

Spectrophotometric observations of some Be stars

Mahendra Singh and B.B. Sanwal

Uttar Pradesh State Observatory, Manora Peak, Naini Tal 263 129, India

Abstract. Using EG & G spectrograph coupled with reticon array detector and Optical Multichannel Analyser (OMA) at the Cassegrain focus of the 104 cm telescope of the U.P. State Observatory, Naini Tal, several well known bright Be stars were observed in the visible region of the spectrum. Their effective temperatures and gravities were estimated by superposing the theoretical atmospheric modes of Kurucz (1991) over the observed energy distribution curves of the stars. The equivalent widths of the Balmer emission lines for these stars were also determined. For Pleione and γ Cas, the change in equivalent widths with time was noted and the possible reason for this change was discussed.

1. Introduction and observations

The Be stars 17 Tau, 28 Tau, ζ Tau, ϕ Per, ψ Per and γ Cas were observed on Nov. 2 and 3, 1993 using EG & G spectrograph coupled with OMA and reticon array detector. The observational technique and the instrumentation used are described in our earlier paper (Sanwal *et al.* 1994). The dispersion of the spectrograph using a 300 grooves/mm grating is $2.5\text{\AA}/\text{pixel}$. Our reticon array consists of 1024 elements of size 2 mm \times 25 microns. Thus the data points are sampled at an interval of 2.5\AA . The standard star α^2 Cet was also observed alongwith the programme stars for evaluating the nightly extinction coefficients and to obtain the standard magnitudes. A computer programme was written for determining the standard magnitudes at individual wavelengths taking into account the nightly extinctions and interstellar reddening corrections for each stars. Transformation of observations to absolute flux values were carried out with the help of the calibration given by Taylor (1984). To determine the interstellar reddening, the colour excess $E(B - V)$ values determined through distance modull method taken from Goraya (1985) were used.

Through a computer programme the equivalent width for the H_α emission lines were determined by calculating the area under the line profiles.

2. Result and discussion

The energy distribution curves for the observed stars are given in Figures 1 - 7. On the X-axis wavelength (in nanometers) and on the Y-axis the flux (in ergs / cm² / sec / hz / sr x const) are plotted. Appropriate theoretical models of Kurucz (1991) are also plotted alongwith the observations to determine the effective temperatures and gravities for these stars. The dotted lines denote the observations and the continuous lines represent the model atmosphere. Their estimated temperatures (in degree kelvins) and gravities are also given in the corresponding figures. Except for the star ϕ Per, the effective temperatures are in good agreement with their spectral type. Since ϕ Per is a spectroscopic binary Be star whose primary component is suggested to be an early B1 type star and the secondary as a K type giant filling its Roche Lobe (Peters, 1976), so, its resultant energy distribution curve may show lower temperature.

For some Be stars namely ϕ Per (eq. width 35.3 Å), ψ Per (eq. width 41.9 Å), 28 Tau (eq. width 37.8 Å) and γ Cas (eq. width 35 Å) the H $_{\alpha}$ equivalent widths are relatively very high 28 – 42 Å and for other stars namely 17 Tau (eq. width 12.8 Å) and 23 Tau (eq. width 12.6 Å) the H $_{\alpha}$ equivalent widths are relatively smaller in the range of 7 - 13 Å.

