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SPECTROSCOPIC MONITORING OF SOUTHERN Be STARS

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RESUMEN. Presentamos los primeros resultados de nuestras observaciones espectroscópicas de estrellas Be con el telescopio Cassegrain de 93cm, ubicado en el Observatorio "Manuel Foster" de la Pontificia Universidad Católica de Chile. 36 estrellas tipo "Be" fueron observadas regularmente para detectar variaciones de la velocidad radial, de los perfiles de líneas y del ancho equivalente (3900 - 5100 Å, 20 Å/mm en Hγ). Un análisis espectrofotométrico de μ Cen (HR 5193 = HD 120324) reveló una anticorrelación significativa de los anchos equivalentes de las líneas de absorción de HeI 4471 y MgII 4481. Las variaciones anticorrelacionadas de estas dos líneas que están presentes en todas las escalas de tiempo de horas hasta años, podrían estar relacionadas con variaciones marginales de la temperatura causados por pulsaciones no radiales en la superficie de la estrella.

ABSTRACT. We present first results from our long-term spectroscopic observations of Be stars with the 93cm Cassegrain telescope of the "Manuel Foster" Observatory (Catholic University of Chile). 36 bright Be stars ($V \lesssim 6^m$) are regularly being monitored for variations in radial velocity, line profiles and equivalent widths (3900-5100 Å, 20 Å/mm at Hγ). A spectrophotometric analysis of 35 spectrograms of μ Cen (HR 5193 = HD 120324) revealed a significant anticorrelation of the equivalent widths of the HeI 4471 and MgII 4481 absorption lines. The anticorrelated variations of these two lines seem to be present in all time scales between a few hours and two years which could reflect marginal temperature variations, possibly related to non-radial pulsations on the star's surface.

Key words: SPECTROSCOPY -- STARS-BE -- STARS-VARIABLE

I. OBSERVING PROGRAM AND INSTRUMENT

Regular spectroscopic observations of southern Be stars are being obtained since early 1984 with 93 cm Mills Cassegrain telescope of the "Manuel Foster Observatory", which is located at Cerro San Cristóbal in Santiago, Chile. The telescope has been described in some detail by Heilmaier and Vogt (1982) and by Sterken and Vogt (1982). We are using the 2-prism version of the Cassegrain spectrograph which gives an inverse dispersion of 20 Å mm^{-1} at Hγ. The spectrograms are secured on IIa-O plates (baked) and cover a wavelength range of 3900-5100 Å.

The main aim of this program is to cover all time scales between a few minutes and several years for spectral variation of a sample of selected bright Be and B shell stars ($V \lesssim 6^m.0$) which are not significantly affected by the bright night sky from the city lights of Santiago. Table 1 lists the Be stars for which five or more spectrograms have been obtained till April 1986. Observing programs of this kind cannot be carried out at the large international observatories in the North of Chile (Las Campanas, La Silla, Tololo) because their schedule procedure impedes to follow spectral variations over periods longer than about one week. Our program intends to fill a gap in the present-day knowledge of Be variability, especially in time scales of weeks and months.

TABLE 1. Observations of Be stars (N ⩾ 5).

