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H_α PROFILE VARIATIONS IN THE Be/SHELL STAR ζ Tau DURING 1990-1992

ζ Tau is one of the well-known V/R variable shell stars and a single-lined spectroscopic binary with an orbital period of 133 days. Losh (1932) first observed irregular radial velocity variations superimposed on the orbital variation. Delplace (1970a) found long-term pseudo-periodic variations in the radial velocities of the shell absorption lines. From radial velocity measurements published before 1976 and summarized by Harmanec (1984) it can be seen that the long-term pseudo-periodic variations started in the late 1950's after a long quiescent phase. Hubert-Delplace et al. (1983) showed the radial velocity variations of visible shell lines during 1975-1980 to be a continuation of the pseudo-periodic variations. Recently Mon et al. (1992) put forward that the pseudo-periodic variation (that started in $\sim$ 1976) has terminated around 1982, and the star seems to have entered a new quiet phase.

Here we present our recent results. All observations were made with the All-Fiber-coupler grating spectograph of the 2.16 m telescope at the Beijing Observatory (Wang 1991) during 1990 Dec.-1992 Feb. The detector was a CCD with 576 $\times$ 512 pixels. The reciprocal linear dispersion of the spectra was 50Å/mm at H_α. One pixel corresponds to 1.15Å. The integration times of every spectrum were chosen to be approximately 80-90 % of what is needed to saturate the CCD in the central part of the H_α emission. The S/N ratio near the continuum level was >150. The spectrum of a neon lamp was recorded for wavelength calibration, and flat-field of the detector was determined by exposing to the light of a mercury lamp several times a night under the same conditions. The data were reduced using the Starlink Image Processing Software on the Vax 11/780 computer of the Beijing Observatory. The main steps of the reduction consisted of the correction for read-out-noise, correction for flat-field, wavelength calibration, and normalization to continuum intensity.

Our results are summarized in Table 1. The first three columns are the date of the observation, the number of H_α profiles, and the duration of the observation (Δt) on each night. The 4th and 5th columns denote the equivalent width (W_α), and the full-width-at-half-maximum (FWHM) intensity of the average H_α profile for each night in angstroms. The 6th to 8th columns give the violet emission, central depression, and red emission intensities, respectively, relative to the continuum (VE, CD, and RE). The last column is the violet-to-red peak intensity ratio (V/R). Fig.1 illustrates the H_α profiles of the star observed at different times. Each panel in the Figure consists of all profiles obtained on a given night. These results show that the H_α profiles underwent marked variations in shape, and its W_α, FWHM, VE, CD, RE, as well as V/R were also changing with time

Table 1. Hα Observations of ζ Tau

Date	No. of profiles	Δt (min.)	Wα (Å)	FWHM (Å)	VE	CD	RE	V/R
Dec. 25, 1990	5	45	19.7	10.69		2.40		
Oct. 09, 1990	20	82	20.1	10.69	2.96	1.60	2.17	1.36
Dec. 16, 1991	15	75	22.5	10.69	2.85	2.02	2.30	1.24
Dec. 27, 1991	4	26	22.3	10.69	2.78	2.02	2.24	1.24
Feb. 26, 1992	4	32	24.4	11.08	2.78	2.02	2.66	1.05
Feb. 27, 1992	6	38	23.8	11.04	2.78	2.03	2.65	1.05

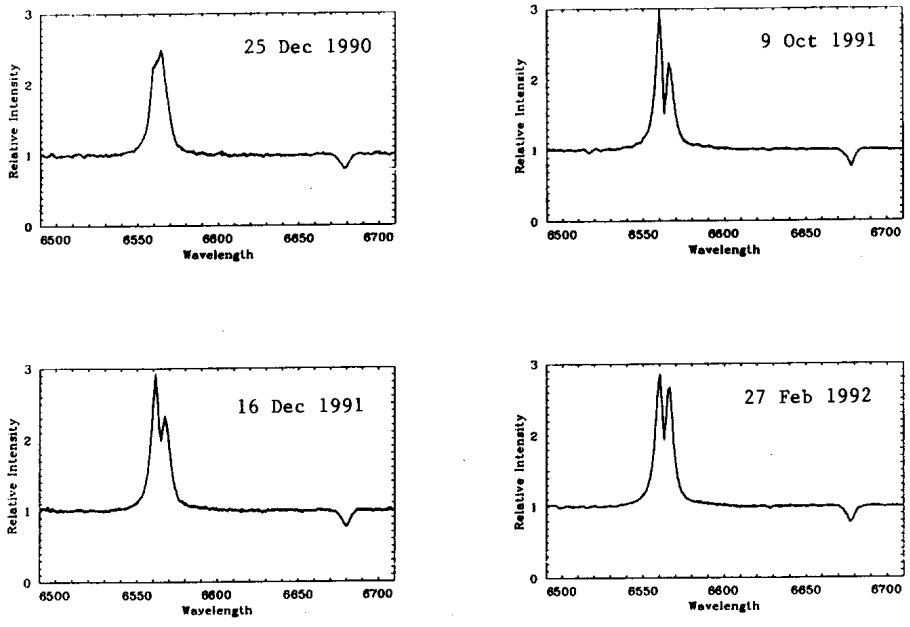

Fig. 1 The Hα profiles of ζ Tau in the different observed periods

in the period of our observations. The 1990 December 25 profiles appeared as a single emission with an asymmetric top (no visible central depression) but the profiles from 1991 Oct. to 1992 Feb. displayed prominent double emission peaks with V > R. These variations indicate that the circumstellar envelope which gave rise to the H_α emission has recently been in some unstable state. In order to understand further the variability, we

try to compare the profile variations of the earlier active phase of the star with more recent changes. It is interesting that we found the H_α profiles in the earlier pseudo-periodic-variation years as published by other authors also exhibited similar variability. For instance, while around 1976, when the radial velocities of the shell absorption lines were near zero on the ascending branch during the 1976-1982 activity cycle, H_α appeared as a single emission (Slettebak and Reynolds, 1978, Fontaine et al. 1982), it displayed, in contrast, double emission with V > R in 1979, near the radial velocity maximum (Gao et al. 1986). In addition, the H_α profiles at different phases of the pseudo-periodic variability presented by Delplace (1970b) during the 1960–1967 activity cycle also showed similar behavior. Therefore, we may speculate that the stellar envelope entered a new active phase near 1990 Dec. or even earlier, that the radial velocity of the shell absorption lines was near zero in a transition from negative to positive in 1990 Dec. and would progressively increase to reach a positive maximum sometime later, although we do not have the nessesary radial velocity information of the shell absorption lines. Interestingly, our speculation is supported by a report on the radial velocity of the H_γ and metallic shell lines by Ballereau et al. (1992). We think it is most desirable to continue monitoring the star and studying the possible cause(s) of its remarkable variations.

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