*High-mass X-ray Binaries: Illuminating the Passage from Massive Binaries to Merging Compact Objects*
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# Binarity of Pleione and its influence on the circumstellar disk

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**Abstract.** Pleione is a classical Be star well known for its cyclic transitions between Be-, shell- and normal B spectral phases. Its nature as a binary system was discussed by McAlister *et al.* (1989), Gies *et al.* (1990), Luthardt & Menchenkova (1994) and Nemravova *et al.* (2010). We present the results that trace the evolution of the dimensions of the circumstellar disk of Pleione that are related to the binary system.

**Keywords.** stars: binaries: spectroscopic, stars: emission-line: Be, stars: individual, Pleione

## 1. Introduction

Harmanec (1982) was the first to propose that Pleione's cyclic variations could be the result of interaction in a binary system with about 13000 days period. McAlister *et al.* (1989) found that Pleione is a visual binary system based on speckle interferometry observations. They reported about a component at 0.217 arcseconds. More detailed discussion of the Pleione system was provided by Gies *et al.* (1990). They supposed that shell episodes of the star are caused by tidal forces during periastron passages. Gies *et al.* (1990) estimated the total magnitudes and conclude that the secondary is a A5V star. They also calculated that the mass of the system is approximately 6 sol. masses. The semimajor axis was estimated to 19.1 AU which is in agreement with the results from speckle- interferometry. Luthardt & Menchenkova (1994) found an approximately 35 year period of radial velocity variations and assumed that they are due to orbital movement in wide binary system. Katahira *et al.* (1996) performed an analysis of photographical spectra of Pleione and determined period of 218 days. They also discussed that this period could reflect orbital movement in a system with secondary component evolved He star. Cases of a neutron star or white dwarf as secondary component were also discussed. Hirata (2007) interpreted his observations of polarization angle and of H$\alpha$ profile as a result of the circumstellar disk precession caused by a secondary companion in a binary with a period of $218^d$. Nemravova *et al.* (2010) analyzed a large set of CCD spectral observations of Pleione. They confirmed a $218^d$ period and, on the basis of an elliptical-orbit solution analyzed possibilities that the second component of this short-period system is an M-type dwarf or hot subdwarf.

## 2. Observations

All observations were carried out with the coudé-spectrograph of Rozhen National Observatory 2m RCC telescope. Bausch & Lomb grating with 632 lines/mm was used in combination with Photometrics AT200 (SITe S1003AB 1024x1024 24$\mu$m pixels) CCD camera. The spectrograph was set in configuration to provide a resolving power of about 34000 at wavelength of H$\alpha$ line. Balmer lines of the Hydrogen and O I lines in the optical

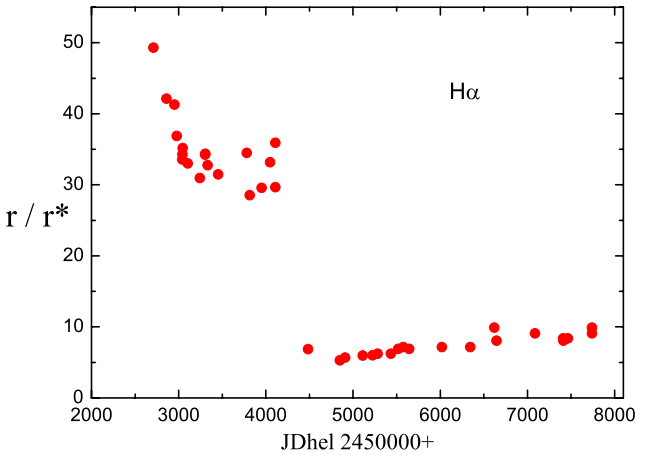


**Figure 1.** Variations of the dimension of H$\alpha$ emitting region of Pleione during the 2003–2016 period. Estimations were made according to Huang (1972) conclusions. The complex shape of H$\alpha$ profile makes it difficult to estimate emission peak velocities.

