RECENT CHANGES IN THE SPECTRUM OF THE Be STAR 48 PERSEI

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Abstract. A search of rapid and slow spectral variations of Balmer lines with time resolution from seconds, minutes, months, and years is carried out for 48 Per. In total, 40 spectral scans in the Hα and 13 spectral scans in the λλ3500–5300 Å region were secured during 6 nights. The results of this study show that, in general, there are rapid variations of Hα at the limit of the noise level. Large changes with time scales of months and years in Hα and higher Balmer lines have been investigated for the first time in 48 Per.

1. Introduction

The Be star 48 Per (B3Vpe; $m_v = 4.0$; $v \sin i = 215$ km s^{-1}) originally classified by Slettebak (1949) as 'pole-on' star was observed many years age to have double emission lines (Burbidge and Burbidge, 1953). Underhill (1960) obtained the spectra of 48 Per in 1953 and found double emission lines. Although, the resolution at Hα was insufficient to show the doubling, but the Hα profile was asymmetric in a manner suggesting a doubling, as at Hβ. Ruusalepp (1982) has reported that the inclination i of this star is of the order of 34–40°.

Observed from 1953–1976, this star exhibited only a slight change in emission. Hα was a strong bright line, Hβ a moderate bright line centrally superposed on a broad absorption, Hγ a sharp, weak bright line on a broad absorption. Between 1963 and 1968, a maximum of intensity of the emission was observed, then a weak emission was present centrally on the absorption Hδ line (Hubert-Delplace and Hubert, 1979).

Bahng (1976), using a low-resolution scanner, found marginal 'short-period' variations in the strength of Hα in 48 Per in December 1973. Slettebak and Reynolds (1978) observed an apparent difference of Hα profile in 48 Per between December 1975 and November 1976. But it was uncertain whether this was a real change.

This paper identifies that 48 Per has most recently entered a state of active variability, as indicated by changes in the line profile of emission at Hα and higher Balmer lines.

2. Observations

48 Per was observed during 1981–1983 on six nights. The observations were made with the 52 cm and 104 cm reflectors. The scanner used for obtaining spectral scans consists of a Hilger and Watts monochromator as described earlier (Goraya, 1985). An exit slit of 28 Å band pass was used for taking observations. The summary of observations is given in Table I.

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TABLE I

Observations of 48 Persei

UT date	Wavelength region	Number of scans	Total monitoring time	Reflector	Configuration	Remarks
14 Oct., 1981	λλ6300–6800 Å	9	17^m00^s	104 cm	Cassegrain	Hα line of moderate emission strength.
17 Nov., 1981	λλ6300–6800 Å	5	9^m40^s	52 cm	Nasmyth	Hα line in absorption.
19 Nov., 1981	λλ3500–5300 Å λλ6300–6800 Å	4 4	55^m20^s	52 cm	Nasmyth	Hα line in absorption. Higher Balmer lines are also in absorption.
2 Nov., 1982	λλ3500–5300 Å λλ6100–7000 Å	5 15	14^m51^s	104 cm	Cassegrain	Hα line strongly in emission. Higher Balmer lines are also in emission.
26 Nov., 1982	λλ3500–5300 Å λλ6100–7000 Å	4 4	6^m00^s	104 cm	Cassegrain	Hα line strongly in emission. Higher Balmer lines are also in emission.
22 Nov., 1983	λλ6100–7000 Å	3	11^m41^s	104 cm	Cassegrain	Hα line strongly in emission.

To evaluate the instrumental contribution to any observed profile variations, the absorption-line standard star ξ^2 Cet was observed many times every night. This procedure shows that long- and short-term instrumental variability does not exceed the limit at which the variations occurred in 48 Per.

The observations of 48 Per and ξ^2 Cet were made with two different recorders at different recording speeds and scanning speeds. The observations on 14 October, 17 and 19 November, 1981 were made with Honeywell strip chart recorder driven at a speed of 2-inch per minute and the scanning speed of 250 Å per minute. The observations on the remaining three nights, i.e., on 2 and 26 November, 1982 and 22 November, 1983 were made with Hewlett–Packard recorder driven at a speed of 12 inch per minute and the scanning speed of 2500 Å per minute. One can clearly distinguish that the quality of spectrum scans obtained with Hewlett–Packard recorder is much better than those obtained with Honeywell strip chart recorder.

