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Photoelectric and spectrographic observations of ρ Vir (HR 4828)

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Summary. — Photoelectric and spectrographic observations of the suspected variable ρ Vir are reported. Analysis of all the available photometric data has been made. The results do not show a clear regular variability of this star.

Key words : Variable stars — δ Scuti stars — Photometry — Radial velocity.

1. **Introduction.** — The star ρ Vir (HR 4828, HD 110411 ; AOV, m = 4.88) was found to be variable by Bartolini *et al.* (1980). They reported small photometric variations up to about 0^m03. These variations appear very irregular ; however, they conclude that it is very probably a very hot δ Scuti star, and it could be a « Maia » variable.

The variability of Maia type is not yet well established, and its history, just since its beginning (Struve, 1955 ; Struve *et al.*, 1957), is characterized by controversial and contradictory observational results (see Breger, 1979, for a review on this subject). More recent papers are those of Beardsley *et al.* (1980), Beardsley and Zizka (1980), and Breger *et al.* (1981).

Figure 1 shows the HR diagram with known variables of B, A, F-type near the main sequence, and the position of ρ Vir. For β Cephei variables the data were taken from Jerzykiewicz and Sterken (1980), and for the early-type ultrashort period variables from Jakate (1979). For 53 Per stars (Smith, 1980) and Maia stars of B-type (Beardsley *et al.*, 1980), the data were derived from *uvbyβ* photometry (Hauck and Mermilliod, 1980) using the calibrations of Crawford (1978) and Davis and Shobbrook (1977). Similarly, for other suspected Maia variables (Beardsley and Zizka, 1980 ; Breger, 1979) and δ Scuti stars (e.g. Antonello and Pastori, 1981), we have used the calibrations of Strömgren (1966) or Crawford (1975, 1979) and Philip and Relyea (1979), with bolometric corrections taken from Hayes (1978) ; for two stars (γ Gem and α Lyr) we have used the data of Code *et al.* (1976).

2. **Observations and reduction.** — Simultaneous photoelectric and spectrographic observations of ρ Vir were made during the night of March, 18, 1981. Photoelectric observations were made at the 102 cm reflector of the Merate Observatory, using a standard *B* filter, an ice refrigerated Lallemand photomultiplier (19 stages) with a S4 response, a Weitbrect-Gardiner amplifier with the integration time set at 15 s, and a semi-automatic device for setting alternatively the variable and the comparison star. The comparison (CP) and the check (CK) stars were SAO 100210 and SAO 100222, respectively. The sequence of measurements was CP-Var-CP-CK-CP-Var and so on, so that it was possible to check carefully the external errors. The differences of magnitudes were adjusted to take into account the differential extinction. The extinction coefficient was determined by means of the Bouguer's method. The individual measurements were organized into normal points, each one consisting of a different number of observations, in order to achieve an optimum compromise between internal scatter and temporal resolution.

The spectra were taken with the Boller & Chivens grating spectrograph at the 137 cm reflector of the Merate Observatory, with exposures of 13-19 min. on baked IIa-O plates. The dispersion was 35 Å/mm. These spectrograms show broad hydrogen lines, a moderate K line and a few very faint lines. For the determination of the radial velocities, the spectrograms were measured with the visual digitized comparator of the Merate Observatory, supplied with a Heidenhain grating (1 μ accuracy). The results of the observations are reported in tables I, II and figure 2.

3. **Data analysis and discussion.** — At first sight, the light curve shows a slight oscillation at the beginning of the night, which then damps down (Fig. 2). A power spectrum, computed between 0 and 60 c/d with the least squares method proposed by Vaníček (1971), gave a peak at 19.5 c/d, but its confidence level against random noise is only of 87 %. If we compare the variance of the data for the check star to that for the variable, we find that, during the whole night the latter is only slightly larger (of about 22 %) than the first, but if we restrict the

comparison at the first part of the night (until to time 0.54), it is 94 % larger, i.e. the ratio S/N is about − 0.3 dB. This result seems to indicate the presence of a weak signal, equivalent to that of a sinusoid with a semi-amplitude of about $0^{m}.003$.

