The Periastron Passages of 28 Tau 2012-2015

(published at IBVS No. 6199)

Within the time span January 2012 to February 2015 a group of 24 observers of the ARAS community (http://www.astrosurf.com/aras/) was successful in documenting four periastron passages of the Be binary 28 Tau. The main purpose of the campaign was to observe the change in radial velocity (RV) along with the V/R ratio of the Hα double peak profile. For this campaign Littrow spectrographs of the type LHIRES III with different spectral resolving power R from 8000 to 17000 resp. were used. Corresponding to the investigations of orbital elements of 28 Tau by Nemravova et al. (2010), we also used first the Hα line to compare our results. The reproducibility of our Hα RV measurements of one spectrum during one night can be indicated by application of the line profile mirror method with (+/-) 2 km/s.

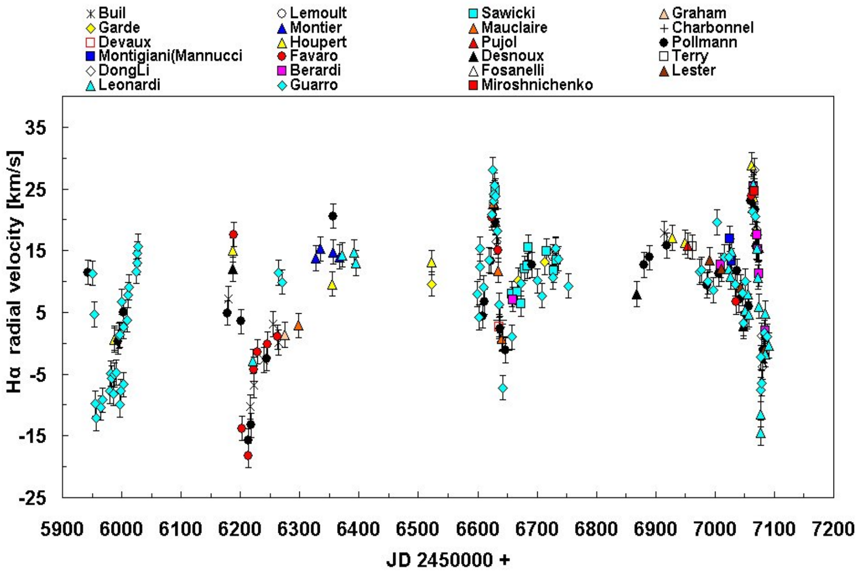


Fig.1: Overview of the time behavior of the radial velocity Hα-RV

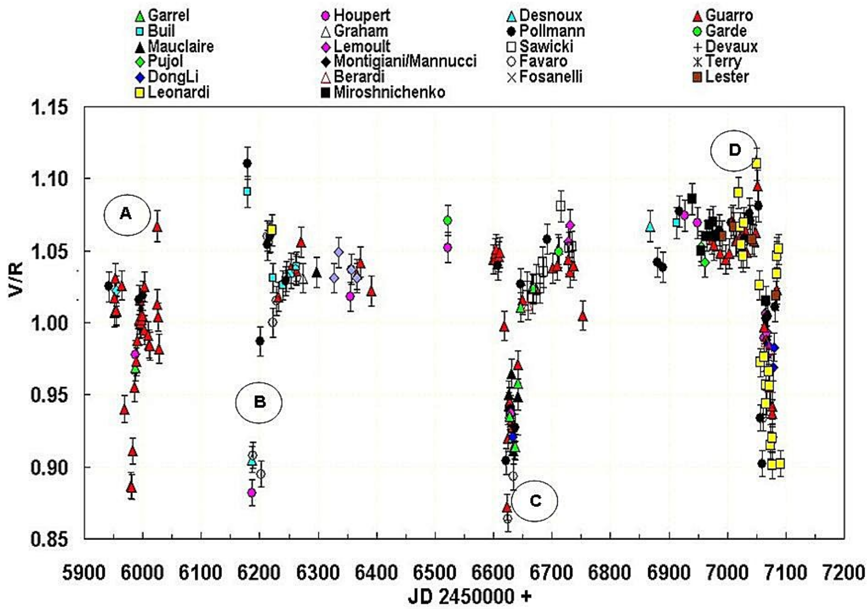
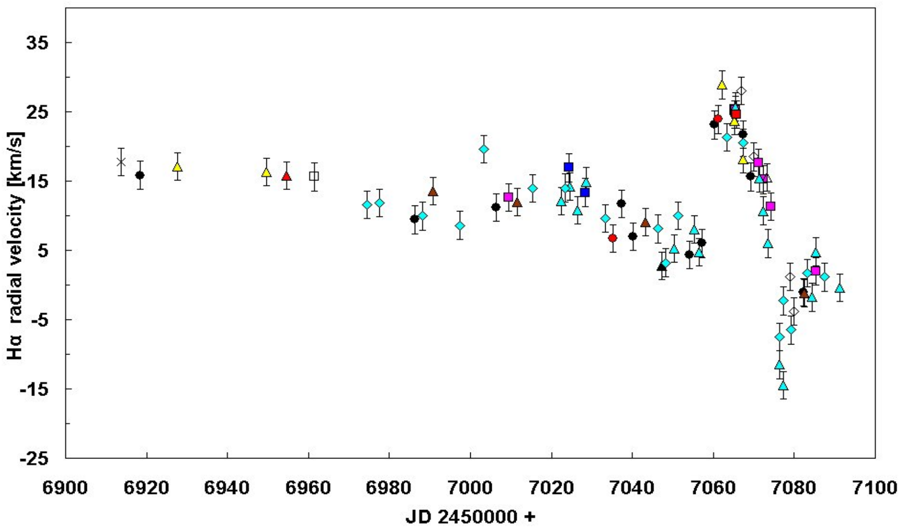
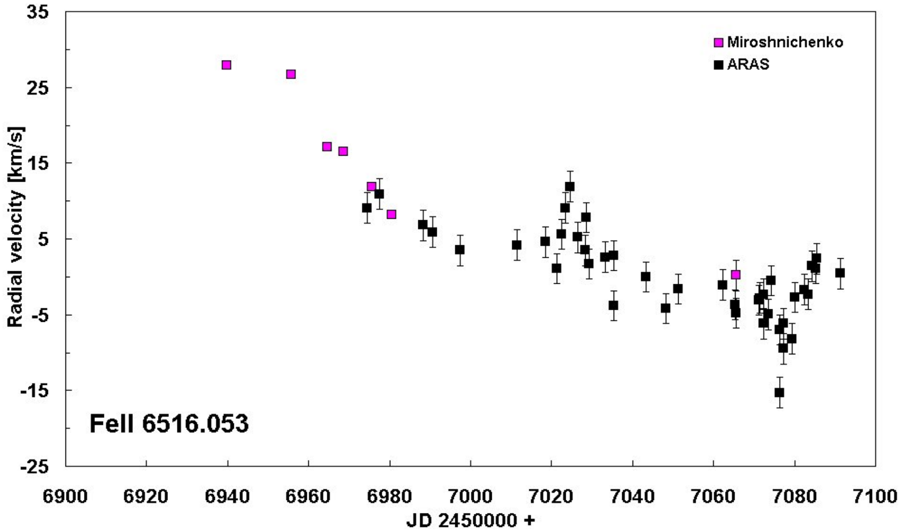


