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Spectroscopic and photometric observations of the Be star 69 Orionis (*)

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Summary. — Spectroscopic and photometric observations of the Be star 69 Ori are reported for the periods Nov. 77-Janu. 78 and Oct. 78-Feb. 79. The structure and the evolution of the stellar envelope are discussed qualitatively *via* the study of the H_α line, the emission of which probably reached a maximum at about the beginning of our observations, then gradually decreased in intensity.

There are indications of a motion of matter towards the observer during the period of intensive activity and of a successive decrease of the rotation of the envelope as the emission began to disappear.

The photoelectric observations show no change.

Key words : Be stars — spectroscopy — photometry.

1. **Observations and data processing.** — 69 Ori (HD 42545, B5V), which appeared as a normal B star in 1973-74 (Massa, 1975), successively showed a double emission in the H_α line, which was observed from January to November 1976 by Doazan *et al.* (1977). To our knowledge no observation prior to this date indicates an emission in the spectrum of this star. In order to follow its evolution we have observed 69 Ori at the Merate Observatory during the periods Nov. 77-Jan. 78 and Oct. 78-Feb. 79 obtaining 20 red spectrograms (6 000-6 800 Å) and 25 blue ones (3 800-4 800 Å) with a dispersion of about 35 Å/mm, using a Boller and Chivens mod. 31523 grating spectrograph attached to the 137 cm Ruths reflector.

Only the results relative to the red spectra are presented in this work.

The spectrograms were digitized on the PDS 1010 A microdensitometer of Napoli and Trieste Observatories with a sampling step of 10 microns. The data were then processed on the DEC PDP 11/45 interactive computer system of Trieste Observatory by means of the standard ELSPEC/4 software package for processing photographic spectrograms (Pasian *et al.*, 1980). The information contained in the spectral lines relevant to this work was then obtained by means of a non-linear least squares fit to a gaussian or lorentzian model (Frazer *et al.*, 1966). This procedure is used here because it allows to compute individually the parameters of blended lines with an accuracy limited by the signal/noise ratio and model matching figures. We emphasize that the model fit procedure is fundamental here to recover with suitable accuracy the position of absorption lines masked by central emissions.

We have also performed *B* and *V* photoelectric observations during 12 nights with a standard photometer attached to the 102 cm Zeiss reflector (Bossi *et al.*, 1977).

2. **Structure and evolution of the H_α line.** — In order to qualitatively examine the wide variations in the emission of the H_α line, which occurred during the two observational periods (see Fig. 1), the following quantities have been determined using the procedures detailed in section 1 (indicated, for each spectrum, in table I) :

E : equivalent width of the observed emission (represented by the corresponding dashed area in Fig. 2) ;

V/R : ratio between the equivalent width of the violet and the red emission (see again Fig. 2) ;

A : equivalent width of the central absorption ;

RE, CA, VE : radial velocities, referred to the photospheric component of H_α, of the red emission, the central absorption and the violet emission ;

P-P : separation (in km/s) between the red and the violet peak ;

HBW : half-width of the total emission (half-distance between the inflexions of the gaussian curve fitting the emission).

The errors reported for these quantities in table I were computed from the theoretical values output from the fit procedure taking into account the pattern-dependent excess factors. These factors were estimated empirically by means of numerical simulations of the typical H_α pattern and were found to approximate 7 and 1.5 for the absorption and emission components respectively.

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Attempts were made to establish a number of correlations between these quantities to obtain some useful indications of the structure and the evolution of the stellar envelope.

The trend of the quantities *E, A* and *CA* during the two observational periods are shown in figure 3. Emission *E*, more conspicuous at the beginning of our series of observations (Nov. 77), has then a continuous meaningful decrease. A similar behaviour is observed for the central absorption *A* due to the matter ejected by the star and distributed along the line of sight. The absorption by this matter is obviously more marked in the period of maximum activity. The velocities *CA*, relative to the photospheric absorption, are negative on the average in the first observational period, in which the observed emission *E* is very intense, whereas in the successive phases their value tends to average around zero. This behaviour may be easily understood if a significant motion of matter is assumed from the star towards the observer during the period of intensive emission activity with a further significant decrease of the former when the activity of the shell decreases. We have also compared the above-mentioned *CA* values with the average values of *V/R, RE* and *VE* during the two observational periods :

	CA	*V/R*	*VE*	*RE*
1977-78	– 25 ± 5	0.94 ± 0.07	– 154 ± 12	103 ± 12
1978-79	6 ± 8	1.19 ± 0.17	– 113 ± 8	124 ± 9

As we could expect on the ground of *CA* behaviour, there is a slight but not meaningless trend towards a simultaneous increase of these quantities with time. The wide variations of the *CA* values from one night to the other, which are probably real because the corresponding errors are rather small (see table I), cannot be explained in this work. It will perhaps be possible to do so after an analysis of the radial velocities of the blue spectra.

