

## Variability of the H $\alpha$ Emission in the Be Star $\sigma$ Andromedae

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**Abstract.** The parameters of the H $\alpha$  line profile of the Be star  $\sigma$  And were determined from observations carried out during the period 1985 - 1998. At this time the line has undergone significant changes – from a pure absorption photospheric profile with no sign of an envelope in 1985 to the transition into the shell phase with a very narrow and deep absorption component in 1989. During 1991 - 1998 the H $\alpha$  emission remained at the level achieved in 1989. The line profile showed short-term changes. The envelope development in the time interval 1985 - 1998 does not confirm the previously found period of 8.5 years.

### 1. Introduction

$\sigma$  And (HR 8762, HD 217675/6,  $V=3.6^m-3.8^m$ , B6 IIIpe+A2p) is a typical and well studied Be star with evolution of the emission spectrum in appearance B > Be > Be/shell > Be > B, i.e. it passes through all phases from normal B stars to the star with emission in hydrogen lines and narrow shell lines of ionized metals.

$\sigma$  And is a multiple system of at least four stars. The primary component *A* (B5 II-III) is the Be star itself (Hill et al. 1988, 1989). The component *B* is the spectroscopically-double late-type B star system with orbital period  $P=33.085^d$  (Harmanec et al. 1987). The system *A* – *B* has an orbital period 68.7 years (Hartkopf et al. 1996). The speckle-component *a* is a faint star and its mass possible does not exceed  $1 M_{\odot}$  (McAlister, 1987). The significance of the orbital period of the system *A* – *a* is not well known but falls in the range 14 – 3.5 years. Distances between components *A* and *B* are  $0.30''$ , and between *A* and *a* less than  $0.05''$ .

Koubský (1984) traced the 90-year history of emission variability and shell spectrum of  $\sigma$  And. Emission in the hydrogen lines was observed repeatedly by many authors. They attempted to find a period in the profile changes. Schmidt (1959), Pasinetti (1968) and Fracassini & Pasinetti (1975) found a significant period of 31 years. Three phases of the envelope occurring in 1966-1968, 1974-1976 and 1981-1983 gave the typical time scale of the emission spectrum variability of 8.5 years (Harmanec 1984). However, Gulliver et al. (1980) supposed, that the reappearance of the envelope for this star may be more complicated and may

not only obey this period. The interval between reappearance of the envelope totals 5-9 years; the shell-phase duration is from 2 to 7 years; the minimum duration of one cycle is 7 years, and the maximum duration is 16 years.

*o* And shows photometric variability on different time scales: from the period of 1.571275<sup>d</sup> double wave photometric variability to a typical time scale of about 11 - 15 years for long-term variability. The amplitude of the 1.57<sup>d</sup> periodicity seems to increase during maximum of the shell spectrum (Harmanec 1984, Harmanec et al. 1987).

## 2. Observations

All our observations were carried out at the Crimean Astrophysical Observatory with the coude spectrograph of the 2.6-m telescope. The detector was a GEC CCD array P8600 (576×380 pixels) before 1995 and an Electronix CCD array (1024×260 pixels) in 1995 - 1998. We performed the H $\alpha$  observations in the first and second orders of a diffraction grating with a reciprocal dispersion of 6 and 3 Å/mm and with a spectral resolution of 25 000 and 35 000, respectively. We took a 60 (30) Å-long spectrum during each observation. The duration of a single exposure was from 5 to 30 min, and the signal-to-noise ratio was 100-200. In total, we obtained 80 H $\alpha$  spectra between 1985 and 1998.

## 3. Line Profile Variations

We measured the equivalent width and central depth of the H $\alpha$  line. Some H $\alpha$  profiles are represented in Figure 1. As seen from the figure, in the observation period the line suffered considerable changes.

In 1985 (JD2446301-408) the H $\alpha$  line profile was pure absorption with no evidence of an envelope. In 1986 (JD2446588-806) the star showed noticeable H $\alpha$  line profile variability which is non-typical for the majority of Be stars, displaying an increase of its depth and diminution of its FWHM. During this period the line profile made noticeable irregular changes, sometimes becoming almost photospheric (JD24466669-670) and the central depth of the absorption component gradually becomes deeper (Fig. 1a).