Fig.2: Overview of the time behavior of the Hα-V/R ratio





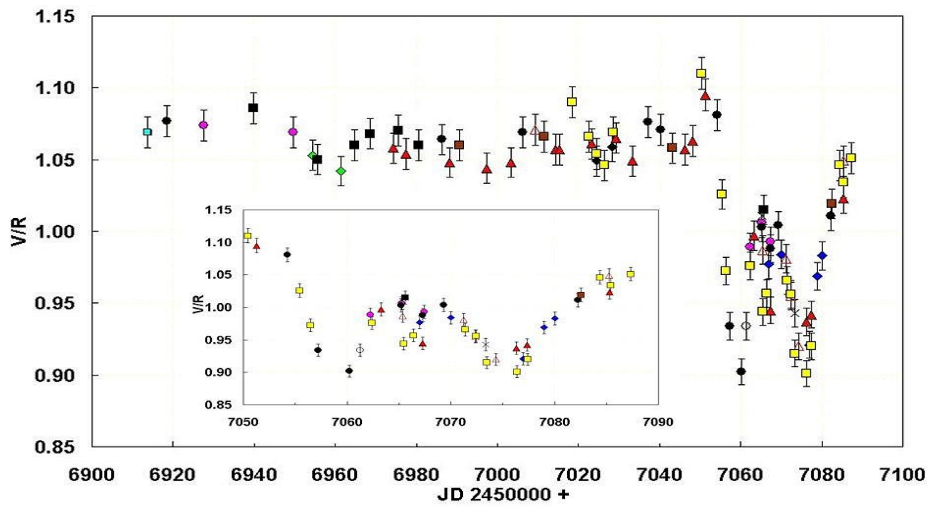


Fig. 3-5: Detail view of the RV monitoring in a higher temporal resolution (upper Fig.);
RV comparison monitoring of the FeII 6516Å (middle Fig.);
Hα-V/R monitoring of the periastron D in Fig. 2 with both minimum structures (lower Fig.)

While Nemravova et al. (2010) used for the calculation of the orbital elements Hα spectra during the time period JD 2449581 to 2455112, which includes the B- and the Be-shell phase of 28 Tau, our observation results represent only the Be-shell time period JD 2459942 to 2457083. In addition, with our campaign we were particularly interested in seeing what happens with changes of the V/R ratio around the minimum radial velocity epoch near the periastron as a consequence of the attractive force of the secondary in the 218-d-binary. The mentioned period January 2012 to February 2015 is shown in Fig. 1 & 2 as a total overview of the RV (upper plot) and the contemporaneous V/R time behaviour.

Our detailed Hα RV representation in Fig. 3 shows a clear jump in the positive (red shift) direction around JD 2457060, which is similar to that found in the RV data (JD 2452860 to 2454186) of Nemravova (2010). Because of this unusual jump in our observations, we followed a recommendation from professional astronomy to check this RV behavior with a line which is formed closer to the central star, and to compare it to the RV at the outer (Hα) radius of the disk.

This is the case with the line FeII 6516 A, which seems to be formed in a dense disk around the star, and which reaches about 70% of the continuum intensity at its minimum. This line has been present in most of our spectra. In order to supplement this monitoring, we were fortunate to receive further spectra from our friend and colleague Prof. Dr. Anatoly Miroshnichenko. In Fig. 4 we see an impressive indication that in fact the FeII 6516 RV is decreasing more or less evenly and undisturbed to the periastron at approx. JD 2457076.4. According to the recently determined orbital elements **(**e.g.: e = 0.596; ω = 148°; $T_{periastr.}$ = 2440040.4 d**)** by Nemravova et al. (2010) at the Hα absorption core, we had to expect this periastron at JD 2457077.0

As mentioned above, with measurements of the Hα V/R ratio we have the opportunity to observe how the disk density structure changes near the periastron, as a consequence of the attractive force of the secondary. The unusual V/R variation as an appearance of two separate minimum components (at JD 2457060 & 2457076) near the periastron in Fig. 5 seems to indicate a distortion and deformation process of the two disks [Hirata (2007) & Tanaka et al. (2007); see Hirata´s illustration at the end of this report] of the system. Only in our previous periastron A & C in Fig. 2, can one recognize such a “double” V/R feature, which means that the quality of disk distortion during periastron passages is not always the same. Hence, it is not difficult to imagine that this kind of profile deformation of the Hα line leads to radial velocities, which are strongly disturbed tidal influences of the secondary.