We finally compared the *P-P* and *HBW* curves with the trend of the observed emission *E* (see again Fig. 3). It appears evident that the rotational velocity of the shell decreases as the emission is weakening : this may be due to the progressive expansion of the envelope. The average values of the shell rotation obtained from the half-width of the total emission, corrected for the instrumental profile, are :

1977-78 : 250 ± 5 km/s ;
1978-79 : 215 ± 7 km/s.

3. **Photoelectric observations.** — We have used HD 43153 (B7 V) and HD 42560 (B3 V) respectively as comparison and check stars. Table II shows the normal points in the *V* colour and the (*B-V*) values, with the relative standard errors.

No significant variations are observed either during a given night, or from one night to another or between the two observational periods, in which the difference of activity of the shell has been very great. This could be explained by the fact that 69 Ori is probably viewed almost equator-on : in fact in this case the observer views the star darkened when the shell is very luminous and *vice versa,* the total luminosity remaining virtually constant.

4. **Conclusions.** — The understanding of the Be phenomenon is strictly connected with the possibility of performing a very long series of spectrographic and photometric observations to be able to follow the slower variations which are linked with the structure of the envelope (Harmanec, 1980). The present study of 69 Ori comes within this context : we intend to continue the observations in the forthcoming years in order to attempt to derive a quantitative model of the envelope from the complex series of spectrographic and photometric data.

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References

Bossi, M., Guerrero, G. and Mantegazza, L. : 1977, *Astron. Astrophys. Suppl. Ser.* **29**, 327.
Doazan, V., Bourdonneau, B. and Letourneur, N. : 1977, *Astron. Astrophys.* **56**, 481.
Frazer, R. D. B. and Suzuki, E. : 1966, *Ann. Chem.* **38**, 1770.
Harmanec, P., Horn, J. and Koubsky, P. : 1980, *Be stars newsletter* n. **2**, 5.
Massa, D. : 1975, *Publ. Astron. Soc. Pac.* **87**, 777.
Pasian, F., Rusconi, L. and Sedmak, G. : 1980, *Mem. Soc. Astron. Ital.* **51**, 3, 405.

TABLE I.

J.D. 244...	E (A)		V/R		A (A)		RE (Km/s)		CA (Km/s)		VE (Km/s)		P-P (Km/s)		HBW (A)	
3493.48	9.8	±.2	1.08	±.03	4.90	±.12	88	±7	-50	±6	-179	±7	267	±2	6.46	±.05
3494.51	11.0	.2	1.24	.04	6.79	.16	123	7	-5	7	-124	7	246	2	5.74	.06
3495.51	11.0	.3	.90	.03	6.24	.15	128	8	-6	7	-134	8	263	2	6.30	.05
3496.47	8.6	.1	1.21	.02	4.12	.08	103	4	-33	5	-154	4	256	1	6.43	.04
3497.49	12.7	.9	.58	.02	3.92	.08	47	8	-68	5	-207	8	254	2	6.82	.04
3498.47	12.1	.1	1.00	.02	5.74	.10	141	3	8	5	-120	3	261	1	6.45	.04
3504.42	10.2	.2	.92	.02	4.51	.11	142	6	24	6	-109	6	261	2	6.62	.06
3514.48	9.6	.1	.83	.02	3.15	.04	83	5	-39	2	-169	5	252	1	6.74	.02
3534.30	6.6	.2	.69	.04	3.61	.14	60	13	-56	11	-196	13	256	4	6.29	.10
3789.56	4.3	.1	1.06	.07	2.79	.09	134	15	13	12	-108	15	243	5	5.89	.10
3805.57	2.5	.1	1.20	.08	2.39	.08	106	14	-17	10	-139	14	245	4	5.34	.08
3810.57	3.9	.1	2.73	.18	1.90	.09	140	15	11	15	-85	15	225	5	6.12	.12
3820.52	7.2	.4	1.27	.06	3.40	.12	155	17	39	11	-87	17	242	5	6.27	.09
3821.50	4.3	.1	.90	.05	1.74	.07	86	15	-24	10	-153	15	239	4	6.14	.09
3828.47	3.1	.2	.98	.04	2.10	.06	115	7	-7	7	-132	7	246	2	5.96	.05
3835.44	2.7	.1	.95	.06	2.01	.08	82	13	-34	10	-152	13	234	4	5.39	.09
3843.42	2.1	.1	1.65	.12	1.51	.05	121	16	11	9	-99	16	219	5	5.01	.07
3876.37	4.0	.1	.74	.06	1.82	.09	108	18	3	13	-114	18	222	5	5.71	.11
3886.41	3.1	.1	.93	.04	1.36	.05	134	10	17	8	-105	10	239	3	6.12	.07
3911.28	1.0	.1	.71	.11	1.66	.09	184	18	57	14	-73	18	257	5	4.75	.11

TABLE II.