Prof. C. Bartolini supplied us kindly with his photometric measurements of ρ Vir, made during seven nights (Bartolini *et al.*, 1980). We have analyzed them with the above quoted method. The power spectra, computed night by night, show always several peaks, but none with a confidence level above 95 %. The different colours gave similar results. These spectra were then stacked (Fig. 3), but the result does not show any relevant feature. Finally, the spectrum for four quasi-adjacent nights was computed, but this is dominated by low frequency features (Fig. 4). If we take into account these features by means of a cubic polynomial, it is possible, recomputing successively the power spectrum, to detect some peaks with frequencies of 48.55, 16.75 and 27.91 c/d. Of these, only the second overcomes the confidence level of 95 %. Incidentally, we note that its position is coincident, within the uncertainty, with that of the peak found in our data.

From all these data we can conclude that : *a*) there is not evidence that periodic terms are present steadily in the light curve ; *b*) may be that different oscillation modes are excited occasionally and then damped down.

As regards the spectrographic data, figure 2 shows some conspicuous variations of radial velocity. However, the error bars represent only the internal error, and we might take account of the uncertainties due to the broadness of the measured hydrogen lines (the projected rotational velocity of this star is 173 km/s, Uesugi and Fukuda, 1970 ; its spectral type is AO V). The mean radial velocity is of about − 23 km/s, rather different from other published data (Abt and Biggs, 1972) ; this could support the hypothesis that ρ Vir is a spectroscopic binary.

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References

ABT, H. A. and BIGGS, E. S. : 1972, *Bibliography of Stellar Radial Velocities* (Latham Process Corp., New York).
ANTONELLO, E. and PASTORI, L. : 1981, *Publ. Astron. Soc. Pacific* **93,** 237.
BARTOLINI, C., DAPERGOLAS, A., PARMEGGIANI, G., PICCIONI, A. and VOLI, M. : 1980, *Inf. Bull. Var. Stars* no. 1753.
BEARDSLEY, W. R., WOREK, T. F. and KING, M. W. : 1980, in D. FISCHEL, J. R. LESH and W. M. SPARKS (eds.), *Current Problems in Stellar Pulsation Instabilities,* NASA Technical Memorandum 80625, 409.
BEARDSLEY, W. R. and ZIZKA, E. R. : 1980, in D. FISCHEL, J. R. LESH and W. M. SPARKS (eds.), *Current Problems in Stellar Pulsation Instabilities,* NASA Technical Memorandum 80625, 421.
BREGER, M. : 1979, *Publ. Astron. Soc. Pacific* **91,** 5.
BREGER, M., HSU, J. C. and BOZYAN, E. : 1981, *Inf. Bull. Var. Stars* no. 1966.
CODE, A. D., DAVIS, J., BLESS, R. C. and BROWN, R. H. : 1976, *Astrophys. J.* **203,** 417.
CRAWFORD, D. L. : 1975, *Astron. J.* **80,** 955.
CRAWFORD, D. L. : 1978, *Astron. J.* **83,** 48.
CRAWFORD, D. L. : 1979, *Astron. J.* **84,** 1858.
DAVIS, J. and SHOBBROOK, R. R. : 1977, *Mon. Not. Roy. Astron. Soc.* **178,** 651.
HARPER, W. E. : 1937, *Publ. Dominion Astrophys. Obs.* **7,** 1.
HAUCK, B. and MERMILLIOD, M. : 1980, *Astron. Astrophys. Suppl. Ser.* **40,** 1.
HAYES, D. S. : 1978, in A. G. D. PHILIP and D. S. HAYES (eds.), *The HR diagram,* IAU Symposium no. 80, D. Reidel, 65.
JAKATE, S. M. : 1979, *Astron. J.* **84,** 1042.
JERZYKIEWICZ, M. and STERKEN, C. : 1980, in *Variability in Stars and Galaxies,* Inst. d'Astrophys., Liège, B.4.1.
PHILIP, A. G. D. and RELYEA, L. J. : 1979, *Astron. J.* **84,** 1743.
SMITH, M. A. : 1980, in H. A. HILL and W. A. DZIEMBOWSKI (eds.), *Nonradial and Nonlinear Stellar Pulsation* (Springer-Verlag), 60.
STRÖMGREN, B. : 1966, *Ann. Rev. Astron. Astrophys.* **4,** 433.
STRUVE, O. : 1955, *Sky and Telescope* **14,** 461.
STRUVE, O., SAHADE, J., LYNDS, C. R. and HUANG, S. S. : 1957, *Astrophys. J.* **125,** 115.
UESUGI, A. and FUKUDA, I. : 1970, *Contr. Inst. Astrophys. Kwasan Obs.,* Univ. of Kyoto, no. 189.
VANIČEK, P. : 1971, *Astrophys. Space Sci.* **12,** 10.

