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The Be Phenomenon in Pleione

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Abstract. The spectral change of Pleione in the present Be phase (1988-1999) is briefly described. The Hα emission reached its maximum in 1995-1999. The V/R values of Hγ and metallic lines changed from $V/R < 1$ in 1995 to $V/R > 1$ in 1998-1999. The broad component of Mg II λ4481 line further weakened in Be phase.

The long-term variation in 1968-1999 is shown for several observational quantities. These quantities which reflect various levels from the photosphere up to the outer envelope did not change in a parallel way. The basic unsolved problems are pointed out.

1. Present Be phase

Pleione entered a new Be phase in late 1988, after the 16-year shell phase. Its optical spectrum in the present Be phase is characterized by:

1) the gradual increase of the Hα emission, reaching its maximum in 1995-1999, accompanied by prominent metallic emission lines even in the blue region (Figure 1.). The Balmer decrement was steeper than that in case B ($I\alpha : I\beta : I\gamma = 3.1 : 1.0 : 0.12$ in 1995 Feb.).

2) the onset of the V/R variation at the epoch with maximum Hα as in the previous Be phase in 1960–1970 (Figure 1.). Both Hγ and metallic emission profiles changed from $V/R < 1$ in 1995 February to $V/R > 1$ in 1998 August and 1999 February and satisfy the characteristic of the so-called V/R variation, although the emission profiles in the preceding progression phase also satisfy this characteristic. So, the Keplerian disk had been established in this phase at the latest.

3) the weakening of the Mg II λ4481 broad component as if its spectral type changed from B9 to B7 in 1995 and 1999 (Figure 1.). Notice that the strength of He I λ4471 is equal to that of Mg II λ4481 at B8 in its definition of MK spectral classification.

2. The long-term variation

Figure 2 shows the long-term variation of Pleione in 1968-1999 for the following quantities (from the top to the bottom): the U and V magnitudes, the aver-

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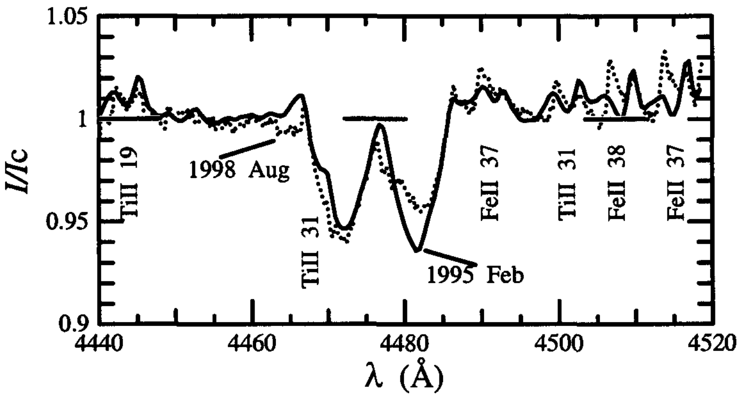

Figure 1. The spectrum of Pleione in the He I λ4471 + Mg II λ4481 region

aged equivalent width of Fe II shell lines (mÅ), the equivalent width of the Hα emission (Å), the equivalent width of Ca II K broad absorption component (Å), the fitted log g (cm s^{-1}) for the Hβ wing part, and the equivalent width of the Mg II λ4481 broad absorption component (Å). Except for the U and V magnitudes (Hirata 1995, Sharov & Lyutyi 1997), the filled circle represents our own material and the open circle is based on our collection. Various observational quantities do not vary in a parallel way:

- The strength of Ca II K very broad component reached its maximum in 1976 and faded out just at the shell maximum.

- The fitting of the Hβ and Hγ wings to the rotationally broadened profiles implies that their strengths have a correlation with the V magnitude. That is, they weaken when the V magnitude becomes fainter. This behavior cannot be interpreted in terms of the veiling effect by the disk and implies that the variation of V mag. and Balmer wings occur in the photospheric level or in between the photosphere and the disk.

- The Mg II λ4481 broad absorption component also varied with a factor of two. The maximum attained at the shell maximum. This indicates that it reflects the inner part of the disk or the region between the photosphere and the disk. The He I λ4471 seems not to show such a large variation (within a factor of 1.3), though heavy blend with metallic shell lines in the shell phase prevents the accurate determination.