In spite of this blur in the periastron time definition, we tried to calculate a period analysis both of RV and V/R. First, Fig. 6 shows the PDM (phase dispersed minimization) RV period calculation of all observed periastron in this paper, which led to a period of 227.4 days. Fig. 7 shows the corresponding phase diagram. The found phase behaviour, as well as the period, is compared with the photographic RV phase plot of Katahira et al. (1996) in Fig. 8, and with the electronic RV phase plot of Nemravova et al. (2010) in Fig. 9. Our larger period results from the fact that we were able to observe in detail RV as well as V/R within certain periastron campaigns, which led to a larger dispersion of the exact periastron time itself. On the other hand, the more or less sharp V/R definition in our observations (except for the last monitored periastron), reflects [with the PDM period analysis (Fig. 10) and its phase diagram (Fig. 11)] fairly exactly the 217.9 day orbital period of Katahira et al. (1996) and Nemravova et al. (2010). All in all the question remains: how can one compare orbital elements (e.g. the period of periastron) based on RV evaluations, if there are such a blur in defining periastron time using RV observations?

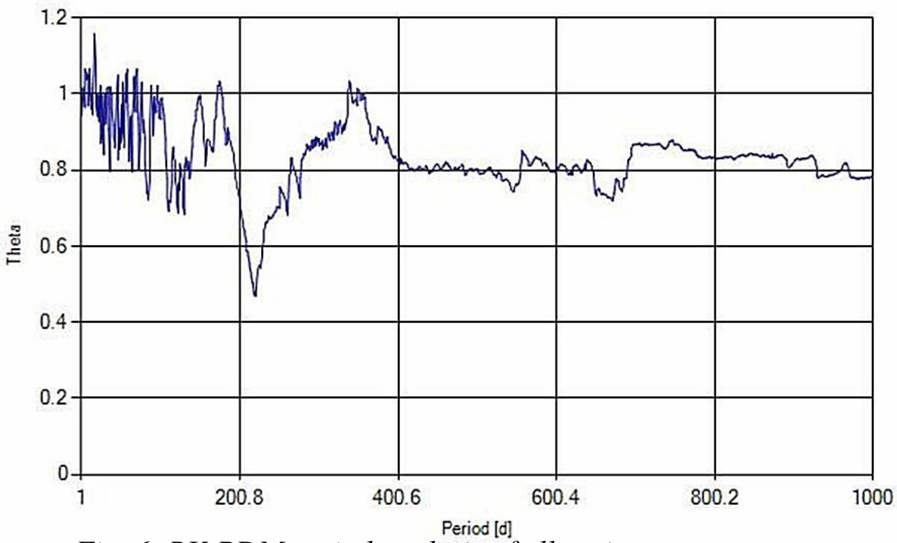


Fig. 6: RV-PDM period analysis of all periastron passages

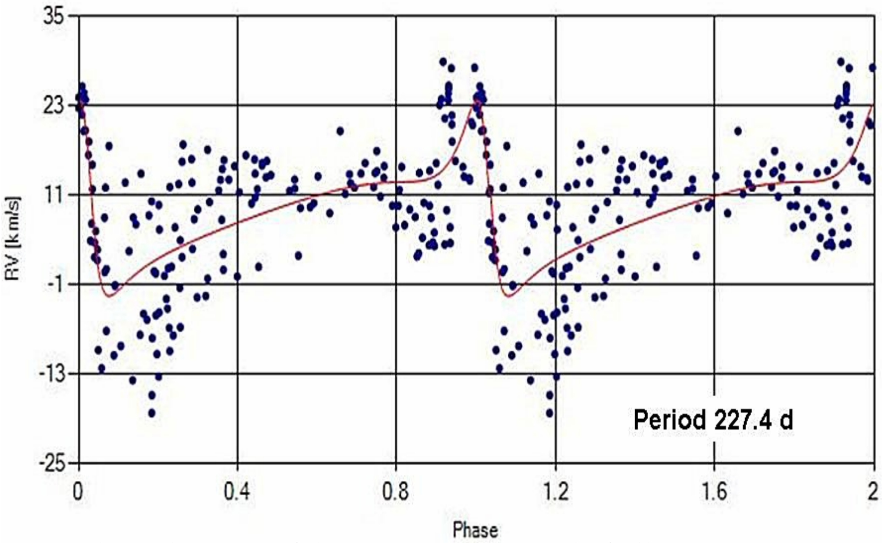


Fig. 7: Phase diagram of the RV period 227.4 d of all periastron passages

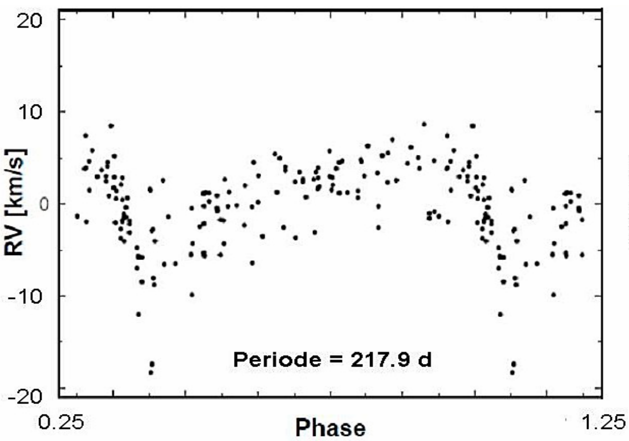