Manuel Foster Observatory, Cerro San Cristóbal, Santiago

Name	HR	HD	Sp.	N (Number of plates Feb. 1984-April 86)
α Eri	472	10144	B3Vpe	14
λ Eri	1679	33328	B2IVne	5
η Ori	1788	35411	B1V+B2e	13
λ Ori A	1879	36861	O8e	11
ε Ori	1903	37128	B0Iae	11
ζ Ori A	1948	37742	O9.5Ibe	5
α Col	1956	37795	B7IVe	10
κ CMa	2538	50013	B1.5IVne	27
ω CMa	2749	56139	B2IV-Ve	66
29 CMa	2781	57060	O7e+O7:	5
NV Pup	2787	57150	B2V+B3IVne	11
NW Pup	2790	57219	B2IVne	5
β CMi	2845	58715	B8Ve	6
o Pup	3034	63462	B0V:pe:	11
ζ Pup	3165	66811	O5Iaf	18
MX Pup	3237	68980	B1.5IIIe	12
V344 Car	3498	75311	B3Vne	15
V345 Car	3642	78764	B2IVe	17
...	3858	83953	B6Ve	15
ω Car	4037	89080	B8IIIe	16
PP Car	4140	91465	B4Vne	28
...	4460	100673	B9Ve	5
...	4537	102776	B3Vne	18
...	4618	105382	B6IIIe	13
δ Cen	4621	105435	B2IVne	22
λ Cru	4897	112078	B4Vne	5
μ^2 Cru	4899	112091	B5Vne	5
μ Cen	5193	120324	B2IV-Ve	43
V795 Cen	5316	124367	B4Vne	12
η Cen	5440	127972	B1.5Vne	16
FX Lib	5941	142983	B5IIIpe	6
χ Oph	6118	148184	B2IV:pe	6
α Ara	6510	158427	B2Vne	13
V2048 Oph	6712	164284	B2Ve	5
λ Pav	7074	173948	B2II-IIIe	7

The spectrograms are being used for radial velocity determinations, as well as for the measurement of equivalent widths and of other spectrophotometric parameters. For this purpose, we use the density-to-intensity conversion method of Vogt and Barrera (1985).

II. EQUIVALENT WIDTHS OF μ CENTAURI

In a first step of our spectrophotometric data analysis we selected 35 spectrograms of μ Cen = HR 5193, obtained in 1984 and 1985. We determined the line profiles and equivalent widths of Hβ, Hγ, HeI 4471 and MgII 4481. The mean values of the equivalent widths of each absorption line are given in Table 2. Fig. 1 shows examples of the Hβ line profiles. In 1984 there was a central emission component superimposed on the broad Hβ absorption line profile. The emission had disappeared in 1985.

The time variations of the equivalent widths of Hβ and Hγ (Fig. 2a, 3a) seem to be irregular, without being strongly correlated. In contrast, the equivalent widths of HeI 4471

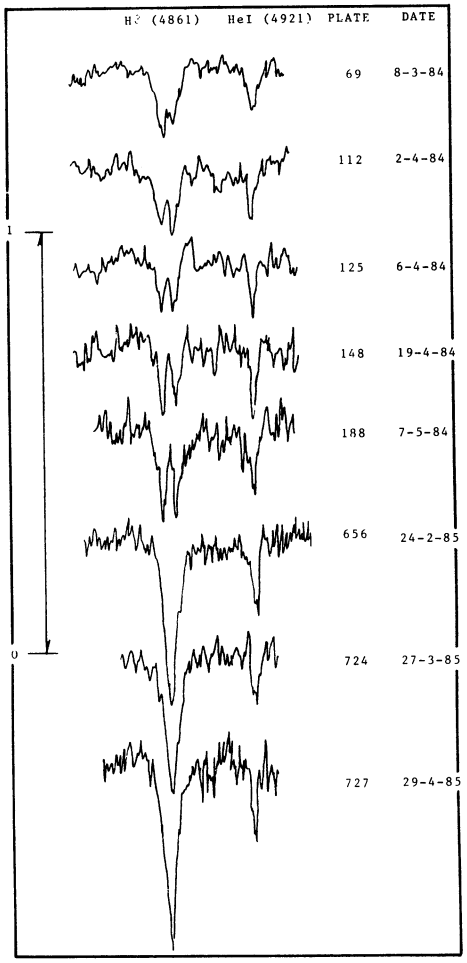

Fig. 1a: Hβ and HeI 4921 line profiles of μ Cen in March 1984 to April 1985.