- The Hα emission in the latest shell phase increased until the Ca IIK broad component reached its maximum (1976) and then kept constant until the shell maximum (1982). It started to increase again when the shell strength began to decrease, accompanied by the Balmer progression. It continued to increase until 1994 through the declining shell phase and subsequent

Be phase. It reached its maximum in 1995-1999, during which the V/R variation began. The peak separations of the Hα and Hβ emission profiles monotonously decreased from the initial shell phase to 1995.

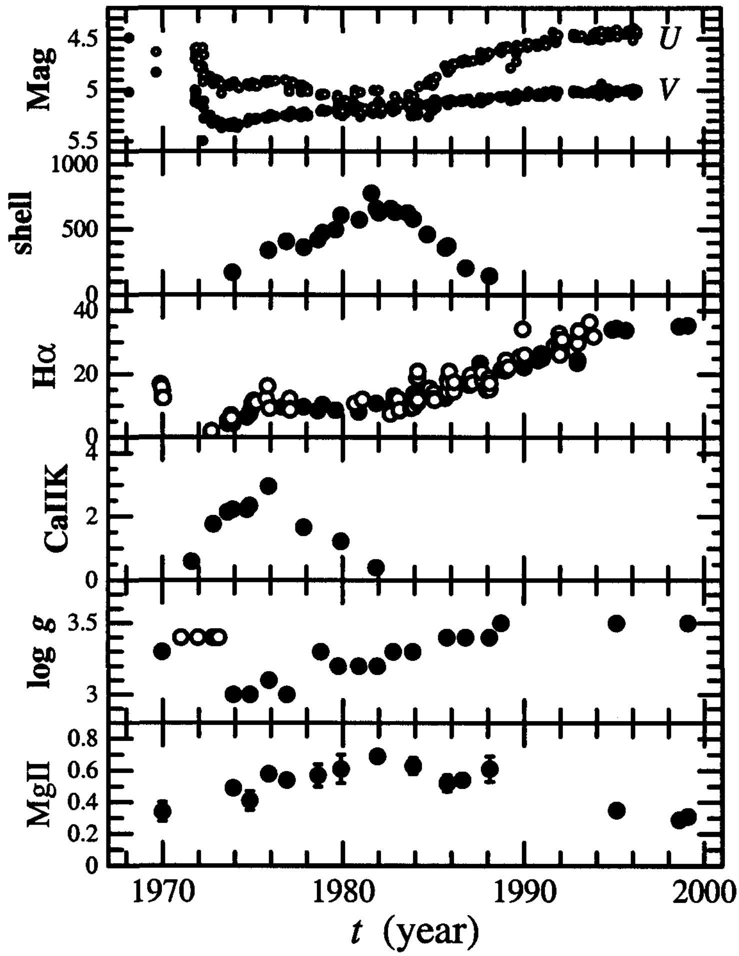

Figure 2. Long-term variation of Pleione.

3. Discussion

No difference was found between the previous shell+Be phase in 1937–1970 and the present shell+Be phase in 1971–1999. We summarize the overall behavior with several problems to be solved.

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- 1971-1982: the accumulation of mass and angular momentum in the disk. The mass supply reached its maximum in 1976. The constant Hα emission in 1976-1982 poses a problem to be solved, since the emitting region was growing during this phase and subsequent phase, judging from the monotonous decrease of the peak separation in the emission lines.

- 1982-1988: Balmer progression phase (the latter half of the shell phase). This phase was interpreted by the expansion of the envelope (Limber 1969). Another possibility is the one-armed oscillation in a quasi-Keplerian disk (Hirata & Okazaki 1999). The smooth transition from $V/R > 1$ to $V/R < 1$ at Hα in 1988 supports this view. However, the followings should be pointed out: Pleione experienced its phase change from shell to Be in 1988 and the beginning from the negative velocity in both shell phases is too accidental in this interpretation. Further detailed comparison between the two progression phases is required.

- 1988- : Be phase. The profiles with $V/R < 1$ changed to those with $V/R < 1$ in 1998-1999 in Hγ and metallic lines. This suggests that the Keplerian disk had been established, at least, in this phase. The observation in the previous Be phase indicates that the V/R variation would last until the coming shell phase or B phase, accompanying the increase of the peak separation.

Another puzzling problem is that the fitted log g for Pleione lies in the range 3.5-3.0. The normal mass for B7-B8 dwarf and the distance to the Pleiades suggest log $g = 3.8 - 4.0$. Peters (1976) also obtained log $g = 3.3$ for Pleione. The smaller log g is in common among metallic shell stars (Peters 1976).

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