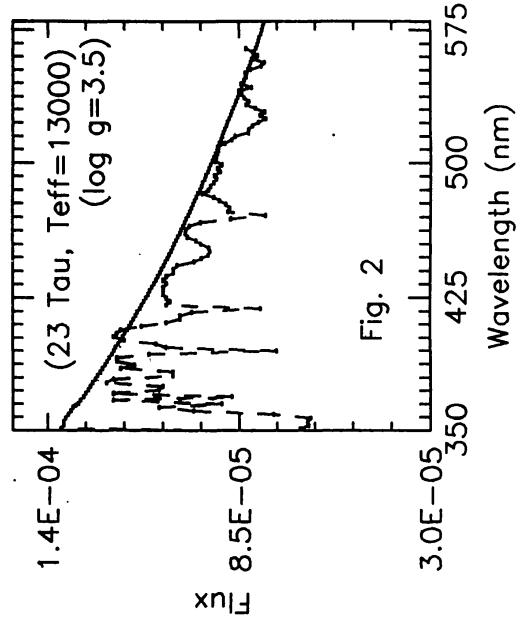
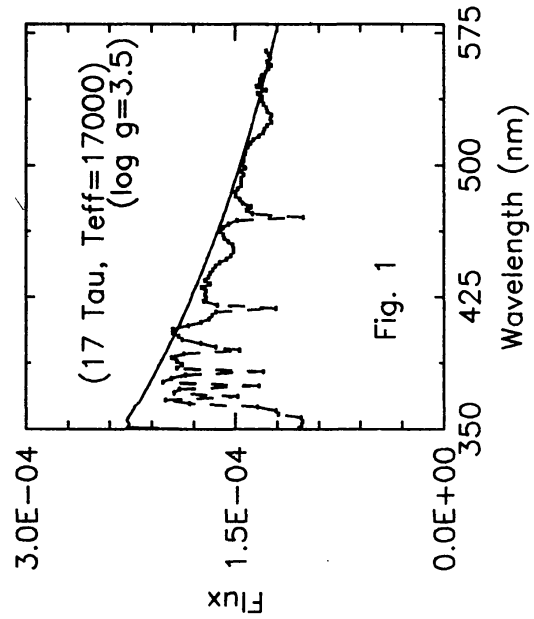
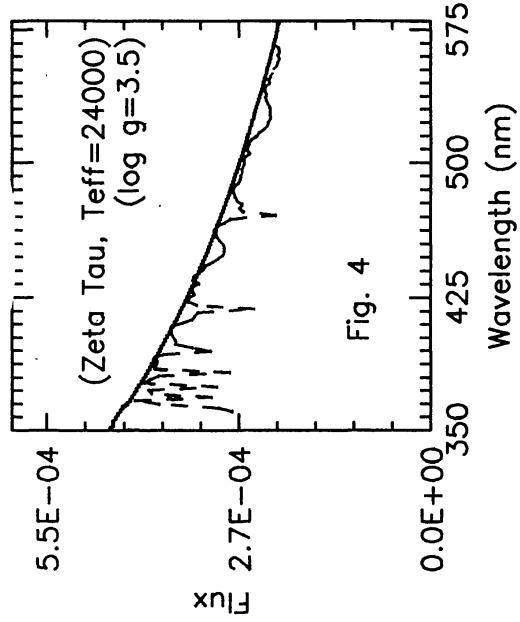
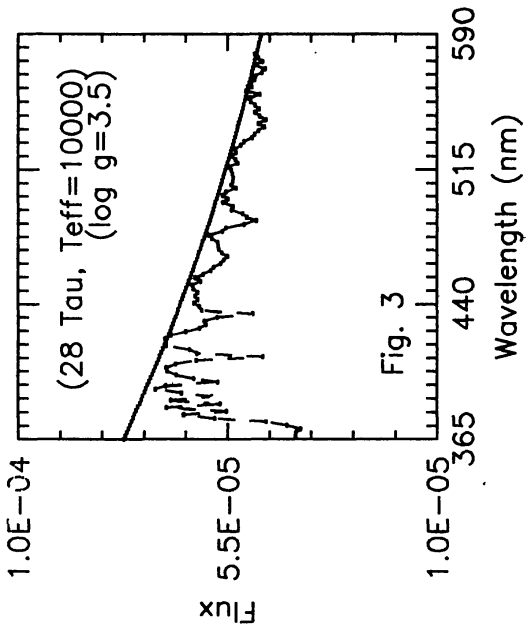
3. Pleione (28 Tau) : A new Be phase