Fig. 8 :Photographic radial velocities from Katahira et al. PASJ, 48, 317

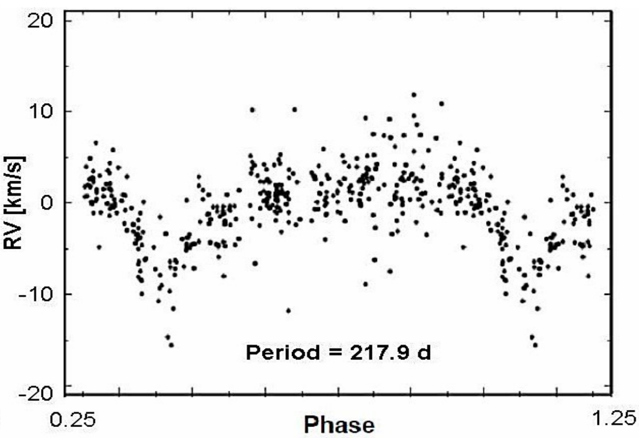


Fig. 9: Electronic radial velocities from Nemravova et al. A&A, 516, A80

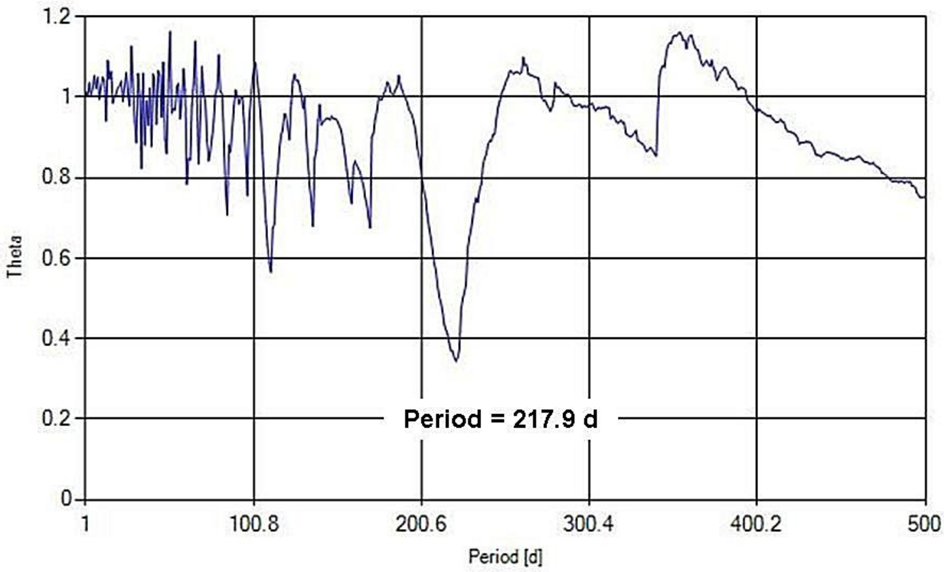


Fig. 10: V/R PDM-period analysis of the periastron D in Fig. 2

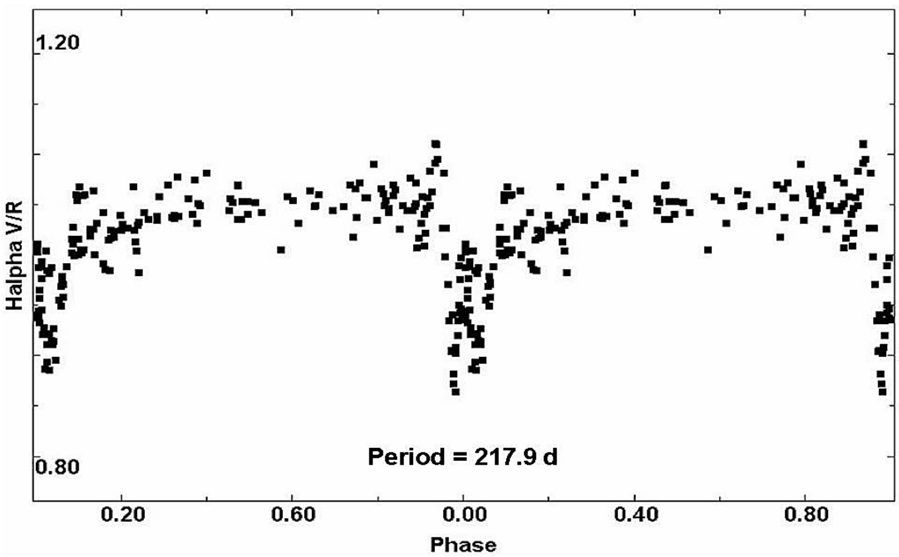


Fig. 11: Phase diagram of the 217.9 d period in Fig. 10

<u>**Disk precession & appearance of a new disk in plejone** (from Hirata 2007)</u>

Spatial motion of the disk axis (12a), and disk developement of a second inner disk projected on the sky between 1974-2003 (12b), caused by tidal forces of the secondary. The second disk is in the process (2007) to come in contact with the pervious (12c).