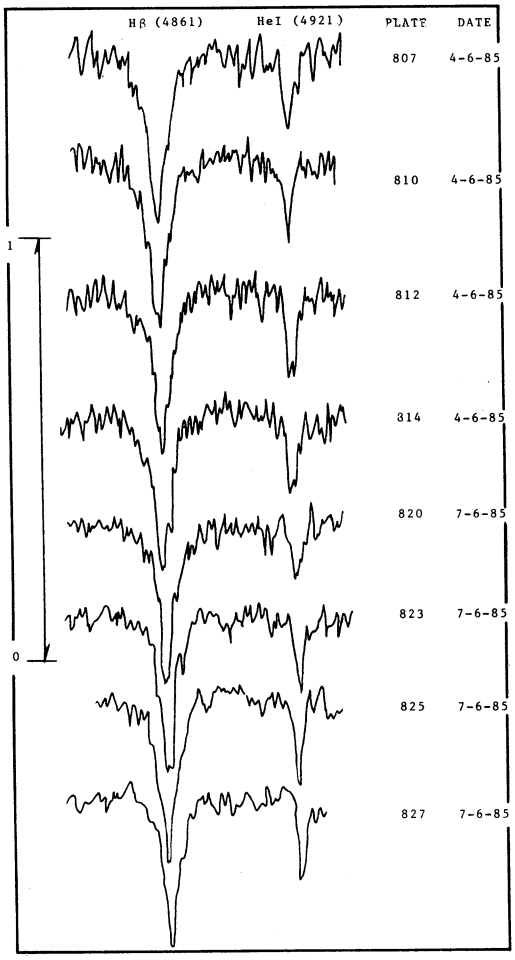

Fig. 1b: Hβ and HeI 4921 line profiles of μ Cen in 2 single nights in June 1985.

TABLE 2. Average Equivalent Widths of μ Cen for the observing seasons 1984 and 1985

	1984			1985		
	$\overline{EW}$	$\sigma(\overline{EW})$	N	$\overline{EW}$	$\sigma(\overline{EW})$	N
Hγ	2.83	0.13	9	3.86	0.09	24
Hβ	1.73	0.20	8	4.18	0.10	25
HeI 4471	0.957	0.033	8	1.089	0.041	26
MgII 4481	0.150	0.019	8	0.214	0.017	26

and MgII 4481 (Fig. 2b, 3b) apparently vary in the opposite way: Maxima of HeI normally coincide with minima of MgII and viceversa. The correlation between the equivalent width's of HeI 4471 and MgII 4481 are shown in Fig. 4a. Since their mean values of 1984 were smaller than those of 1985 we applied a common correction factor of 1.20 and 1.26 respectively, to all equivalent widths of 1984 in order to normalize them in accordance with the 1985 observations. The anticorrelation between the equivalent widths of MgII and HeI is confirmed by an appropriate linear least squares fit which takes into account the errors of both quantities

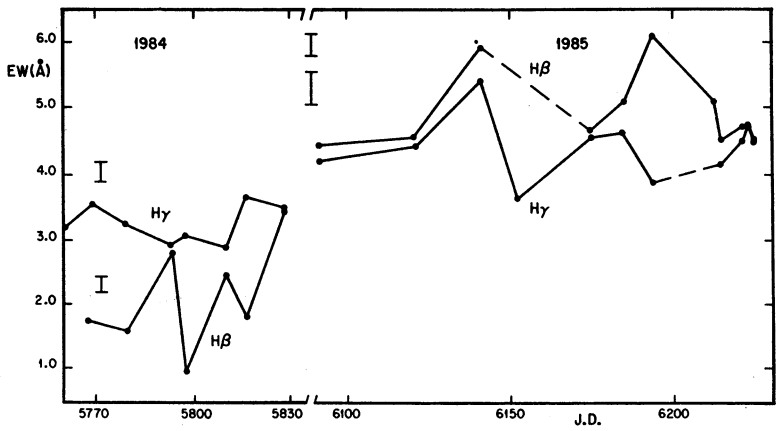

Fig. 2a: Variations of the Hβ and Hγ equivalent width of μ Cen in 1984 and 1985 (average value per night)