3. Results

The spectrum scans of 48 Per are shown in Figures 1 and 3. In Figure 1 only Hα lines are shown as observed on six nights. The Hα scans of ξ^2 Cet are shown in Figure 2 for

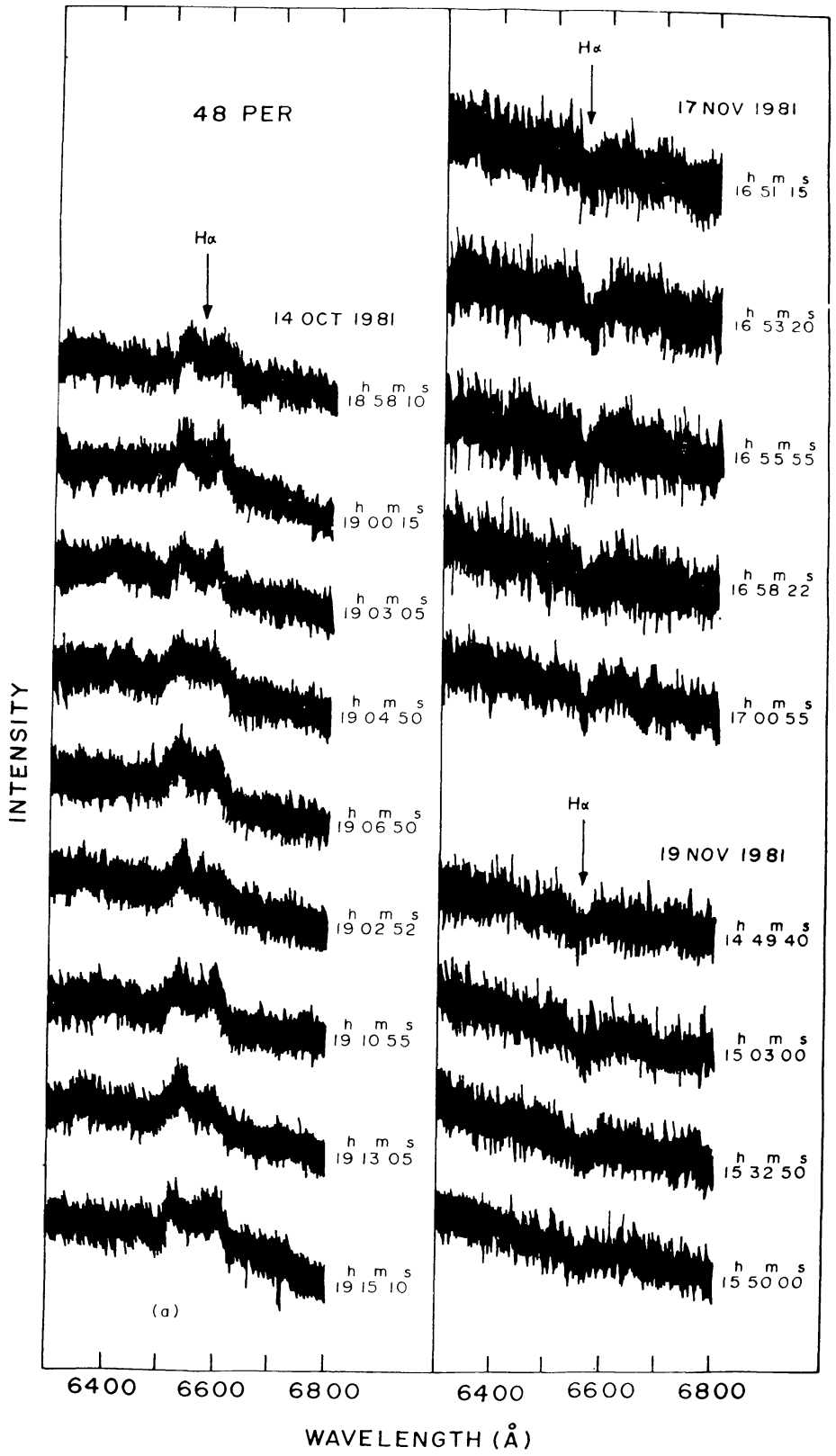

Fig. 1a.

