<u>Observations of non-radial pulsations of HeI4713 in ζ Tau</u>

Phenomenon (description following Yang et al. ApJ 74, 595, 1990)

Subfeatures (~ 0.5 % of the continuum) moves from blue to red across the rotantionally broadened lines (here HeI4713). Their acceleration (a) and velocity (V) are used for modal analysis and identification of the pulsation mode (by the professional astronomy). Changes in velocity can be identifications of changes in the pulsation modes.

Instrumental

Telescope: C14 Observatorium „Vereinigung der Sternfreunde Köln“
Spectrograph: LHIRES III, grating 2400 l/mm, spectral resolution R = 17000
CCD-camera: Nova 402, pixel size 9µ, detector KAF 400
Linear dispersion: 0.028 Å/pixel
Exposure time single spectra: 300 s
Addition of 4 single spectra to a sum spectrum
Signal / Noise: > 1000

Results and Figure description

Fig. 1: Observation 2013-12-19
7 sum spectra from 0.252-0.563 (fraction of day)
3 moving sub-features A, B, C
Moving velocities of A, B, C versus JD (= acceleration) in Fig. 5
Acceleration of A = 1117 km s^{-1} d^{-1} Δ t = 0.131 d
B = 1019 = 0.242 d
C = 902 = 0.220 d

Fig. 2: Observation 2014-01-11
6 sum spectra from 0.394-0.515 (fraction of day)
1 moving sub-feature
Moving velocities versus JD (= acceleration) in Fig. 5
Acceleration = 617 km s^{-1} d^{-1} Δ t = 0.121 d

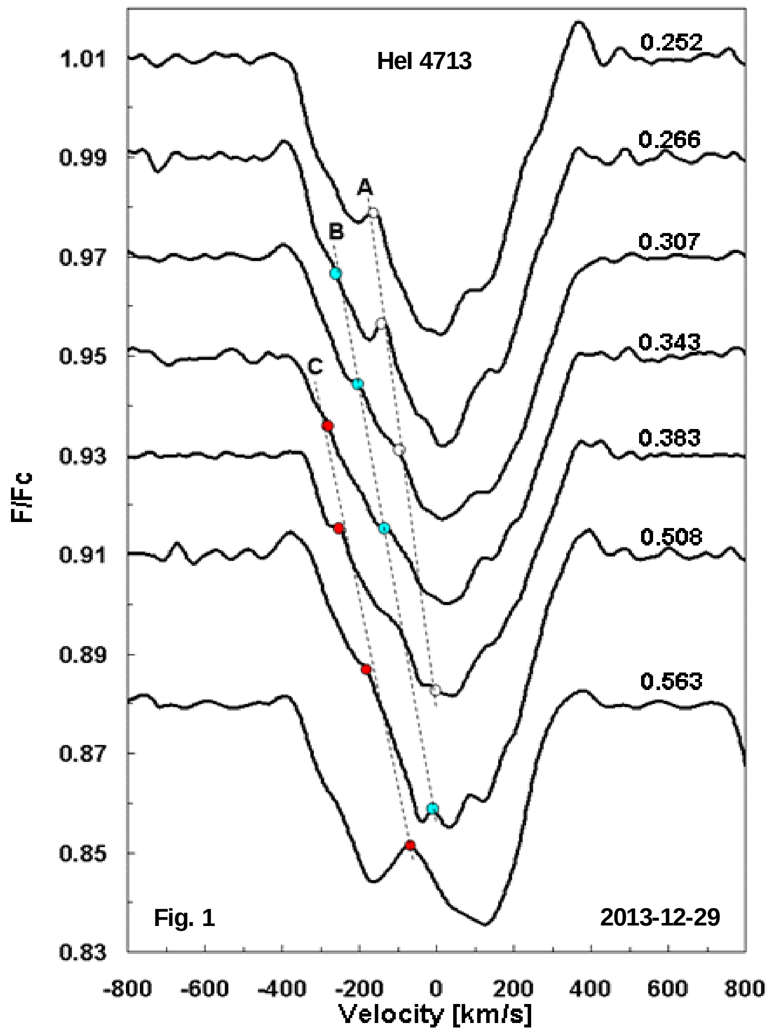
Fig. 3: Observation 2014-01-12
Note: Identification of moving sub-features in sum spectra (e. g. Fig. 1 & 2) not possible.
Thus looking for moving sub-features in residual spectra (Fig. 4).
Average of 6 sum spectra from 0.252-0.408 (fraction of day)

