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ON THE BEHAVIOR OF THE BALMER LINES IN THE SPECTRUM OF P CYGNI IN 1971

(Presented by J. Einasto)

1. Introduction

On the basis of the observational studies it is known [1–4] that the lines in the spectrum of P Cygni have time-dependent parameters. Thus, variations of line intensities and of the positions of some characteristic features in line profiles are observable. Concerning the line intensities there are conclusions mainly about strengthening or weakening at certain time intervals. Conclusions about displacements of line features say somewhat more. M. de Groot [4] has found a period of 114^d in variations of the position of the most violet-displaced absorption component in hydrogen lines. But L. Luud et al. [5] have discovered for the neighbouring absorption component a 57^d-period not found in de Groot's study. Comparing these two results, we cannot be sure of the real behavior of the absorption components. In the present paper we have tried to check it up with the help of the observations that cover some months in 1971.

2. Radial velocity measurements

The near-ultraviolet spectra (15 Å/mm) measured by us are a part of the sample used by L. Luud et al. [5] in their study. We have chosen 29 spectra photographed by O. P. Hollandsky at the Crimean Astrophysical Observatory during 11 nights in the period from May to November 1971. The main differences from the investigation of [5] are:

a) we have measured also the position of the most displaced component a_1 (see Fig. 1),

b) we have used more spectral lines (H_9, ..., H_{13} instead of H_9, H_{10}).

Our spectra have been recorded to have a simultaneous plot of the stellar spectrum and of iron arc spectrum. This method of recording has allowed to measure the positions of line components in the wavelength scale deduced from iron arc spectrum. We have expressed the displacements of these components from the laboratory wavelengths as heliocentric radial

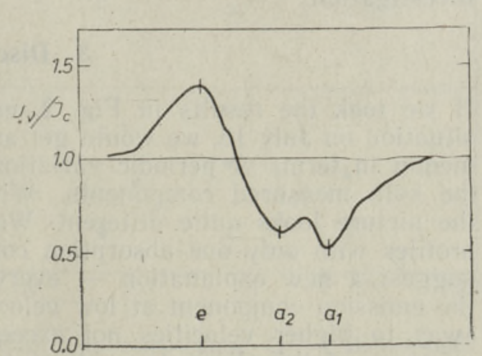


Fig. 1. Typical profile of a higher member of the Balmer series. The positions of different line components are marked.

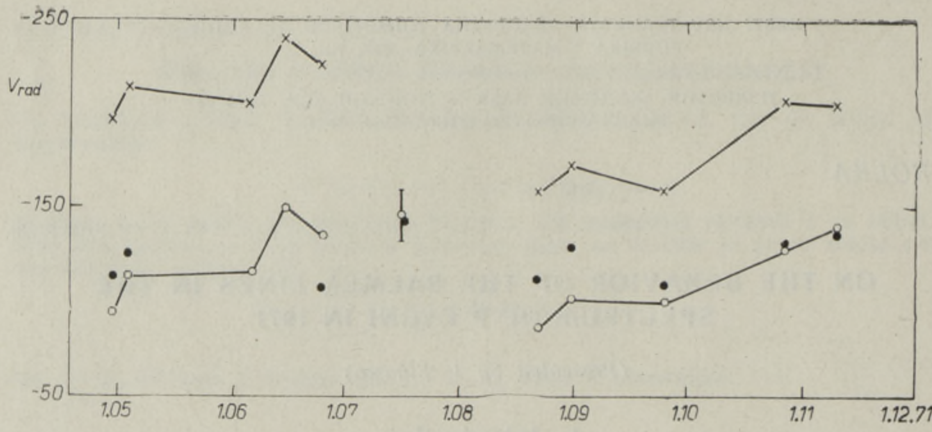


Fig. 2. Mean values of the Doppler-shifts of two absorption components: × — component a_1, ○ — component a_2, ● — mean for a_2 from [5].

velocities corresponding to the Doppler-effect. To have a realistic estimate of the motion velocities in the envelope of P Cygni, we have averaged the results obtained at every observing night. And so in Fig. 2 the mean values have been given and the typical error bar $\pm\sigma$ has also been presented. There are two main reasons for a quite large scatter of individual measurements (± 14 km/s):

a) the spectral resolution has not been high enough,

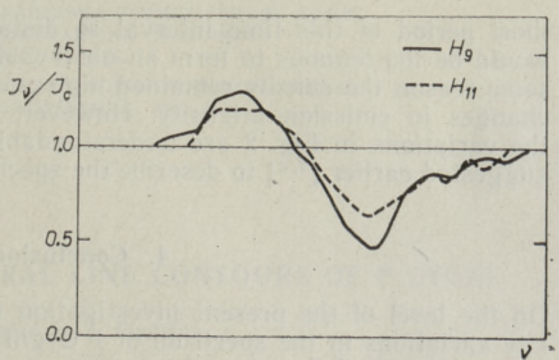
b) it is not easy to distinguish the actual point of the minimum in the broad asymmetrical core of the absorption component (see Fig. 1).

The interstellar lines in the spectrum of P Cygni are sharper and therefore the scatter of measurements has been smaller, e. g. the mean value for interstellar Ca II K-line has been found to be -21 ± 10 km/s. One can compare this result with that of W. S. Adams [6]. He has found from high resolution spectrograms that Ca II interstellar lines are blends of four components, two of which are the main contributors to the line intensity, having velocities —10.8 and —18.6 km/s, respectively. On our records we have not been able to distinguish those components and therefore the comparison has been made with the mean velocity of the components that lies quite well within the error limits of our results. In Fig. 2 we have checked our measurements also with the mean values calculated with the help of the data in [5]. Except for some points, there is a satisfactory accordance. We can conclude that our results give a reliable picture of the radial velocity variations in the period under investigation.