J.D. 244...	Δm_V		Δ(B-V)	
3492.46	.421	± .011		
.49	.405	.010		
.50	.385	.005		
3493.42	.385	.005	-.028	± .008
.46	.387	.004	-.031	.010
.48	.384	.002	-.030	.008
.50	.379	.002	-.030	.005
.53	.378	.003	-.036	.005
.56	.380	.002	-.037	.005
.58	.381	.004	-.039	.007
.61	.383	.002	-.035	.005
3494.50	.387	.002	-.038	.003
3495.49	.381	.001	-.039	.003
.53	.382	.002	-.037	.004
.55	.388	.002	-.038	.004
.59	.383	.002	-.042	.005
3496.43	.382	.002	-.036	.004
.44	.378	.001	-.040	.003
3497.44	.392	.001	-.033	.003
3508.34	.380	.002	-.043	.005
3534.31	.379	.003	-.034	.005
3535.31	.391	.003	-.033	.006
3596.30	.373	.002	-.037	.004
3820.48	.386	.003		
3821.55	.385	.001	-.035	.003

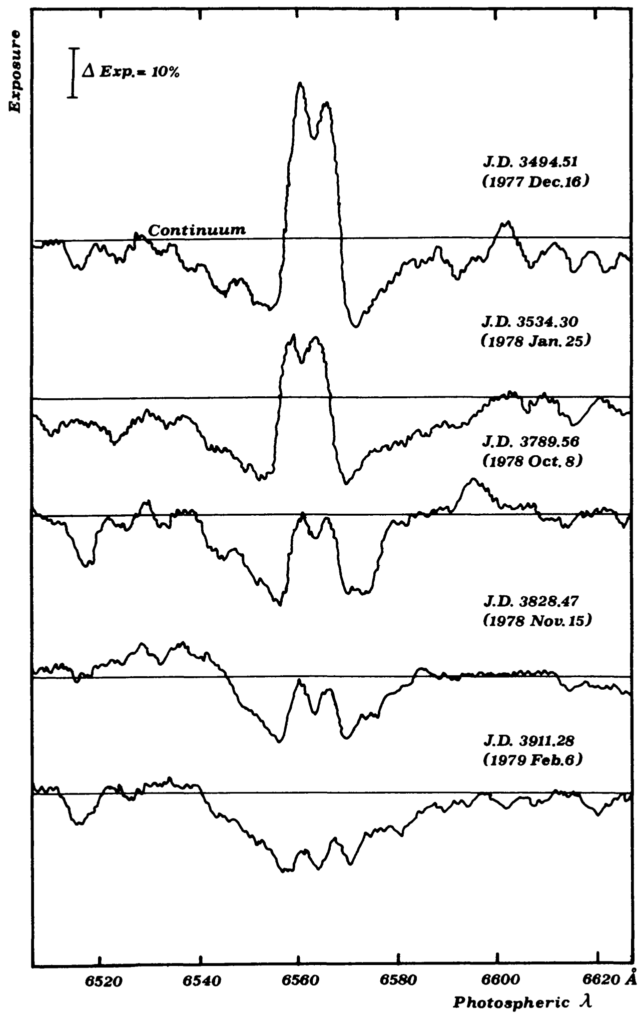

FIGURE 1. — Variations of the H_α profiles (exposure *versus* photospheric λ) during the two observational periods.

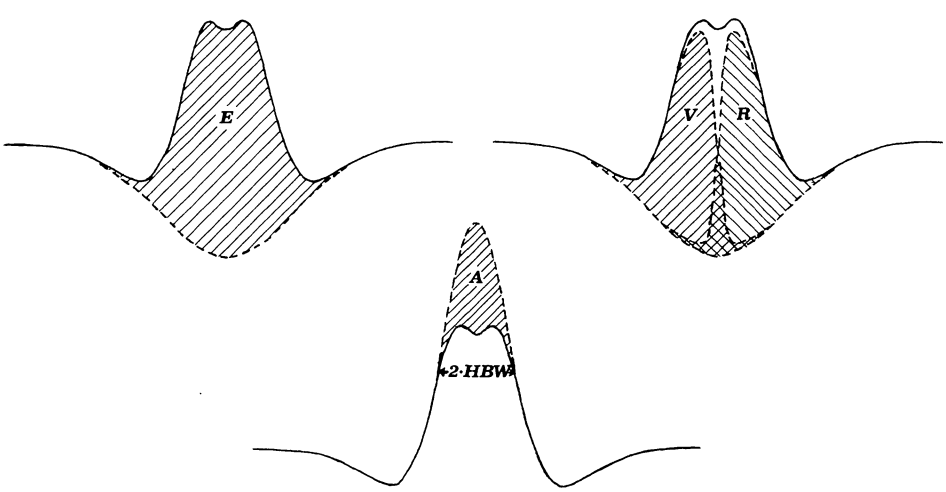

FIGURE 2. — Graphic explanation of the meaning of the parameters *E, V/R, A* and *HBW* used in the text.