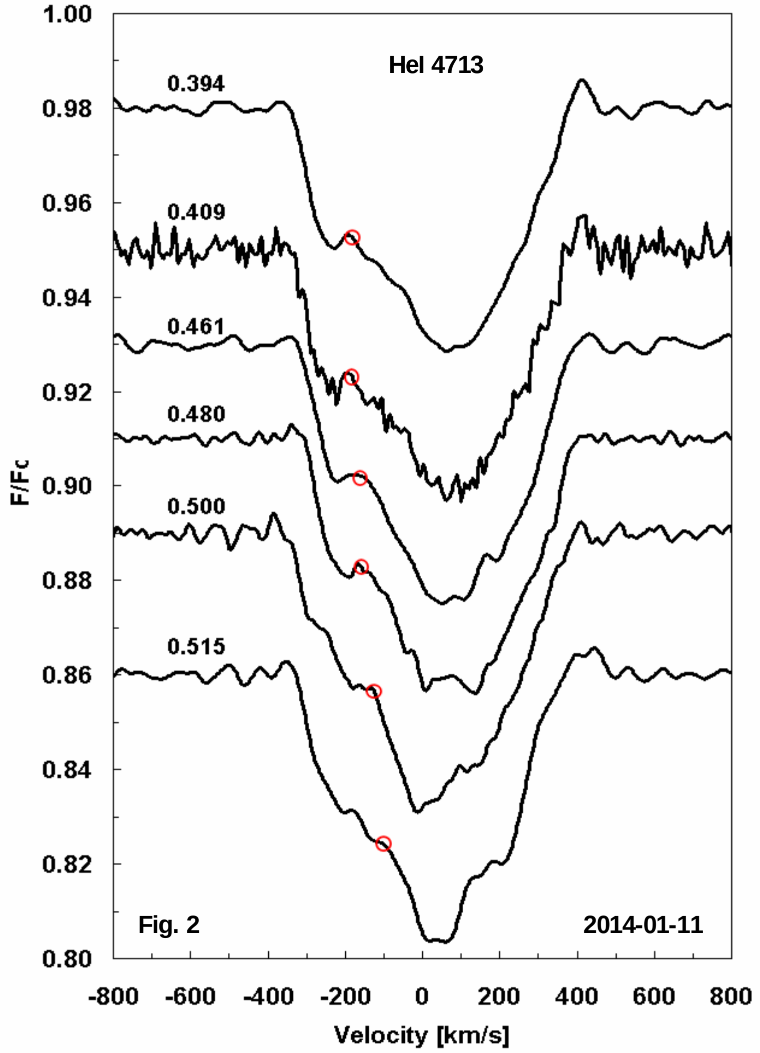
Fig. 4: Observation 2014-01-12
Residual spectra = average spectrum - sum spectra
1 moving sub-feature
Moving velocities versus JD (= acceleration) in Fig. 5
Acceleration = 1654 km s^{-1} d^{-1} Δ t = 0.156 d

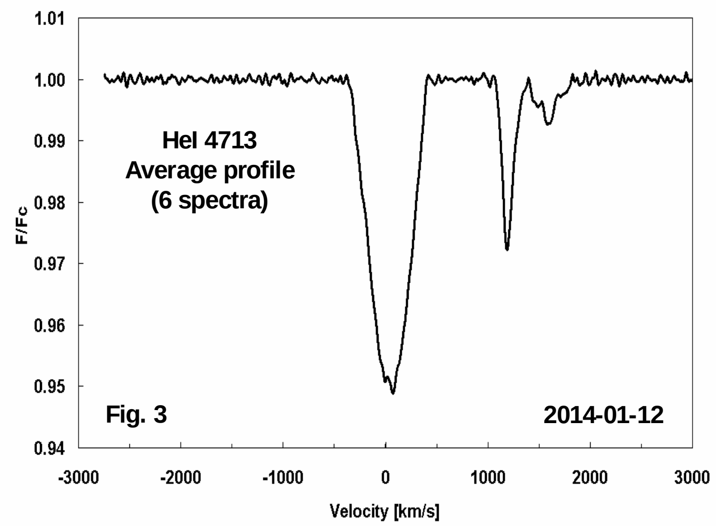
Sub-feature acceleration and time delays

