VARIABILITY OF THE Hα EMISSION IN ϕ PER

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Abstract. Photoelectric spectrum scans of the Be shell star ϕ Per in the Hα region have been taken to investigate the variations of Hα emission lines. Definite variations with time-scales of a few minutes have been detected. It is hoped that hydromagnetic instability within the envelope is responsible for such variations.

1. Introduction

ϕ Per is a well-known shell star having strongest Hα emission line. Its binary nature has been well established in literature and it is suggested that the system consists of a B1 primary and a B3 secondary, both of which are emission-line stars (Hendry, 1976). Variations on a long time-scale in Be star spectra are well known (cf. Underhill, 1966). Some studies (Bahng, 1971, 1976; Hutchings *et al.*, 1971; Mcbeath, 1974; Sanyal, 1974; and Slettebak and Reynolds, 1978) indicate the variations in the total emission strength of hydrogen-emission lines with time-scale of 1 to 10 min.

The spectral variations over time-scales of years and months have already been known to exist in Be stars and seem to be real. But a few reports on the spectral variations over time-scales of days, hours, and even minutes seem to be less convincing as has been pointed out by Slettebak and Reynolds (1978). Still it is important to understand the reality and nature of spectrum variations in Be stars. This is an attempt to detect such changes in ϕ Per.

2. Observations

The observations of ϕ Per were obtained during November 1977 to December 1979 on three nights. The star was observed on the 52 cm reflector of the Uttar Pradesh State Observatory with spectrum scanner. The scanner consists of a Hilger and Watts monochromator with a 600 lines mm^{-1} grating used in the first order giving a dispersion of 70 Å mm^{-1}. An exit window of 0.7 mm admitting 50 Å of the spectrum to fall on photomultiplier was used. A cooled (−20 °C) EMI 9658B photomultiplier was used as a detector and standard d.c. techniques were employed for taking observations. Alongwith ϕ Per, the standard stars γ Gem and ξ^2 Cet were also observed for standardising the observations of ϕ Per. The range of the spectrum covered in each scan was $\lambda\lambda$6000–7000 Å. The interval between two successive data points in the line spectrum was 20 Å and in the neighbourhood continuum was 50 Å. The monochromatic instrumental magnitudes of ϕ Per were reduced to absolute values with the help of standard stars. The absolute values correspond to Tug *et al.* (1977) calibration of α Lyr. The

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standard deviation of the measurements on an individual night is $\pm 0^{m}.03$. The monochromatic absolute magnitudes were corrected for interstellar reddening using the value of colour excess, $E(B - V) = 0.04$ (Plavec *et al.*, 1982), $R = 3.25$ (Moffat and Schmidt-Kaler, 1976) and the interstellar reddening curve given by Lucke (1980). The de-reddened magnitudes were converted into fluxes and a plot of line profiles is shown in Figure 1, wherein the time (in UT) and the date of observations are written with each scan. Because ϕ Per is a spectroscopic binary, so we have also indicated the phase of the system to which our observations correspond.

