Short-Periodic Radial Velocity Variations of the B9p Star ET And

Ewald Gerth
D-14471 Potsdam, Gontardstr 130, Germany.
e-mail: ewald-gerth@t-online.de

Address of the institute in 1985: Zentralinstitut für Astrophysik der Akademie der Wissenschaften der DDR, DDR-1500 Potsdam Telegrafenberg

Abstract. Spectroscopic observations of the B9p star ET And secured at the Bulgarian National Observatory Rozhen in the years 1981-1984, consisting of 97 plates, show clearly a radial velocity period of 0.198 d - with a ratio to the photometrical period of exactly 2:1. This behavior would hint at a close binary system; but there arise difficulties in explaining it by this way because of the extreme short period, so that pulsation must be taken into account. However, besides of the confident period of 0.198 d, there is evidence for shorter periods in the region of 45 min, which may be attributed only to pulsational processes.[1]

Key words: Radial velocity, short-periodic variations, star: ET And

Since 1981 the peculiar B9 star ET And (HD 219749) was taken under cooperative investigation of the *Bulgarian National Observatory Rozhen* and the Central Institute of Astrophysics of the GDR. The detection of a short-periodic photometric variation of about 0.1 d for this star by *Panov* [1] suggested to carry out simultaneous photometric and spectroscopic observations. In the years 1981 to 1984 97 spectrograms with the reciprocal dispersion 9.2 Åmm^{-1} resp. 17.5 Åmm^{-1} were obtained, based on the observations of several consecutive nights each year. Thus the search for periods was restricted to time scales of the order of one day. Longer periods for this star are known, too. After Ouhrabka and *Grygar* [2] ET And is a binary with an orbital period of 48.304 d and the eccentricity of $\varepsilon = 0.50$. *Hildebrandt* and *Hempelmann* [3] determined from photometric observations a period of 1.61883 d, attributing it to the rotation of the primary star. The period of 0.1 d found by *Panov* obviously has neither any rational relation to the orbital period nor to the adopted rotational period.

Using all measurable *Balmer* and Si II lines we determined from radial velocity measurements of the 81 plates a period of 0.198 d [4], which corresponds exactly to the double of the photometric period, namely 0.099 d. Of course, this statement depends on the accuracy and the significance of measurement and evaluation. Therefore, to strengthen the conclusions, some remarks on the period search Programme should be given.

The search for periods was performed by a method according to that of *Deeming* [5] but completed by the application of weights for all measuring values. A significance criterion is given by the power quotient, which means the ratio between the power of a wave of any frequency to the square standard deviation, i. d. σ_f/σ. Independently, in order to decide whether or not a conspicuous peak in the power spectrum may belong

[1]Publication: C. R. Cowley et al. (eds.), Upper Main Sequence Stars with Anomalous Abundances, 235-238.
(The article has been scanned in 2007 from a reprint of the conference-book).

to a real period, the convolution-shift theorem was used, in consequence of which the special pattern of the spectral window function in the frequency space of the Fourier transform is shifted to every frequency contained in the unequally spaced data set. In the case of our data with observational windows in three consecutive nights, the power spectrum exhibits a complicated structure, being ambiguous whether the highest peak corresponds to the true period (Fig. 1a).