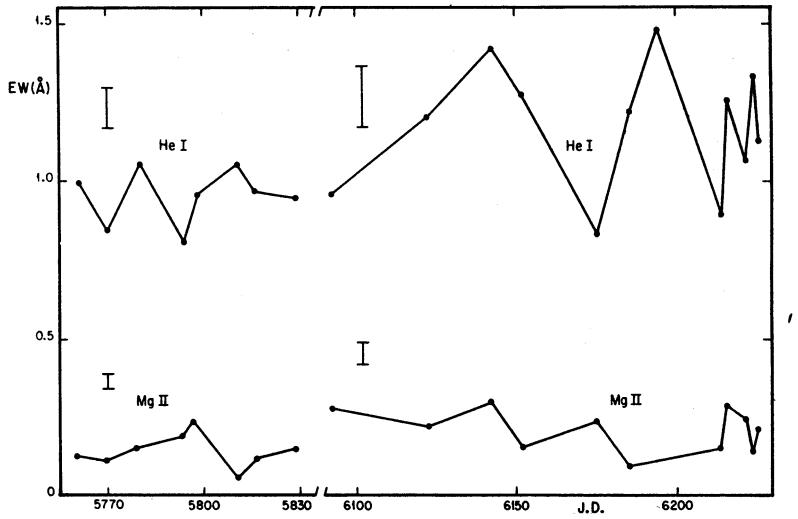

Fig. 2b: Variations of the HeI 4471 and MgII 4481 equivalent width of μ Cen in 1984 and 1985 (average value per night).

and which reveals a slope of -0.28 ± 0.08 (straight line in Fig. 4a). Although it is not possible to derive reliable slopes of sub-sets of our observations the tendency of an anti-correlation seems to be present even within single nights. The anticorrelation may display a special type of variability which is present in different time scales between hours and months.

We compared our results with typical equivalent widths of BO-B6 dwarfs and giants as given by Didelon (1982). In Fig. 4b our observations are shown together with the mean

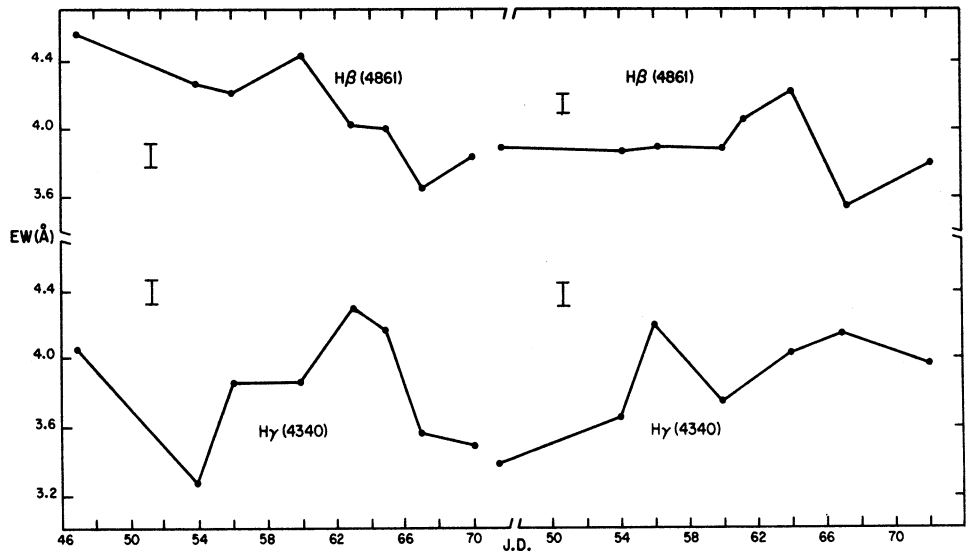

Fig. 3a: Variations of the Hβ and Hγ equivalent width of μ Cen in two single nights (1985, June 4 and 7)

