Periodic phases in the V/R variability of ζ Tauri ?

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Summary

Although ζTau from view of the professional research can be regarded as well understood star system, the quasi-periodic intensity behavior of the V- and R-component of the Hα-emission is still in such a manner puzzlingly, that also long-term amateur observations can contribute to clarify the mystery.

While the geometry of the Be star's circum stellar gas disks or shells seems to be well understood there is still a lack of understanding as far as their physical properties (for example: the density distribution) is concerned. As far as radial disturbances are involved the density oscillation model of Okazaki, which is based on theoretical results proposes instabilities of thin Keplarian discs without gravitational interaction. Altogether there may be an initiation of a one-armed-mode resulting in a respective density wave spreading across the entire disc. The generation of such a one-armed density wave will be explained in fig. 1. Due to a radial disturbance the gas atoms are moving on eccentric orbits resulting in a one-armed density wave located in their common periastron. This global pattern remains to be stable.

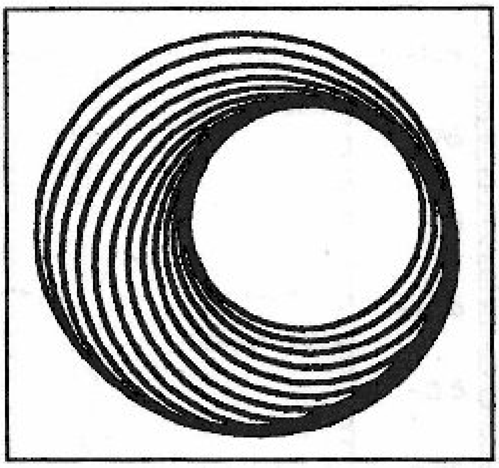

Fig. 1: Generation of a one-armed density wave by disturbed orbits

Regarding the binary system ζTau this density wave precesses within a time frame of several years around the star. In case this density disturbance is situated at the disc's edge approaching us the result will be V>R. In the opposite case i.e. the disturbance is receding from us the result will be R>V. In those two cases where the disturbances are situated either directly in front or behind the star both result in V=R. Fig. 2 shows such V/R-variations for the period Nov./2000 to April/2003 with 0,39A/Pixel dispersion.

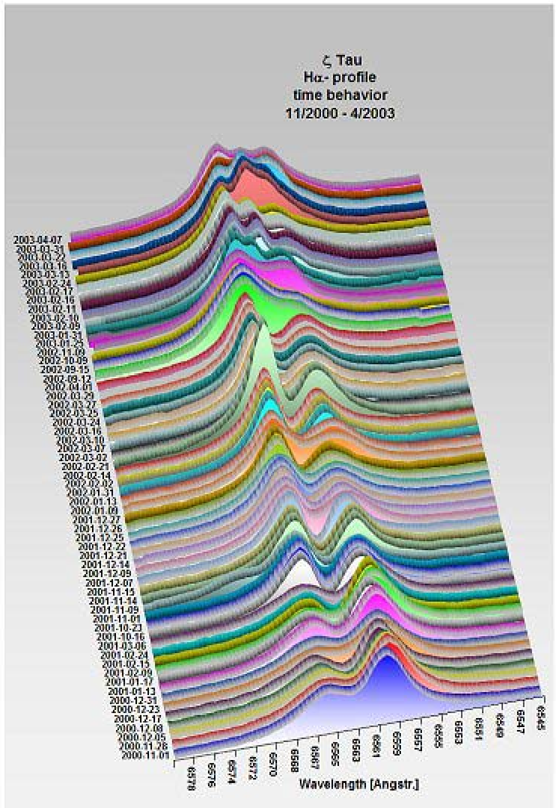

Fig. 2: Hα-profile behavior of ζTau 11/2000-04/2003

One of the earliest publications covering the V/R long time behavior (Delplace, 1970) determines the V/R turn-around-cycle to be 6 – 7 years. These observations took place between March 1960 and Sept. 1967 and were based on 2 – 3 observations per year. Should the exact point of the phase reversal be of interest, there is a clear necessity for a more dense observation sequence of approximately 20 per year.