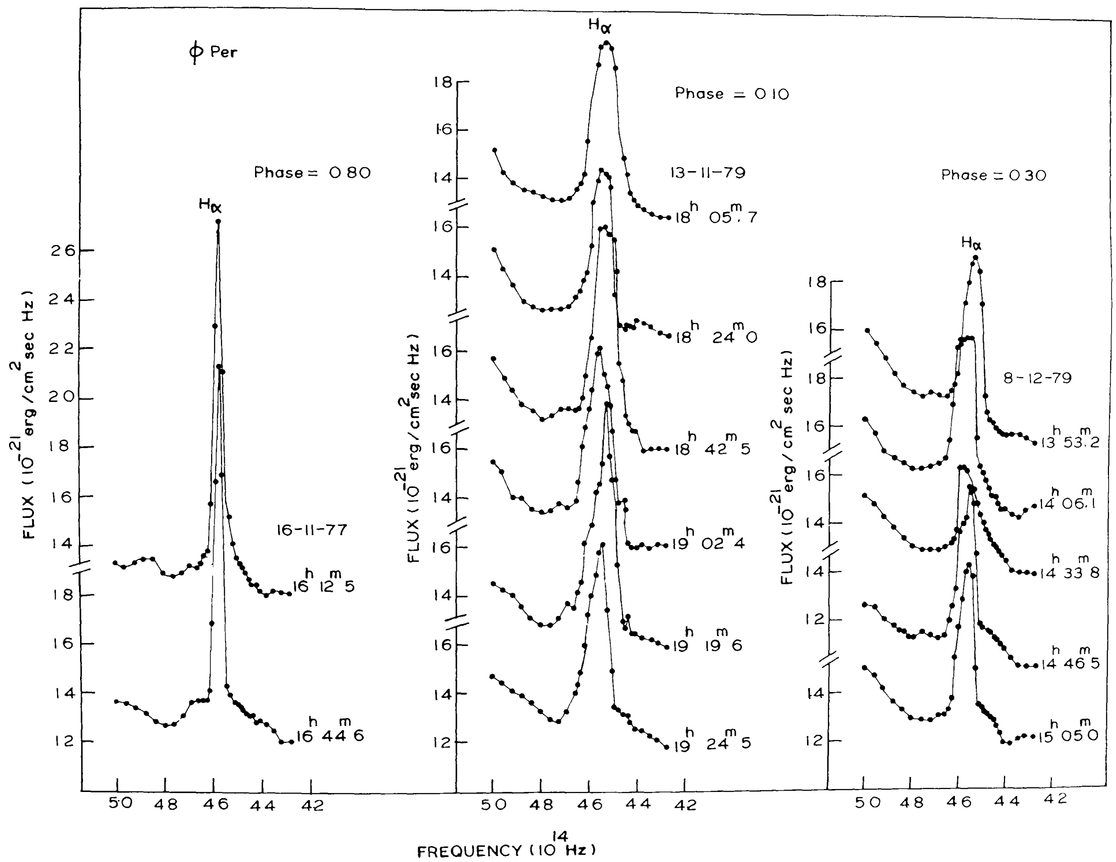

Fig. 1. Hα line profiles of ϕ Per.

3. Results and Discussion

Since the spectral resolution is too low, the line-profile study cannot be made. Study of the V- and R-components separately is also not possible. Only the total energy emitted at Hα lines could be measured. From Figure 1 it is obvious that ϕ Per has undergone appreciable variation in line profiles accompanied by variations of total emission strength over time-scale of years. In November 1977, the Hα emission is seen to be narrow, sharp and strong having the symmetrical profiles. But in November 1979 the Hα emissions were very broad and even asymmetric. Again in December 1979 the Hα emissions were changed to narrow profiles. The variations of emission profiles during an individual night in November and December 1979 are also seen in Figure 1. The variation of total emission line strength on three nights is clearly seen.

Abt and Golson (1966) observed ϕ Per during the interval 1963–1965 and found drastic changes in the period from one month to one year.

Slettebak and Reynolds (1978) have studied the Hα variations of ϕ Per. They noticed the Hα emission symmetrical in December 1975, changing to asymmetrical in November 1976 and becoming asymmetrical again in January 1977. They found a striking change in emission line strength between November 1976 and January 1977. They also found some evidence for night-to-night variations during December 1975.

It is clear from Figure 1 that the short-term variations observed at Hα line in ϕ Per are significant and make it possible to establish that short-term time variations do exist in ϕ Per. Although ϕ Per has been reported as a binary, these rapid changes cannot be explained in terms of the binary orbital motion (Delplace, 1970). Also, these variations cannot be related to oscillations or pulsations of the star or shell, since the observed time-scale is much too short. As yet, no satisfactory theoretical models exist to explain these rapid phenomena. The short-term time variations in ϕ Per can be related to the possibility of hydromagnetic instabilities within the envelope. Whatsoever, the mechanism of envelope formation may be, if there are pre-outburst photospheric magnetic field strengths of the order of tens of gauss or more and if the outward velocities within the inner part of the envelope are quite small with respect to the circular components of velocity there, then the mass motions within the inner portions of the envelope by the effect of combination of differential circular motion and outward motion, will lead to severe stretching and winding around of the magnetic field lines until conditions would become favourable for the snapping and reconnection of field lines. Quite possibly such snappings and reconnections of field lines will take place from time-to-time within the envelope giving rise to flare-like outbursts. These outbursts may be interpreted as being responsible for the short-term time variations in the range of minutes to hours that have been observed in the profiles and integrated strengths of Hα emission-lines in ϕ Per.

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