NEW AIMS OF THE SPECTRAL RESEARCH OF BE-STARS

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Abstract:
An overview of the basic concepts development of the spectral research of Be stars is presented.

Adventures of one definition

First two Be-stars were observed about 140 years ago. Observations of Padre Angelo Secchi were result of implementation of "new" at that time technology – a prism spectroscope attached to refractor-telescope. In 20-s and 30-s of XX-th century large optical telescopes with standard spectrographs and high sensitivity photographic materials started the era of modern astrophysics. Not by coincidence first hypothesis about origin of Be stars was created at that time by Struve in 1931 [1]. Regular spectral observations with powerful telescopes show the fact that emission spectral lines in stars of B spectral type are common. In 1918 abbreviation Be was accepted by IAU.

In the second half of XX-th century first attempts for classification and statistics were made. First wide definition of Be-stars and related phenomenon was given by Collins in [2] as: **non-supergiant B type star whose spectrum has or had at some time, one or more Balmer lines in emission.**

More recently the term **classical Be star** is commonly used to exclude Herbig Ae-Be stars, Algol systems and other similar by appearance but obviously different by origin phenomena. In broad context Be stars are class of stars that rotate so fast that are close to the limit where centrifugal force balances with the gravity at the stellar surface. Some well known Be stars rotate at speed of more than 300 km/s. The reasons the Be-stars to rotate so fast are unknown and represents one of the greatest challenges to the modern stellar astrophysics.

According to some recent investigations massive stars during their MS stage could significantly change some of their “surface” parameters. Outer layers could spin up as a result of angular momentum distribution as was shown by [3]. Thus Be stars became test laboratory for studying angular momentum evolution and rotationally induced instabilities.

Line-profile variations

Photospheric absorption spectra of Be-stars show normal parameters of gravity, temperature and abundance for a B type star. The only difference is the rotational broadening. Variability is the most prominent feature of Be stars.

Time scales vary from several minutes to several decades. About 1/3 of all Be stars show V/R variability connected with phase transitions and geometrical position of circumstellar disks.

Variability of the emission strength in Be stars spectra is remarkable. It may disappear completely for a certain period and in a decades develop to very high values

Shell lines presented in some late subtype Be-stars also could exhibit high degree of variability usually in connection with phase changes.

Short term variability of Be stars

In addition to the long-term and gradual variability most common for all classical Be stars, there is spectral variability of shorter term with characteristic times from several minutes to several days. Short-term spectral variations are most often found in early type Be-stars. Vast majority of LPV were found in stars of up to B6 spectral subclass.

Similar distribution was found from photometrical observations. Statistical research of several groups of investigators show that nearly 90% of stars up to B5 are variable, and only 28% of those later than B6 were found to vary. Wide implementation of cross-dispersed echelle-spectrographs boosted the research of short-term spectral variability. Because of the large spectral coverage and high accuracy new discoveries could be expected in this field.

Spectral phase transitions

The strongest variability of circumstellar envelopes and their spectral evidences are so called spectral phase transitions. Variations of the spectrum spread from complete loss of any traces of emission to fully developed complex of emission spectral lines (Balmer, FeII, He etc.). Usually transitions between emission line and shell spectrum are explained by inclination differences. They were observed in γ Cas, Pleione, 59Cyg, HR2142 and other stars.

One possible explanation is eventual precession of stellar equatorial and envelope disk planes. Transitions between emission phase and normal B phase are explained by different mechanisms of dissipation of the material in the envelopes.