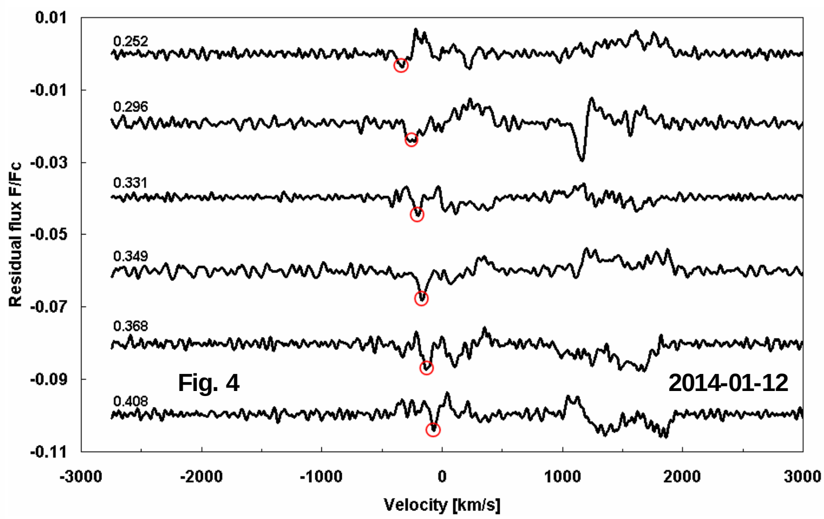
2013-12-29	A = 1117 km s^{-1} d^{-1}	Δ t = 0.131 d	V = 294 km s^{-1}
2013-12-29	B = 1019	= 0.242	= 246
2013-12-29	C = 902	= 0.220	= 198
2014-01-11	= 617	= 0.121	= 75
2014-01-12	= 1654	= 0.156	= 258
		Average	= 214 km s^{-1}

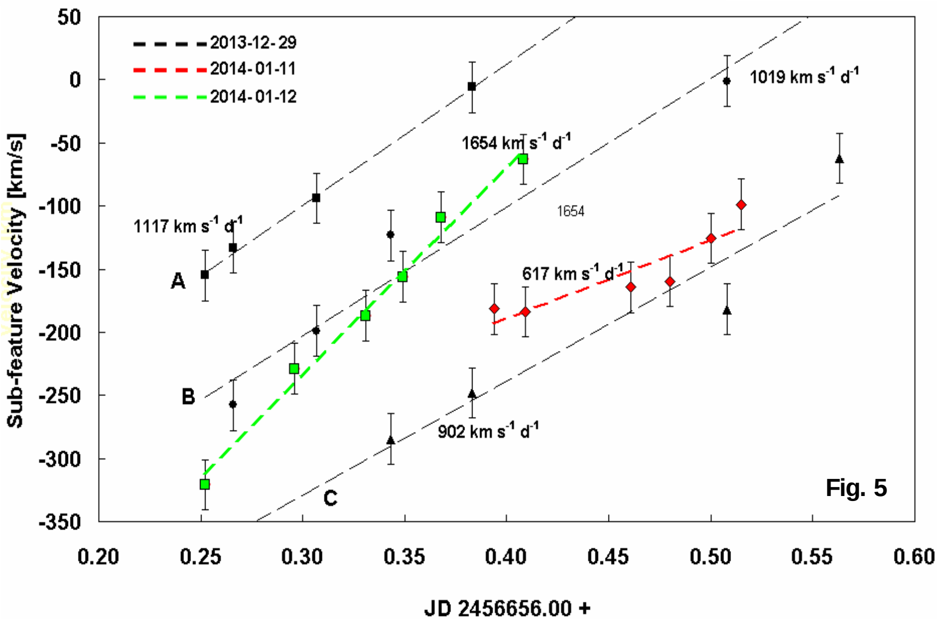
<u>Yang et al. ApJ 74, 595, 1990</u>
1983-1988 = 1547 km s^{-1} d^{-1} Δ t = 0.0952 d V = 147 km s^{-1}