Fig. 1a–b. Spectrophotometric scans of 48 Per in Hα region. The time is given in UT.

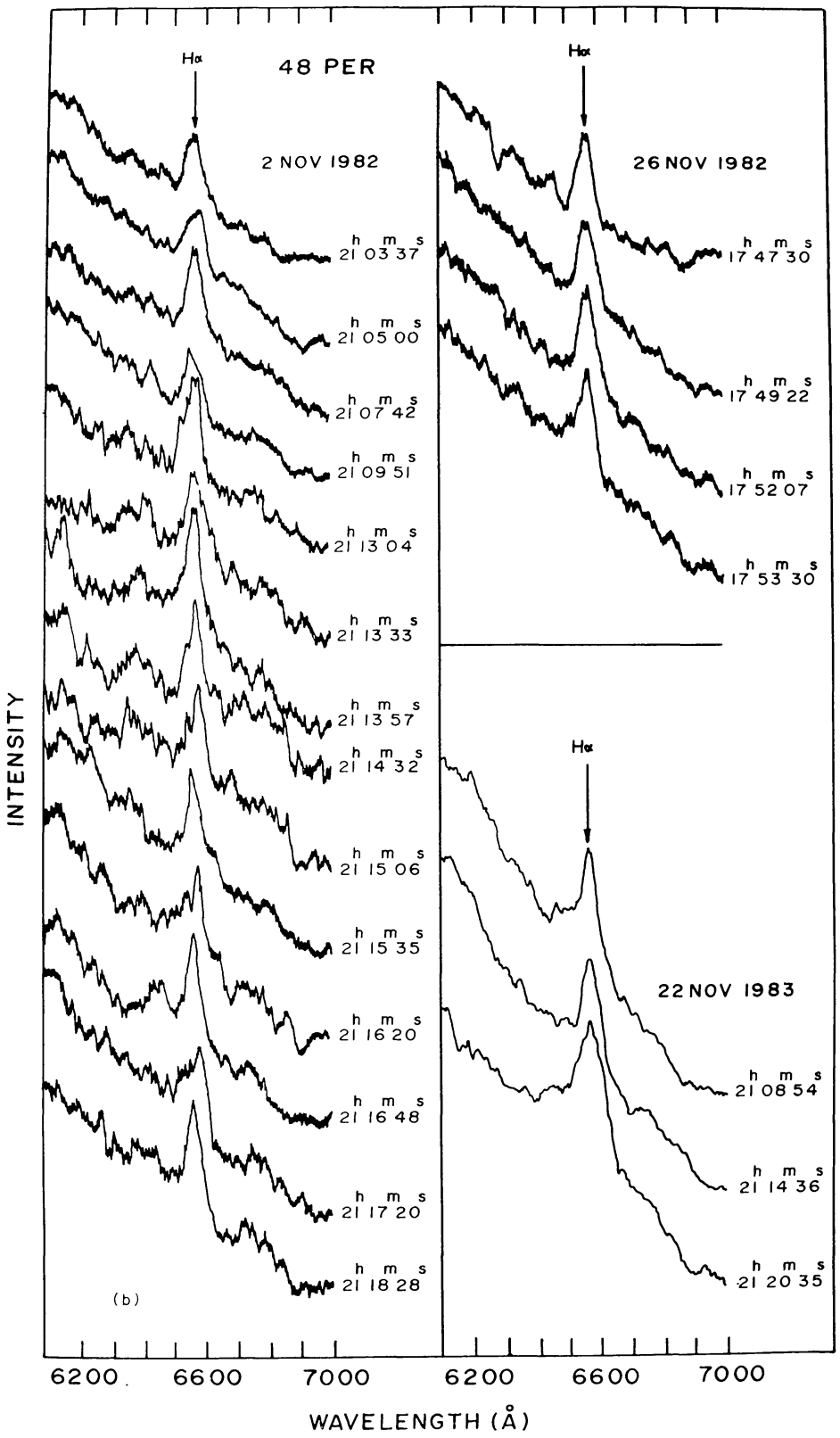

Fig. 1b.