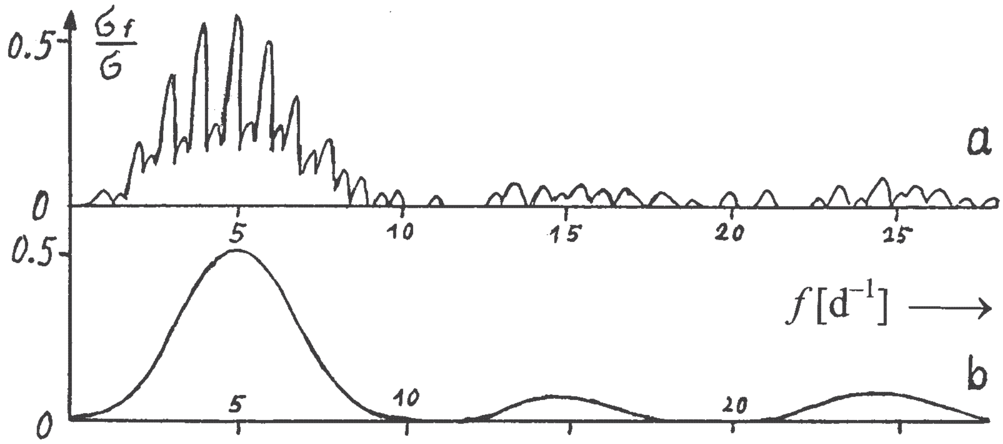

Fig. 1. a) Power spectrum of the spaced data set
b) Overlaid power spectra of three consecutive nights

The ambiguity is eliminated by deriving the product of the power spectra of all nights. Such a procedure corresponds either to the multiplication rule of superposed probabilities or rather to the cross correlation of the data in the original space (Fig. 1b). The same procedure was performed for all results from 1981 to 1984, yielding a consistent power spectrum with a prominent peak at 0.198 d. The Fourier transform of the data of the 97 plates altogether gives the best fit of the phase curve for the period 0.198155 d (Fig. 2).

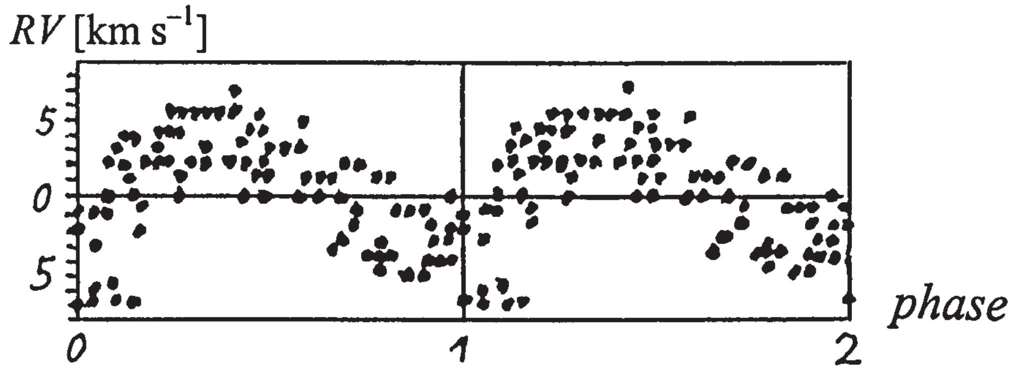

Fig. 2. Plot of the measuring data in a phase diagram

Hence we conclude that the radial velocity of ET And presumably continues to vary with a period of 0,198 d over the time of three years with an amplitude of 3.2 kms^{-1}. In Fig. 3a the double period 0.396 d is present, too, requiring further investigation.

Besides of these periods another peak at the period 0,032 d and an amplitude of 1,9 kms^{-1} is indicated. This feature is especially pronounced if we take into account the measuring results of the '84 plates alone (Fig. 3a), but it does not contradict to all the other measurements. Subtracting the waves with these two periods, 0.198 d and 0.396 d, the significance criterion by the power quotient σ_f/σ for the period 0.032 d advances from 0.16 to 0,49 (Fig. 3b).

Further support is given by comparing the power spectrum with the spectral window function (Fig. 3c) and regarding the site of the peak located before the limit set by the *Nyquist* frequency. Thus, based on the given data set, the existence of the period 0.032 d is secured from the mathematical point of view, but we cannot exclude completely the influence of measuring inaccuracy and artifacts.