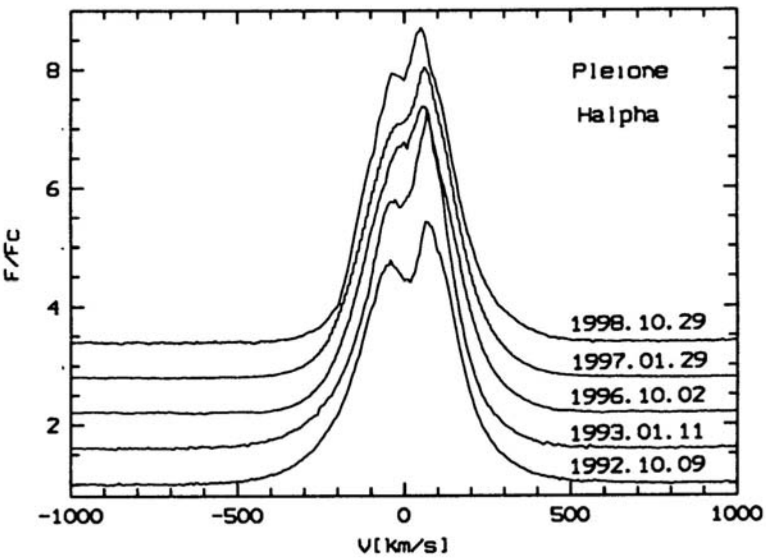
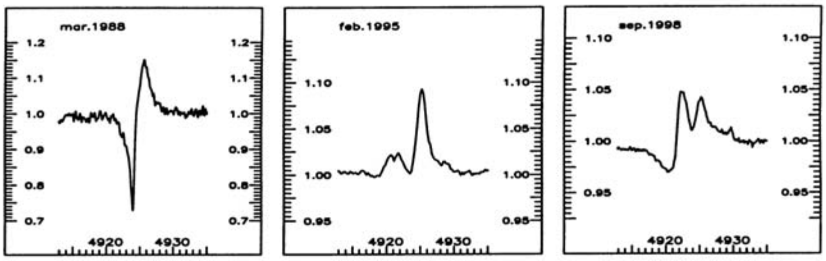


Fig. 1 Hα profile variations of Pleione from Rozhen observations taken from [4].



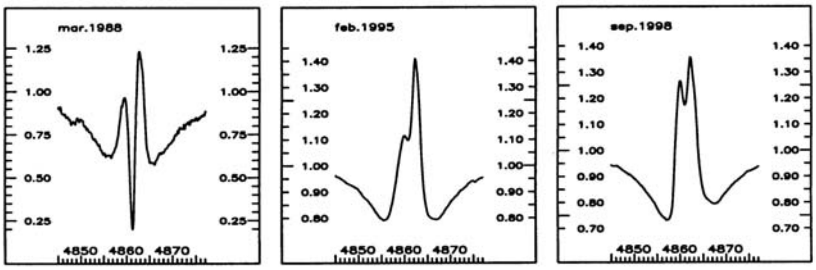


Fig. 2 Hβ profiles of Pleione as shown by [5].