The Hα-profile shows normally two separate emisson peaks with an absorption core, whereby the emissions can have occasionally complicated appearance either as „simply emission", or as asymmetrical complicated structures. Guo assumed these profile structures to be in close relation to the quasi cyclic change of the V/R ratio. During the following visible phase since September 2003 these triple peak structures show up again from Dec. 2003 till Sept. 2004 (fig. 3).

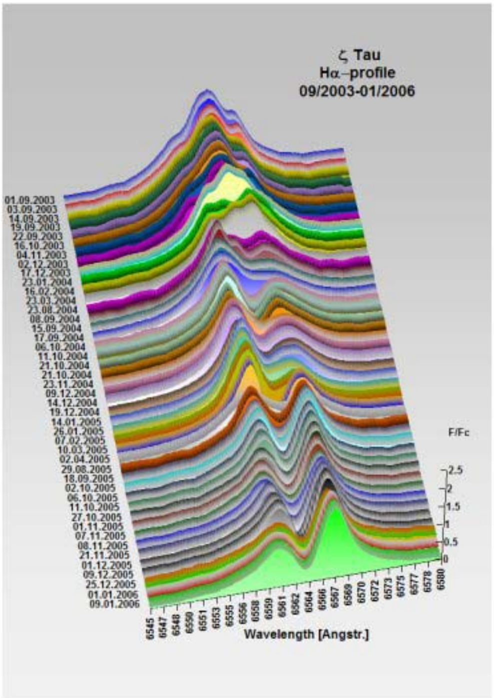

Fig. 3: Hα-profile behavior of ζ Tau 09/2003-01/2006

These so far discussed variations are in close relation to changes and activities of the shell formed H II disc which in case of Be binarys are determined by material transfer from the secondary component to the primary star.

Here in today's judgment the V/R variations are being interpreted as the result of the so called "binary interaction" whereas expectedly these interactions are reflected in the Hα–-emission strength's temporal behavior. The detailed processes affecting the profiles are still unclear. The more it will be important to observe the future evolution.

Generally the variations of the Hα-emission show that the circumstellar disc is not in a steady state. The overview in fig. 4 from Oktober 1975 to January 2006 shows changes of the disc in density and/or volume.

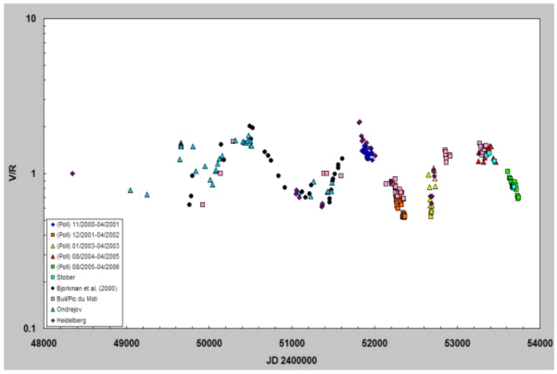

Fig. 4: Hα-equivalent width in the past decades, comparing measurements by professional instruments

Further it seems to indicate that an adjacent outburst with an influx of material into the disc has taken place. Theoretically a smaller disc comprising a smaller mass but equal density may be imaginable since expectedly neither the disc's orientation nor the star's radiation have changed. The decrease in density seems to be the more likely candidate since Be star discs are being fed from the inner region as well as being diluted at the outer regions.

Especially such long-term monitoring can deliver important data for the professional community. The interpretation of time-limited observations with professional resources often profits from the knowledge of the disc state in the course of the long-term evolution. You may easily recognise the apside rotation of the periastron as well as at least at 50450 and 51800 a maximum clearly can be defined which corresponds to a period of 1350 days or 3,7 years

My observation campaigns (fig. 5) indicate a periodicity of about 65 d (exception: campaign Dec. 2001 – April 2002). All respective time axis have been shifted in order to get the best sinus approximation match. It seems to be worth mentioning that these periodicities represent about half the orbital period (132,97 d) of the star system. Moreover the individual amplitudes turned out to be different.

According to A. Miroshnichenko (2001) the V/R ratio will be influenced by the orbital movement and its interactive tidal influence upon the disc. Hence, period modulations of the reported kind are to be expected.

References:

Delplace, A. M., 1970, A&A 7, 65-85
Miroshnichenko, A., 2001, Private Communication