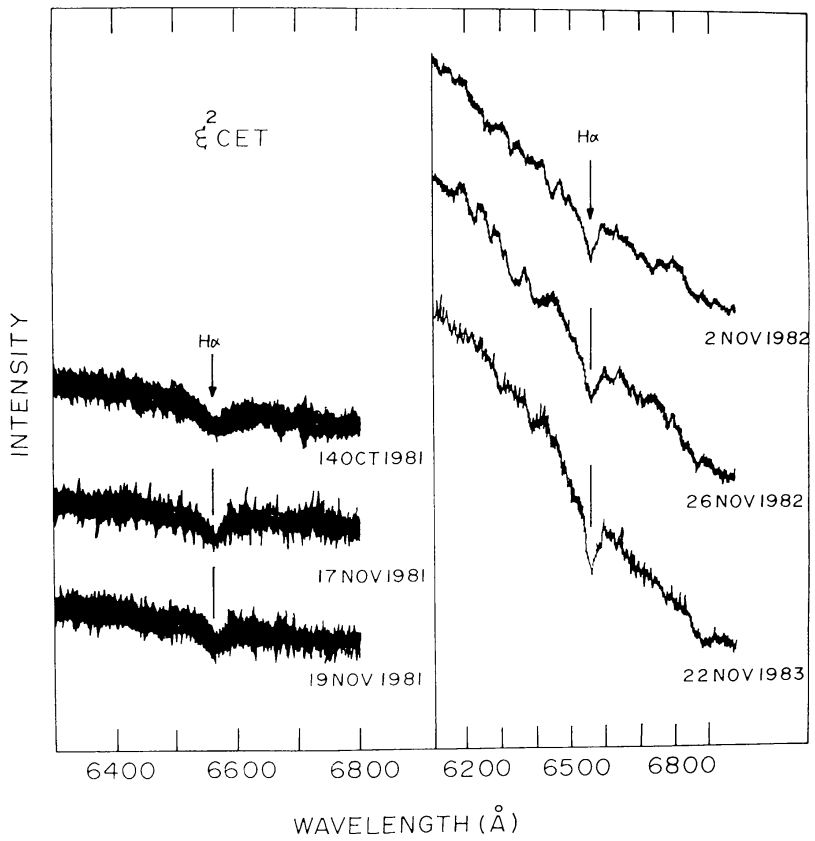

Fig. 2. Spectrophotometric scans of ξ^2 Cet in Hα region. The time is given in UT.

comparison. In Figure 3 are shown the scans of 48 Per along with ξ^2 Cet in the higher Balmer lines region.

3.1. Rapid variations in Hα

To investigate rapid variations in Hα line we have observed 48 Per with the smallest possible time resolution (30 seconds–2 minutes) as is shown in Figure 1. From the Hα scans obtained on 2 November, 1982 it is clear that rapid variations with time scales of the order of 30 s are present in 48 Per. The observations of Hα line obtained on 14 October, 1981, 2 and 26 November, 1982 show small variations of Hα line with time scales ~ 2 min.