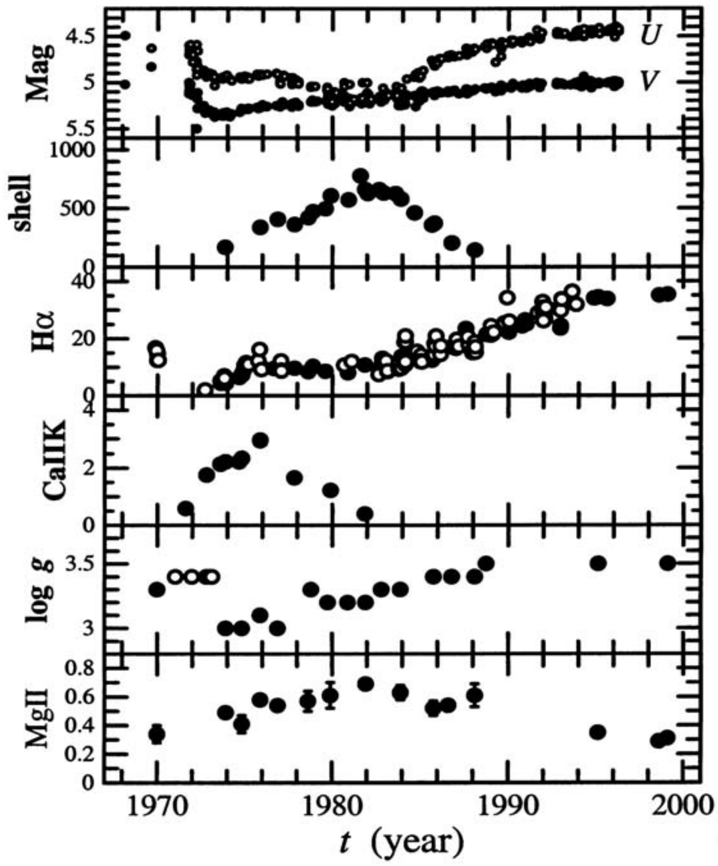


Fig. 3 Variation of other spectral features of Pleione's spectrum during last several decades from [6].

Special interest is called by Be stars that came through all 3 types of spectral phases. One example is the well known Be star Pleione, which undergone its last phase transition in 1987-88 [7]. The variation of some of the spectral evidences of the Be phenomenon in this star are shown on the panels of Fig. 3.

Rotational modulations

Rotational modulation was first proposed as hypothesis explaining observed spectral variations in Be stars. It was supposed to be caused by star spots cooler than the surrounding regions of stellar surface. Later hypotheses supposed rotation spectral modulations to originate in the circumstellar environment.

Natural way to support this type of variability is to assume existence of oblique magnetic field. This hypothesis explain well the possible transfer of angular momentum. Searches for magnetic field in Be stars is not successive till now. General detection limit is still above than the expected mean magnetic field strengths. Predicted by simulations values are about 500 G.

Rotation modulations themselves are in strong competition with NRP in explanation of small scale short term LPV.

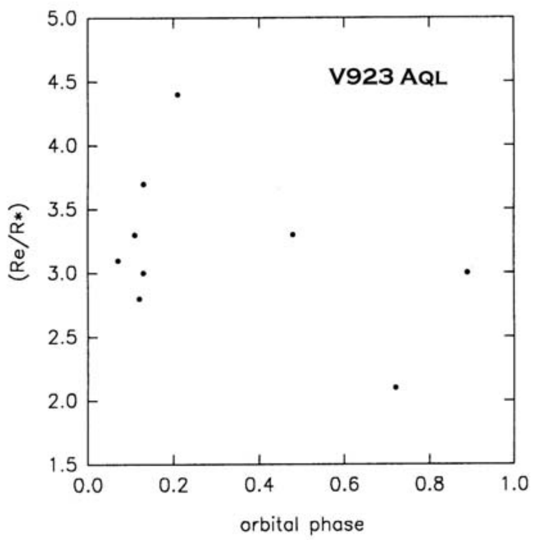


Fig. 4 Phase dependence of envelope dimensions of V923 Aql from [8].

Be-stars in binaries

[9] proposed that all Be-stars are binary systems. The secondary component is undetected and the system is at mass transfer stage. This general conclusion was not supported by the observation, but binary systems with Be star as one of the components are important tool for understanding Be phenomenon.

Influence of the binary companion may help the spin-up of the primary. Tidal forces can help the outflow of the matter from equatorial regions of the primary. The presence of the binary may impose additional conditions on the model calculations and this type of systems could be used as probes.

One good example of the variations of the parameters in the circumstellar envelope is the Be binary star V923 Aql. This type of variations were first reported by [10] and later studied in detail in the works of [7] and [11].

Concluding remarks

Despite their large number and relative closeness, Be stars continue to be significant challenge to the modern astrophysics. New accurate observations, implementation of up to date techniques supplied astronomers with new knowledge about the Be-phenomenon. In the same time this new facts turned most of previous statistical and theoretical conclusions to critical reestimation.

All above mentioned makes Be stars extremely relevant objects for international co-operation programmes. It is impossible for single observing teem on single observatory to carry out decent programme able to follow up important features of Be-phenomenon like phase transitions, variations connected with the orbital periods, etc.

New technology instrumentation is highly desirable to continue and develop new reviews embracing large number of Be stars possibly not only from our own Galaxy. This instrumentation is a challenge that could be met by united efforts of a group of neighbouring countries. (example of nordic astronomical cooperation).

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