TABLE I.

Hel. J.D. 2444682.	Δ B mag		σ	n
.409	2.106	±	.002	5
.416	2.099		.001	4
.423	2.101		.002	5
.431	2.099		.002	4
.443	2.100		.002	10
.457	2.106		.002	7
.468	2.103		.001	4
.476	2.102		.002	6
.485	2.097		.001	4
.495	2.100		.002	7
.513	2.107		.002	4
.520	2.104		.002	4
.531	2.097		.002	9
.563	2.102		.002	4
.574	2.102		.002	9
.590	2.100		.002	10
.604	2.100		.002	6
.615	2.103		.002	6
.625	2.101		.002	4
.634	2.096		.001	4
.643	2.097		.002	5
.653	2.102		.002	5
.664	2.094		.002	6
.674	2.100		.003	6

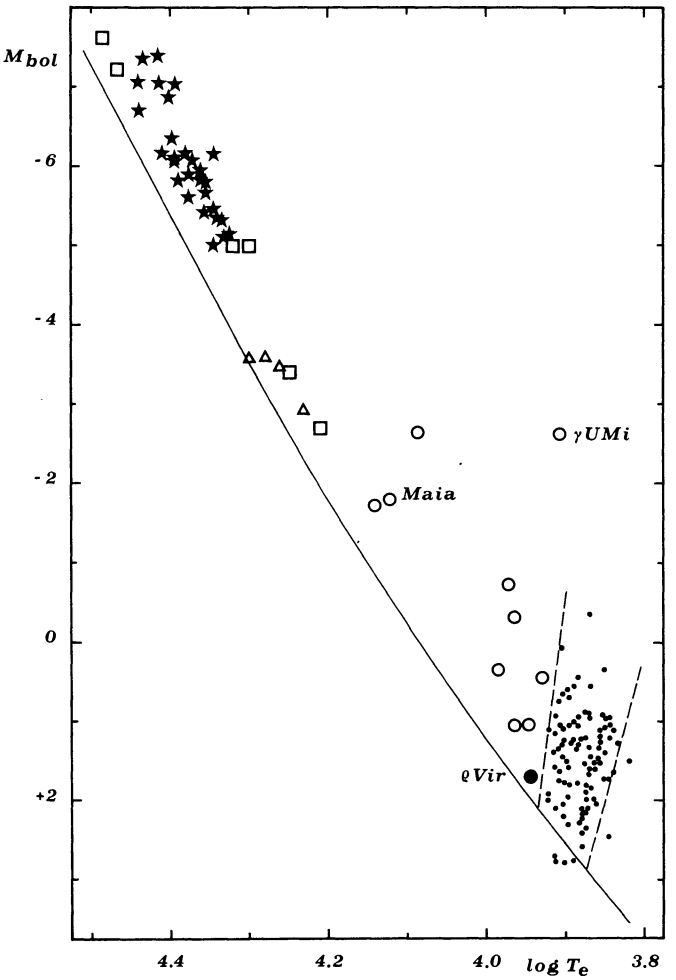

FIGURE 1. — Variable stars of B, A, F-type near the main sequence : squares : 53 Per variables ; stars : β Cephei variables ; triangles : early-type ultrashort period variables ; open circles : Maia stars ; dots : δ Scuti variables. The continuous line is the ZAMS taken from Crawford (1975, 1978, 1979) ; the dashed lines are the edges of the lower part of the instability strip (Breger, 1979).

TABLE II.