Sub-feature acceleration and time delays

2013-12-29	A = 1117 km s-1 d-1	Δt = 0.131 d
2013-12-29	B = 1019	= 0.242 d
2013-12-29	C = 902	= 0.22 d
2014-01-11	= 617	= 0.121 d
2014-01-12	= 1654	= 0.156 d

Line Width Variation

Line widths of the HeI 4713 line were measured for all the spectra of the 2013/12/29, 2014/01/11 and 2014/01/12 observations by using Gaussian fitting of the line profiles and estimation of the FWHM width (Fig. 6).
In spite of the low amount of FWHM data, we were searching for periodicities by using the program SpecTSA of R. Buecke (http://www.astro.buecke.de) for phase dispersion minimization technique (Stellingwerf 1978). This procedure did yield a period of 0.702 days ± 0.0388 (Fig. 7). Gies and McDavid (1987) found at HeI4471 a period of 0.683 d. The current set of data is of course still too small for such a period analysis, but it will be supplemented with data during the next observation period (particularly because of the bad ratio of rms to amplitude).

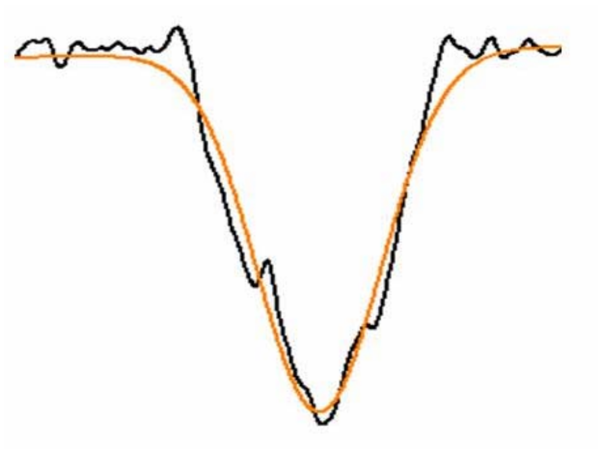


Fig. 6: Gaussian profile fit of the HeI4713 line for estimation of FWHM

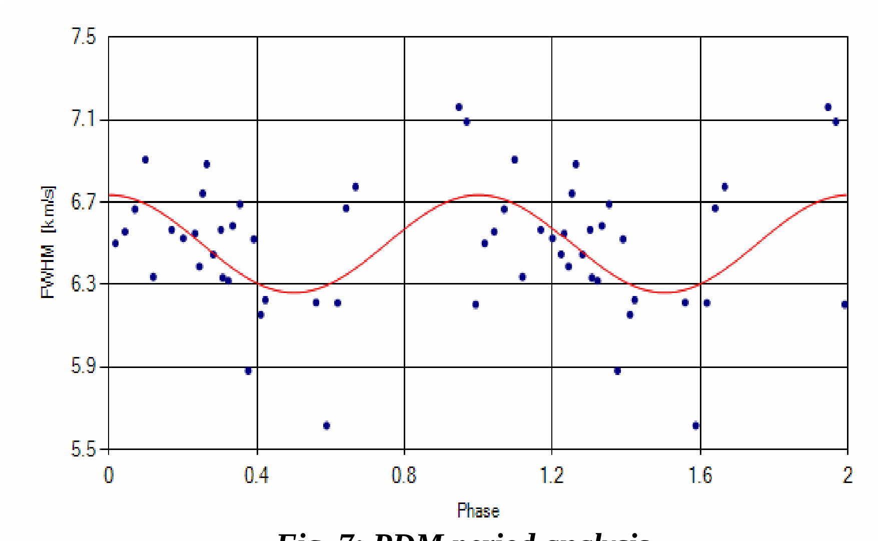


Fig. 7: PDM period analysis
Period = 0.702 d (± 0.0388, Monte Carlo Simulation)
Amplitude = 0.234 km/s (± 0.211, MCS)
RMS = 0.2767 km/s

References:
Gies, D. R., McDavid, D., BAAS, 1987, Vol. 19, 1051
Stellingwerf, R. F., ApJ, Vol. 224, 1978, 953-960

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