3.2. Slow variations in Hα

Definite slow variations of Hα lines are detected in 48 Per as is shown in Figure 1. Observations of Hα on 14 October, 1981 show that Hα line has moderate emission intensity with two separately resolved components. The Hα line was broad superposed on broad underlying absorption. The Hα scans obtained one month later on 17 and 19 November, 1981 show large variations in Hα line. The emission line was changed

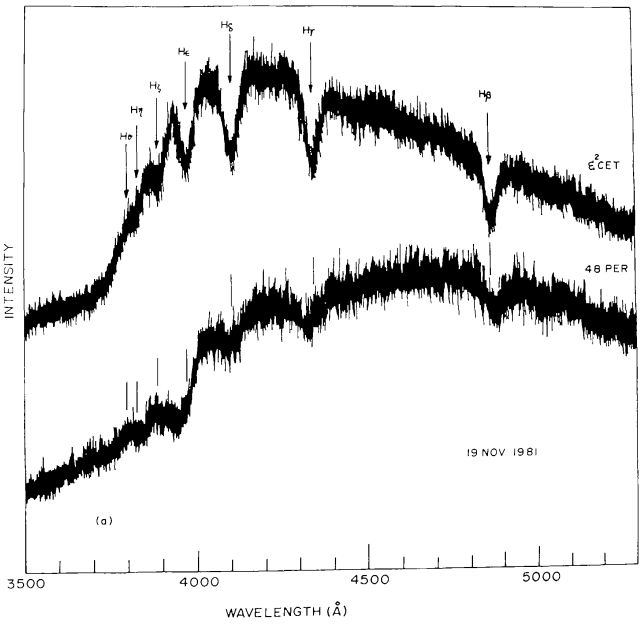

Fig. 3a.

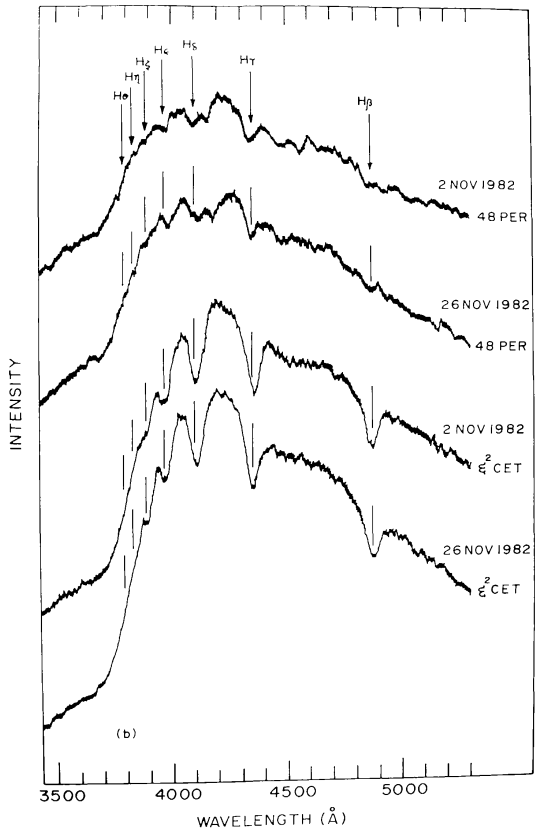

Fig. 3b.

Fig. 3a–b. Spectrophotometric scans of 48 Per and ξ^2 Cet in higher Balmer lines region. The time is given in UT.

to absorption (Figure 1a). The observations obtained after one year on 2 and 26 November, 1982 show Hα line strongly in emission again. The Hα emission of nearly same strength was also observed on 22 November, 1983.

3.3. Slow variations in higher Balmer lines

Figure 3 displays the spectrum scans of 48 Per alongwith ξ^2 Cet obtained on three nights in the lower wavelength region. It is obvious from Figure 3a that 48 Per has Balmer lines in absorption on 19 November, 1981. However, the spectrum scans obtained on 2 and 26 November, 1982, as shown in Figure 3b, show that the underlying absorptions were filled-in by emission lines. The same behaviour has been seen in Hα line as described earlier. Thus, 48 Per is among those stars which can lose their emission features with several months and years interval and vice versa.

4. Discussion

Although variability is a fundamental characteristic of Be stars but the episodes of variability are transient and occur at irregular intervals. Be stars variability with time scales of days, months, and years is well established (e.g., Underhill and Doazan, 1982). The numerous of Be stars have shown changes in brightness, colour and emission line profiles. Also, there are many Be stars which can lose their emission features with several years interval and vice versa (Hubert-Delplace and Hubert, 1979; Jaschek *et al.*, 1980).