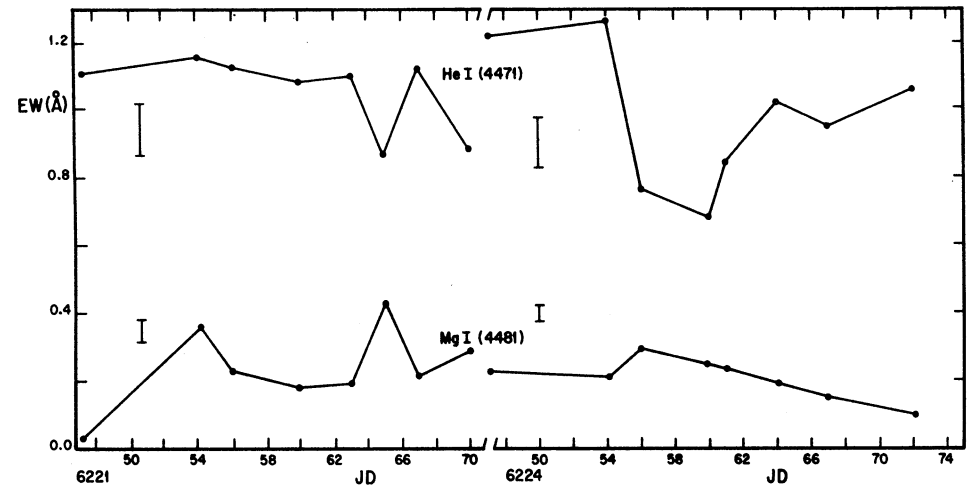

Fig. 3b: Variations of the HeI 4471 and MgII 4481 equivalent width of μ Cen in two single nights (1985, June 4 and 7).

values expected for each spectral type of luminosity class III (left limit of each box) and V (right limit; the equivalent width of the MgII lines does not depend on luminosity class). The slope of our anticorrelation is very similar to that expected by a variation of the effective spectral type within the range B2-B5, which could reflect temperature variations. Non-radial oscillations as proposed by Baade (1984) could possibly explain this effect because the rotating pattern of nodes of these oscillations will cause small changes in the average temperature as exposed towards an observer at Earth.