The following active phase of *o* And can be related to the time interval between 1987 and 1989 (Fig. 1b). During this period we observed a smooth emission increase with a gradual transition into the shell phase with a very narrow and deep absorption component. Its depth achieves 0.6 continuum units.

During 1991 - 1998 the emission kept to the level reached in 1989. The central depth of the absorption component changed within 0.6 - 0.8 continuum units. Emission of the blue V and red R peaks sometimes exceeded the continuum level by more than 0.1 (fig. 1c).

Emission changes appeared in the line profile: during a small increase of the equivalent width the central depth of the absorption component increases from 0.25 to 0.8 of the continuum level. Variability of the equivalent width and central depth of the H $\alpha$  line from 1985 to 1998 are represented in Figure 2.

As seen from Figure 2, the central depth of the absorption component remains on the level conforming to a high envelope activity pending 8 years. This

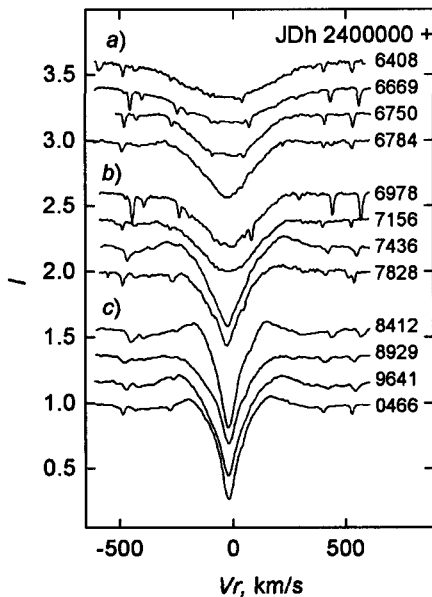


Figure 1.  $\sigma$  And. The  $H\alpha$  line profile variations in the period from 1985 to 1998.

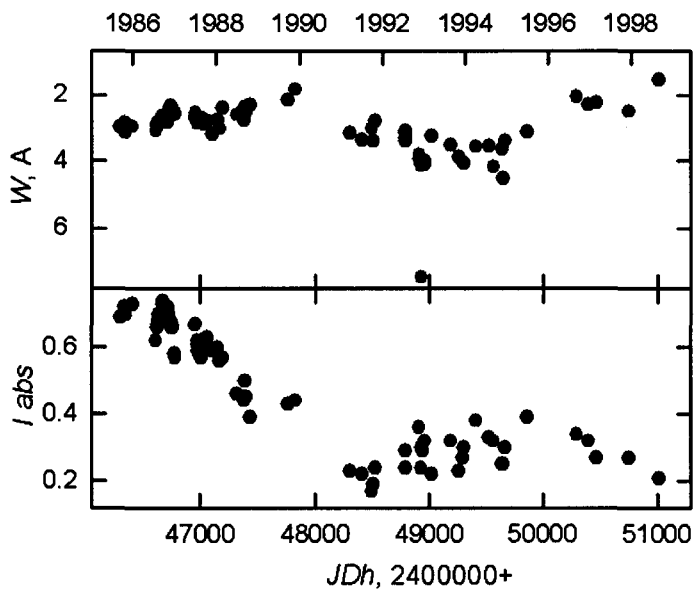


Figure 2.  $\sigma$  And. The  $H\alpha$  line profile variations in the period from 1985 to 1998.

interval exceeds the maximum shell-phase duration stated by Gulliver et al. (1980). It is possibly the full cycle duration which will also exceed the maximum significance stated in their paper. In Figure 2 the extraordinary and rapid (at least a few days) variability of the equivalent width on HJD 2448934 is clearly seen. The  $H\alpha$  line had a for the shell phase normal central depth of  $I_a=0.24$ , but very broad wings.

#### 4. Conclusion

The envelope development during 1985 - 1998 does not confirm the period of 8.5 years. The origin of emission related to other typical time scales. The envelope development takes place smoothly, simultaneously with a slow but considerable depth increase of the absorption component and is accompanied by irregular profile variations and an insignificant increase of the equivalent width. Although the period of our observations does not exceed the maximum duration of one cycle (Gulliver et al. 1980) the envelope existed longer than observed previously.

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