Barker (1983) has identified some Be stars which more recently entered a state of active variability as he concluded from the significant emission-line variability at Hα line. Slettebak and Reynolds (1978), Hubert-Delplace and Hubert (1979), Andrillat and Fehrenbach (1982), Slettebak (1982), and Chalabaev and Maillard (1983) have reported the variations of many Be stars at Hα.

To formulate the dynamical theories applicable to the emission-line B-type stars, it is of vital importance to understand observationally the nature and time scales of the spectral variations exhibited by these objects. The earlier works, which claim the reality of the rapid variations of the line profiles are: Hutchings *et al.*, 1971; Luud, 1978; Mamatkazina, 1978; Slettebak and Snow, 1978; Bijaoui and Doazan, 1979.

The present paper has identified that 48 Per exhibited strong variations in Balmer lines and has entered a state of active variability. This is a first attempt to discover such significant real spectrum changes in 48 Per. Observations of 48 Per from 1953–1980 show that this star did not display any significant real change in its spectrum. Only slight apparent changes in emission have been recorded for this star prior to 1981. The present observations suggest that 48 Per is among those Be stars which can lose their emission features with several months and/or years interval and vice versa.

5. Conclusions

The present results show that in a small time scale (30 seconds–2 minutes) the spectra of the Be star 48 Per in the Hα region are variable which is evident from the observations

obtained on 2 November 1982. Rapid distortions of the Hα line profile is due, most likely, to the effects of mass loss from the central star to the envelope and vice versa. The slow changes of Hα and higher Balmer lines are shown to exist. Unambiguously, the strong variations from average emission to absorption and again to strong emission occurred in 48 Per which indicate that 48 Per is currently displaying active emission variability.

References

Andrillat, Y. and Fehrenbach, Ch.: 1982, *Astron. Astrophys. Suppl.* **48**, 93.
Bahng, J. D. R.: 1976, in A. Slettebak (ed.), 'Be and Shell Stars', *IAU Symp.* **70**, 41.
Barker, P. K.: 1983, *Publ. Astron. Society Pacific* **95**, 996.
Bijaoui, A. and Doazan, V.: 1979, *Astron. Astrophys.* **73**, 285.
Burbidge, G. R. and Burbidge, E. M.: 1953, *Astrophys. J.* **117**, 407.
Chalabaev, A. and Maillard, J. P.: 1983, *Astron. Astrophys.* **127**, 279.
Goraya, P. S.: 1985, *Astron. Astrophys.* **138**, 19.
Hubert-Delplace, A. M. and Hubert, H.: 1979, *An Atlas of Be Stars*, Observatoire de Meudon, Paris.
Hutchings, J. B., Auman, J. R., Gower, A. S., and Walker, G. A. H.: 1971, *Astrophys. J.* **170**, L173.
Jaschek, M., Hubert-Delplace, A. M., Hubert, H., and Jaschek, C.: 1980, *Astron. Astrophys. Suppl.* **42**, 103.
Luud, L.: 1978, *Pis'ma Astron. Zh.* **4**, 454.
Mamatkazina, A. V.: 1978, *Trudy Astrofiz. Inst. Alma-Ata USSR* **31**, 73.
Ruusalepp, M.: 1982, in M. Jaschek and H.-G. Groth (eds.), 'Be Stars', *IAU Symp.* **98**, 303.
Slettebak, A.: 1949, *Astrophys. J.* **110**, 498.
Slettebak, A.: 1982, *Astrophys. J. Suppl.* **50**, 55.
Slettebak, A. and Reynolds, R. C.: 1978, *Astrophys. J. Suppl.* **38**, 205.
Slettebak, A. and Snow, T. P.: 1978, *Astrophys. J.* **224**, L127.
Underhill, A. B.: 1960, *Contri. Dom. Astrophys. Obs. Victoria*, B.C. No. 68.
Underhill, A. B. and Doazan, V.: 1982, *B. Stars With and Without Emission Lines*, NASA SP-456.