3. Discussion

If we took the results in Fig. 2, excluding the data that describe the situation on July 16, we would get an obvious explanation for the phenomenon in terms of periodic variations that would look very similar for the both measured components. With two spectrograms from July 16 the picture looks quite different. We have found there typical P Cygni profiles with only one absorption component (see Fig. 3). Therefore we suggest a new explanation — every absorption component arisen near the emission component at low velocity with the passing of time, moves away to higher velocities not exceeding the level of —250 km/s. The existence of this limit is understandable with the help of Fig. 4. The

Fig. 3. Spectral line profiles on July 16, 1971.



maximum depth in the most displaced components tends to decrease with the increasing velosity at the values higher than —200 km/s. We suppose that features with Doppler-shifts over —250 km/s are indistinguishable from the noisy continuous spectrum. In general, the trends in the behavior of central intensities of both absorption components (Fig. 4) seem to support our idea of moving individual components one after another rather than the idea of oscillating two components. It is worth mentioning that central intensity of emission does not show any meaningful correlation with changes in the radial velocity picture (Fig. 4 and Fig. 2).

On the basis of our measurements we cannot say to what extent the variations are real inside the limits of main trends in Fig. 2. There may be oscillation — like variations, or perhaps the resolution of the used observations in time is not adequate, and the intrinsic time-scale of the phenomenon is much shorter. However, if the characteristic time ($\sim$ 8 months) we have found is valid, the physical interpretation of this fact is not straightforward. For example, it is difficult to imagine a shell of gas moving so long away from the star at such velocities. With every reasonable estimate for the stellar radius, the shell would be after a

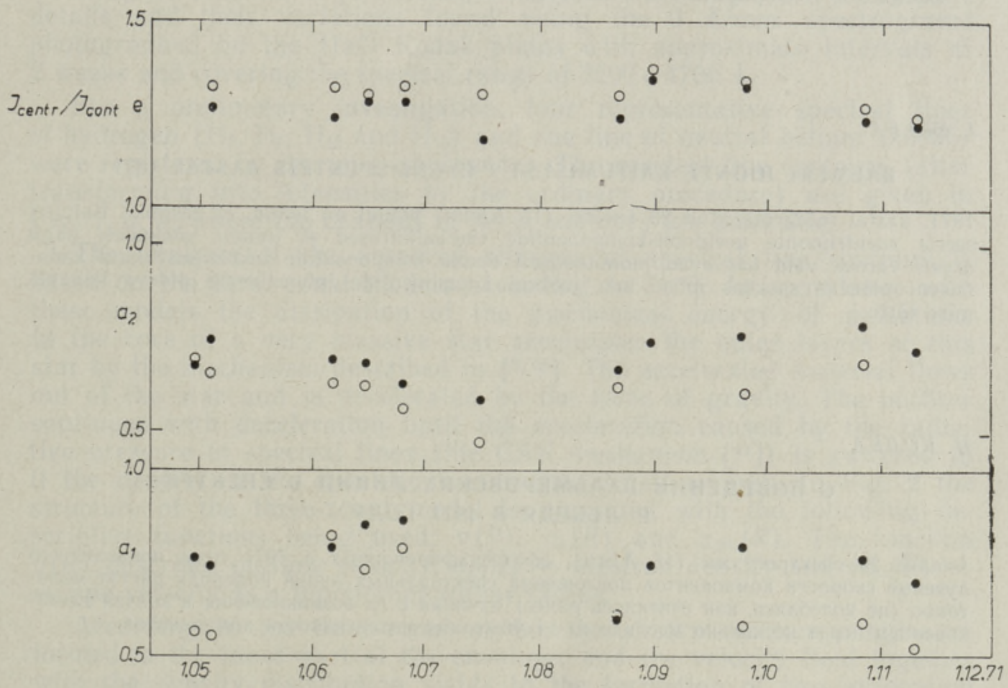


Fig. 4. Relative central intensities of different line components: ○ — Balmer-line H_9, ● — Balmer-line H_{10}.

short period of this time interval so distant from the star that the gas would be too tenuous to form an observable absorption component. If for some reason the density remained high enough, we would observe serious changes in emission intensity. However, we hope that the reasons for the variations in Fig. 2 are understandable in the limits of ADA-models suggested earlier [7, 8] to describe the spectrum of P Cygni.

4. Conclusions

On the level of the present investigation it is plausible that radial velocity variations in the spectrum of P Cygni have one-directional character. To make a final decision about the real nature of this phenomenon, one needs data with higher spectral and time resolution. Only then it is reasonable to check the describing possibilities of different models.

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BALMERI JOONTE KÄITUMISEST P CYGNI SPEKTRIS AASTAL 1971

1971. aastal fotografeeritud 29 spektri (15 Å/mm) põhjal on leitud, et vesiniku Balmeri seeria spektrijoonte neeldumiskomponentide radiaalkiirused ei muutu võnkudes, nagu arvati varem, vaid kasvavad monotoonselt nende komponentide tekkimisest kuni kadumiseni pidevas spektris mõne kuu jooksul komponentide intensiivsuse pideva kahanemise tõttu.

И. КОЛКА

О ПОВЕДЕНИИ БАЛЬМЕРОВСКИХ ЛИНИЙ В СПЕКТРЕ Р ЛЕБЕДЯ В 1971 ГОДУ

Анализ 29 спектрограмм (15 Å/мм), сфотографированных в 1971 году, показал, что лучевые скорости компонентов поглощения спектральных линий водорода растут монотонно (не колеблясь, как считалось ранее) начиная с их возникновения и кончая исчезновением через несколько месяцев из-за убывания интенсивности компонентов.