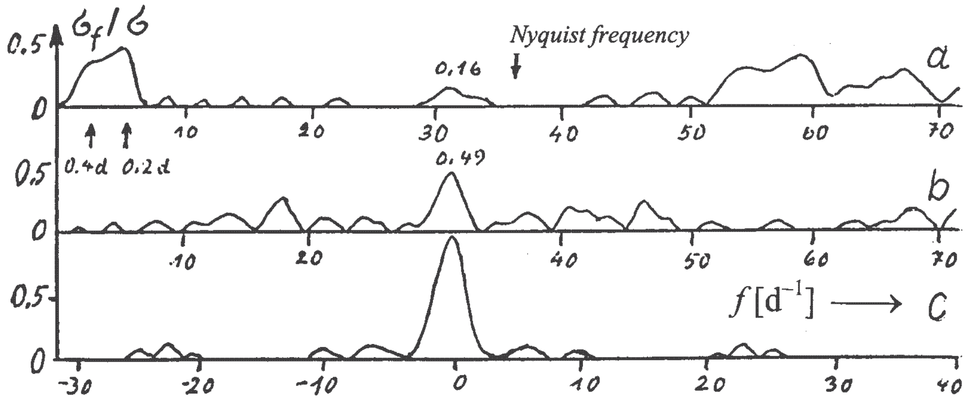

Fig. 3. Power spectra of the of the observational data in comparison with the spectral window function - see text

It was the intention of this report to present mainly observational results. Of course, we asked for the possible causes of the observed facts, too. The striking fact that the ratio of the periods of the radial velocity to that of the brightness is exactly 2:1 seems to hint at the existence of a close binary system, which was discussed by *Scholz* and *Gerth* already in [4, 6]. Even the phase shift between the waves of the radial velocity and the brightness secured by the simultaneous observations would not contradict. But there arise other serious difficulties. First of all the radius of a main sequence star with a adopted mass of 3.3 $M_\odot$ would amount to 2.2 $R_\odot$, whereas the orbital radius would be of the same magnitude, so that we had to conclude the companion being at least grazing along the surface of the primary.
Moreover, we have to assume a larger stellar radius than it corresponds to the ZAMS, which is asserted by the value of log$g$ = 3.6 taken from the H_γ profile and further observations (line strengths etc.) indicating a location of ET And in the region of the luminosity classes II to III of the HR diagram (*G. Scholz,* paper in preparation). Therefore, approaching to the region of the instability strip of the HRD, this star can be expected to perform pulsations. This view is supported by the minor period of 0.032 d resp. 46 min, too. Further we mention the photometric observations of *Panov* [7] yielding periods of 9.3, 7.5 and 5.8 min.

The very short-periodic variations obviously are caused alone by the property of the primary as an evolved B9p star. But which kind of pulsation can we expect regarding the 0.2-day period? - The frequency ratio 2 : 1 suggests that nonradial pulsations are taking place which may be excited by external forces, for example by the changing distance of the secondary in the orbital motion producing surface oscillations at the eigenfrequency by the tidal action. The tangential component of the interaction forces induces the oscillations to run around the star as a wave forming the momentary surface into an ellipsoidal figure, thus showing two times the bright side during one run around.

- But such conclusions are based on a temporarily too poor observational material. Therefore, further observa tions of ET And are needed.

References

[1] Panov, K. P.: 1978, III Sci. Conf. on Magnetic Stars, Praha, Czech. Acad. Sci., Astron. Inst., p. 19

[2] Ouhrabka, M., and J. Grygar: 1979, IBVS No 1600

[3] Hildebrandt, G., and A. Hempelmann: 1981, Astron. Nachr. **302**, 155

[4] Gerth, E., G. Scholz, and K. P. Panov: 1984, Astron. Nachr. **305** 75

[5] Deeming, T. J.: 1975, Astrophys. Space Sci. **36**, 137

[6] Gerth, E., G. Scholz, and K. P. Panov: 1984, VI Sci. Conf. on Magnetic Stars, Riga, Astr. Counc. SSSR, p.68

[7] Panov, K. P.: 1984, VI Sci. Conf. on Magnetic Stars, Riga, Astr. Counc. SSSR, p. 77