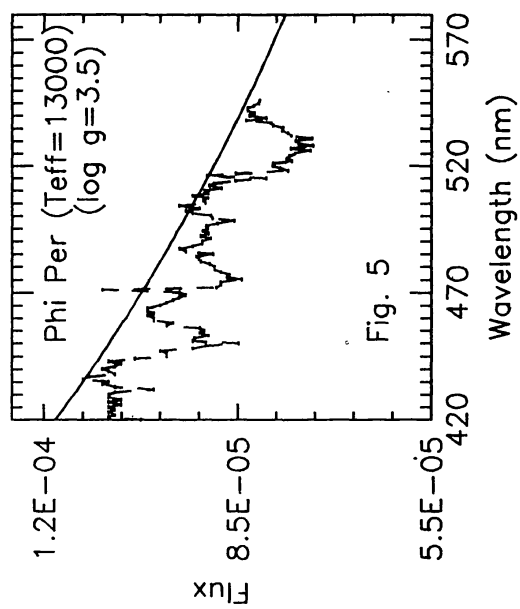
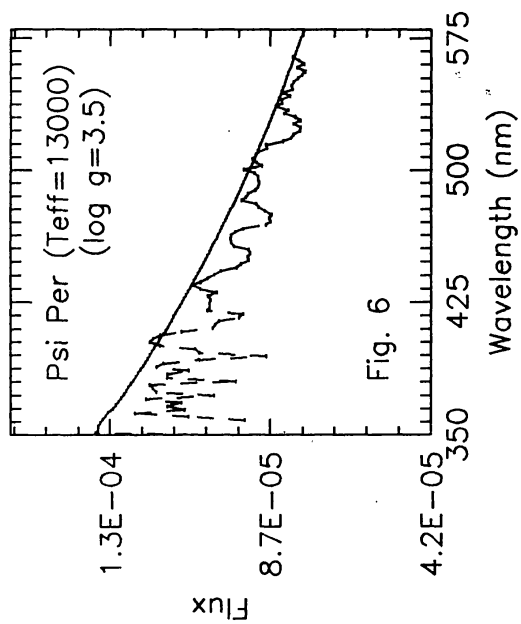
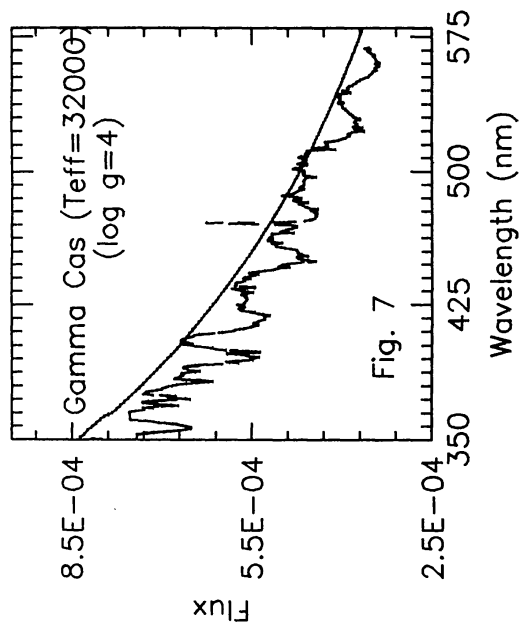
Phase transition is the most striking feature of the variability in Be stars. A few Be stars exhibited the phase transition of B-Be, B-shell and vice versa. Pleione is one of these stars. Since it was discovered to be a Be star, it has undergone one B star phase, two Be phases and two shell phases (Kogure, 1990). The shell strength of the last shell phase, which began in 1972-73 reached the maximum around 1981 (Goraya *et al.*, 1987). Since 1986, a number of authors have pointed out that the shell phase was ending since 1986 (Chauville and Ballereau, 1986 and Guo, 1988). Recently, Guo (1993) has presented the equivalent widths and maximum intensity (I_{\max}) relative to the adjacent continuum of the H $_{\alpha}$ profiles observed during December 1991 – January 1993. The equivalent width changed from 26 Å to 33 Å. An increasing trend of equivalent width with time (1981–1994) was also reported by Ballereau and Chauville (1994) for the H $_{\beta}$ line. The equivalent widths measured by us also lie within this range.

Taking into account the above observations we can infer that the Pleione has again entered a Be phase since the end of 1991 as occurred during 1960–1964 (Hirata & Kogure, 1976). All these changes in the structure of the Pleione shell support the phase changing model proposed by Kogure (1990).

4. γ Cas : Fluctuations in equivalent widths

The Be star γ Cas has always been of the special interest to observers because of its several variable nature. The star was observed by Guo *et al.*, (1994) on Nov. 5 and 6, 1992. They noticed rapid fluctuations in equivalent widths on a time scale of about 45 minutes. The equivalent width measured by us is nearly double of Guo *et al.*, (1994). However, we could





not notice such fluctuations which may be because of insufficient observations in that time interval. The change in equivalent width indicates that some material in the envelope has fallen back on the central star at the time of observations.

5. References

- Ballereau D., Chauville J., 1994, IBVS No. 4095.
Chauville J., Ballereau D., 1986, IAU Cir. No. 4282.
Goraya P.S., 1985, Ph.D. Thesis, Punjabi Univ., Patiala.
Goraya P.S., Tur N.S., Rautela B.S., 1987, IBVS No. 3052.
Guo, Yullian, 1988, Be star Newsletter, No. 19, 24.
Guo, Yullian, 1993, IBVS, No. 3922.
Guo, Xiao-zhen, Wang, Jun-jie, Jiang, Shi-yang, 1994, IBVS No. 4035.
Hirata R., Kogure T., 1976, PASJ, 28, 509.
Kogure T., 1990, Astrophys. Space Sci. 163, 7.
Kurucz R.L., 1991, CD ROM No. 13 (private communication).
Peters G.J., 1976 in Be and shell stars, IAU Symp. No. 70, ed. A. Slettebak, Dordrecht, Reidel, p. 417.
Sanwal B.B., Rautela B.S., Singh M., Srivastava J.B., 1994, Earth, Moon and Planets, 64, 130.
Taylor B.J., 1984, ApJS, 54, 259.