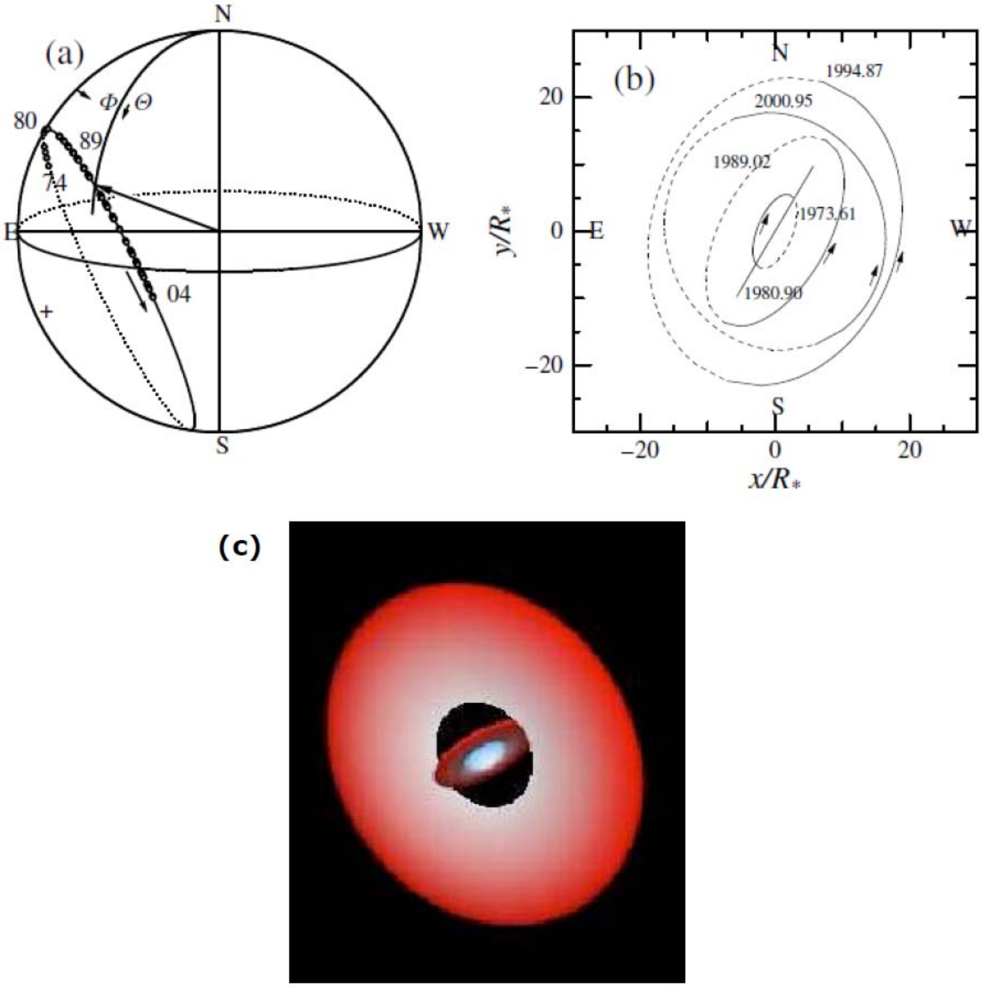


Fig. 12 a-c: Disk precession & appearance of a new disk in Plejone (Hirata 2007)

Demonstration of the temporal V/R variation

The following animation of the temporal V/R variations of the Hα double peak profile, aquired from a spectra sequence of January 1th to March 9th 2015, makes this dynamic process descriptive. This animation was made with the program ISIS. The used spectrograph was the type L200, equipped with an 1800 lines/mm grating, mounted on a Celestron 9.25 telescope.

The animation is shown at: http://www.astrospectroscopy.de/media/files/28Tau-Animation.gif

References:

Hirata, R., 2007, PASJ Conference Series, Vol. 361, 267-271
Katahira, J., I., Hirata, R., Katoh, M., Ballereau, D., Chauville, J., 1996, PASJ, 48, 317-334
Nemravova, J., Harmanec, P., Kubat, J., Koubsky, P., Lliev, L., Yang, S., Ribeiro, J., Slechta, M., Kotovka, L., Wolf, M., Skoda, P., 2010, A&A, 516, A80
Tanaka, K., Sadakane, K., Narusava, S., Y., 2007, PASJ 59, L35

The following ARAS observer contributed with their spectra:
Th. Garrel, C. Sawicki, J. Montier, J. S. Devaux, M. Pujol, M. Leonardi, V. Desnaux, P. Berardi, Ch. Buil, K. Graham, B. Mauclaire, F. Houpert, E. Pollmann, N. Montigiani, M. Mannucci, J. N. Therry, J. Guarro, Th. Lemoult, O. Garde, St. Charbonnel, T. Lester, A. Favaro, Dong Li, P. Fosanelli

Ernst Pollmann — Observatory of the „Vereinigung der Sternfreunde Köln“
Leverkusen, Gemany

Marco Leonardi — Observatory “Cotoletta”
Gorgonzola (Milano), Italy