى تعريف خطوط الامتصاص والانبعاث المتوافرة في طيف الثنائي β Gem ضمن المنطقة (2950-3150) Å.