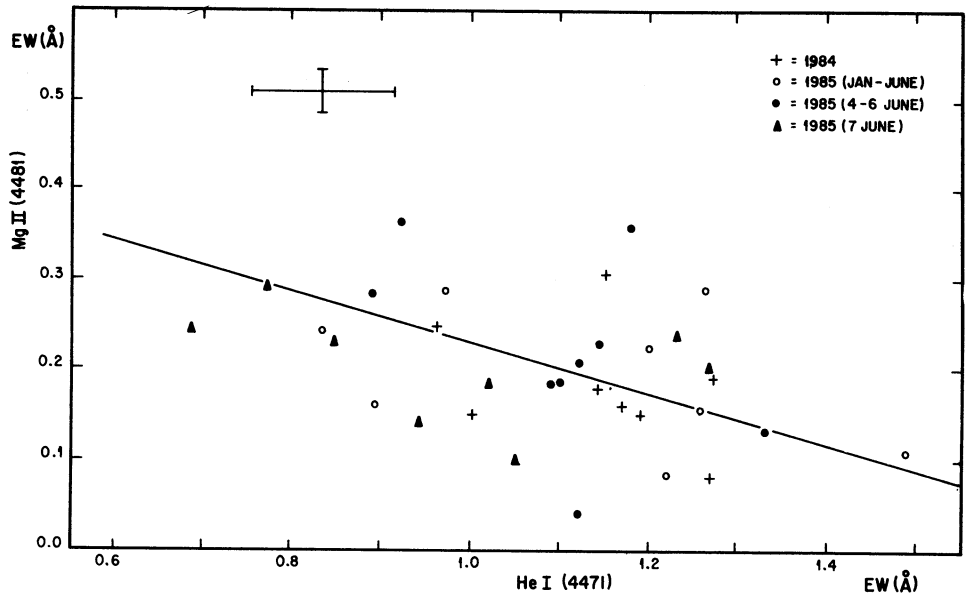

Fig. 4a: Anticorrelation between the MgII and HeI equivalent width of μ Cen. Symbols refer to different epochs. The straight line corresponds to a linear least squares fit.

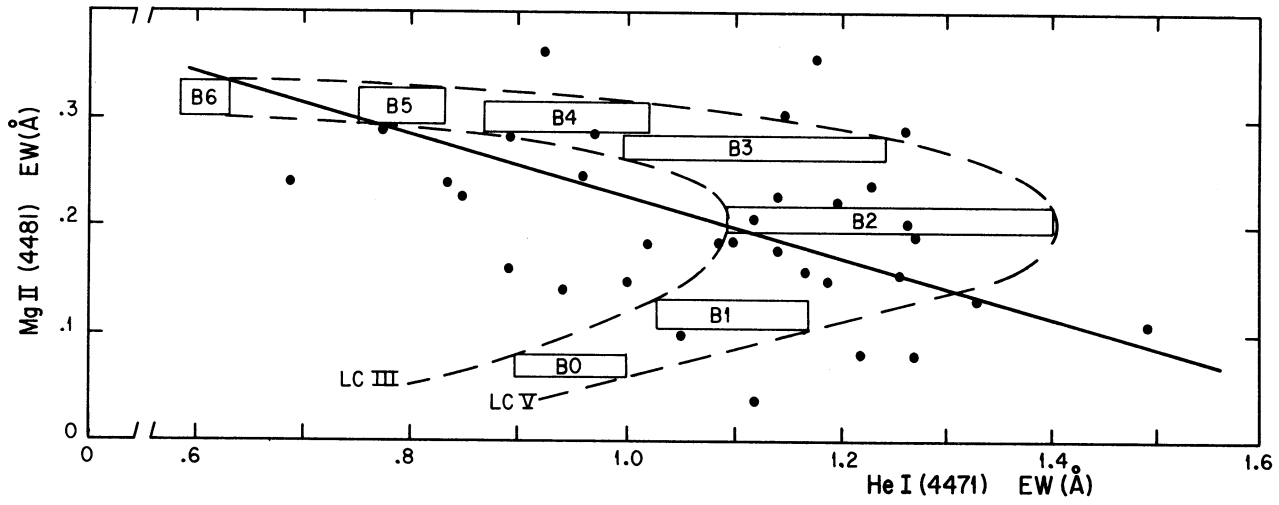

Fig. 4b: Anticorrelation between the observed MgII and HeI equivalent width as in Fig. 4a, compared to mean equivalent widths of B stars of various spectral subtypes (luminosity classes III and V, both marked with broken curves) according to Didelon (1982). The slope of the observed anticorrelation is similar to that obtained in the spectral range B2-B5.

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DISCUSSION

M. ALVAREZ: Lo felicito por la decisión de su trabajo sistemático. Hay que añadir los puntos estudiados por Uds. a los valores que Feinstein y colaboradores han estudiado y reportado en la literatura. La coordinación en fotometría y espectroscopía, así como en latitud es de mucha importancia para el estudio de las estrellas B y Be, puesto que efectivamente tienen variabilidad de corto, mediano y largo plazo.

N. VOGT: Como hay varios grupos trabajando en Latinoamérica en estrellas Be (especialmente en Argentina y México), propongo mantenernos en contacto, coordinar los esfuerzos y, tal vez, cooperar en programas específicos, como campañas de observación simultánea en fotometría y espectroscopía de distintos lugares.

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