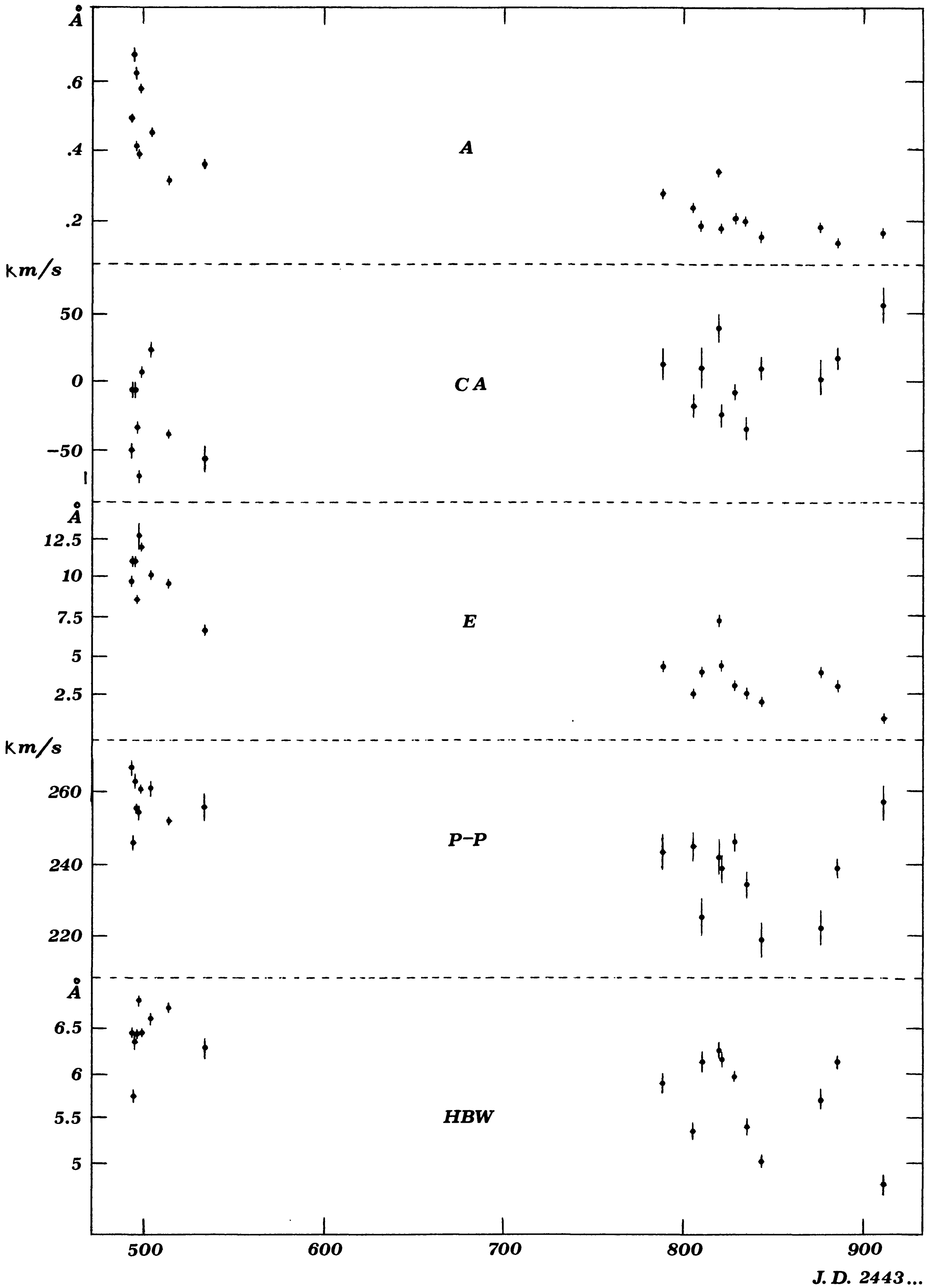

FIGURE 3. — Trends of the quantities *A, CA, E, P-P* and *HBW versus* the observational times.