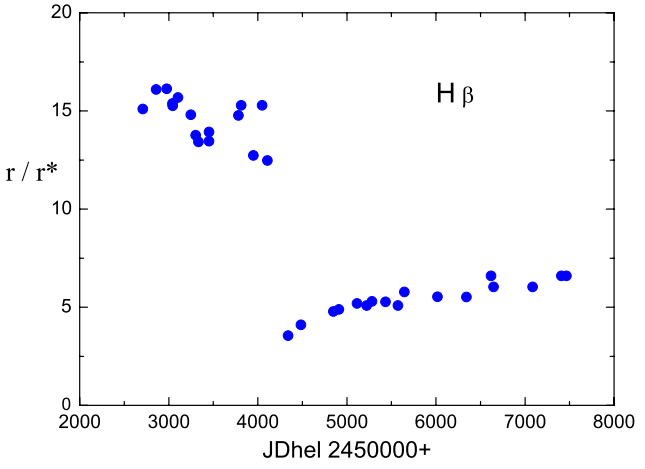


**Figure 2.** Variations of the dimension of H$\beta$ emitting region around Pleione in the 2003–2016 period.

near IR region were chosen as the main targets of our observations as it was found that they are quite sensitive to the processes of Be star activity (Iliev 2015). The mean S/N ratio of the observations was usually better than 200 and in some cases exceeded 400.

## 3. Results and discussion

During spectral phase transitions, as well as during the development of the spectral phases, Pleione demonstrates changes that are typical for Be star spectral features. Fig. 1 and Fig. 2 show variations of the estimated dimensions of the emitting region in H$\alpha$ and H$\beta$ lines of Hydrogen. As can be seen from the figures, the start of the new "shell" phase is clearly distinguished by the corresponding abrupt change in the emitting circumstellar envelope. In general, the start of the new spectral phase follows the 34 years cycle with emission-shell phase, the transitions already observed for Pleione. This period of Pleione cyclic variations is suggested by Hirata (1995) and Katahira *et al.* (1996) as connected with the orbital movements in a wide binary.

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The period of our observations cover the medium and concluding parts of the current shell-phase of Pleione. In that time span, the central absorption core of Balmer lines became deeper. Small V/R variations can be noted as well in the profiles of H$\alpha$ and H$\beta$ lines. At the same time, the shell lines of the metal ions also strengthened.

## 4. Conclusions

The variation in the dimension of the emitting regions in the circumstellar envelope of Pleione in general appeared to be synchronized with an orbital period of 34(35) years. This period is connected with a suspected wide component of the stellar system found with speckle-interferometric observations and radial velocity measurements. Such a synchronization could be the result of tidal forces from the wide component, that act to distort the disk around the Be primary. We are approaching the end of the current spectral phase of Pleione which provides a timely opportunity for more detailed studies of this fascinating star.

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## References

Gies, D., McKibben, W., Kelton, P., Opal, C., & Sawyer, S., 1990, *Astron. J.*, 103, 1601
Harmanec, P., 1982, in *IAU Symp. 98*, 279
Hirata, R., 2007, in *ASP Conference Series*, 361, 267
Hirata, R., 1995, *Publ. Astron. Soc. Japan.*, 47, 195
Huang, S.-S., 1972, *Astrophys. J.*, 171, 549
Iliev. L., 2015, *Bul. Astron. J.*, 22, 37
Katahira, J.-I., Hirata, R., Ito, M., Katoh, M., Ballereau, D., & Chauville, J., 1996, *Publ. Astron. Soc..Japan*, 48, 317
Luthardt, R., & Menchenkova, E. V., 1994, *Astron. & Astrophys.*, 284, 118
McAlister, H., Hartkopf, W., Sowell, J., Dombrowski, E., & Franz, O., 1989, *Astron. J.*, 97, 510
Nemravová, J., Harmanec, P., Kubát, J., Koubský, P., Iliev, L., Yang, S., Ribeiro, J., Šlechta, M., Kotková, L., Wolf, M., & Škoda, P., 2010, *Astron. & Astrophys.*, 516, 80