Hel. J.D. 2444682.	R V Km/s		σ
.473	-25.1	±	2.7
.484	- 7.4		3.6
.500	0.8		9.4
.512	-28.0		3.4
.527	-42.6		4.3
.543	-19.8		6.4
.563	-27.5		7.1
.574	-13.4		8.5
.590	-23.8		3.6
.609	-17.9		4.4
.621	-47.8		7.0

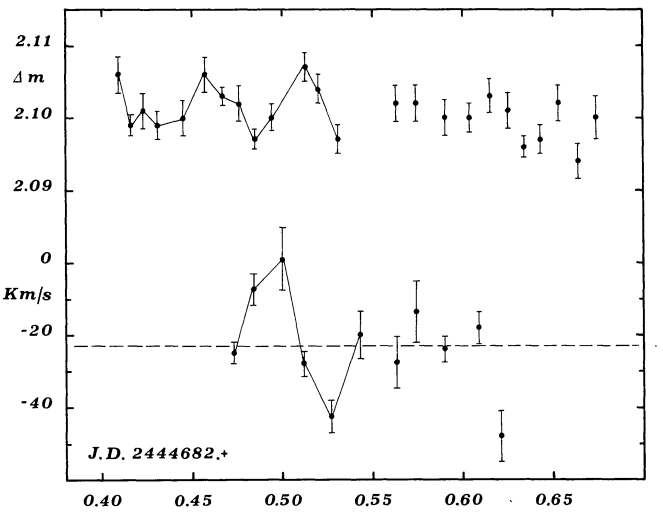

FIGURE 2. — Light and radial velocity curves of ρ Vir.

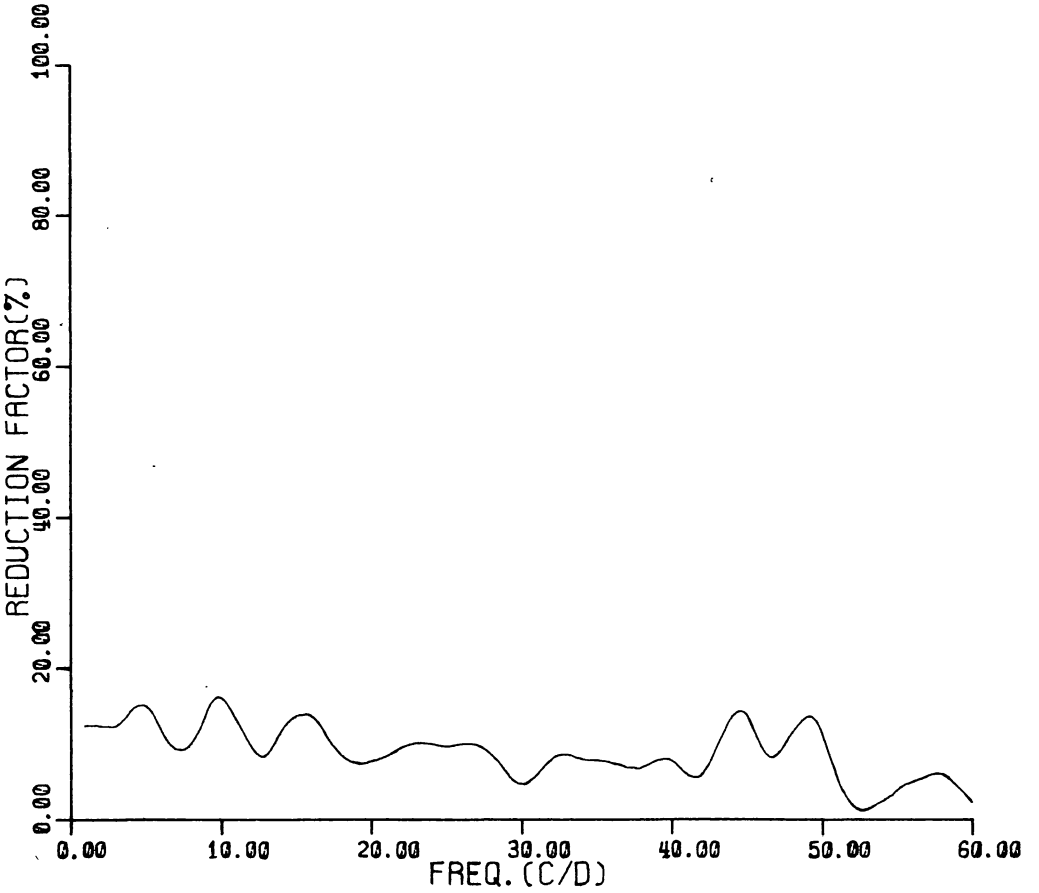

FIGURE 3. — Power spectrum obtained by stacking the spectra of seven different nights ; the computations were performed for the ΔV data.

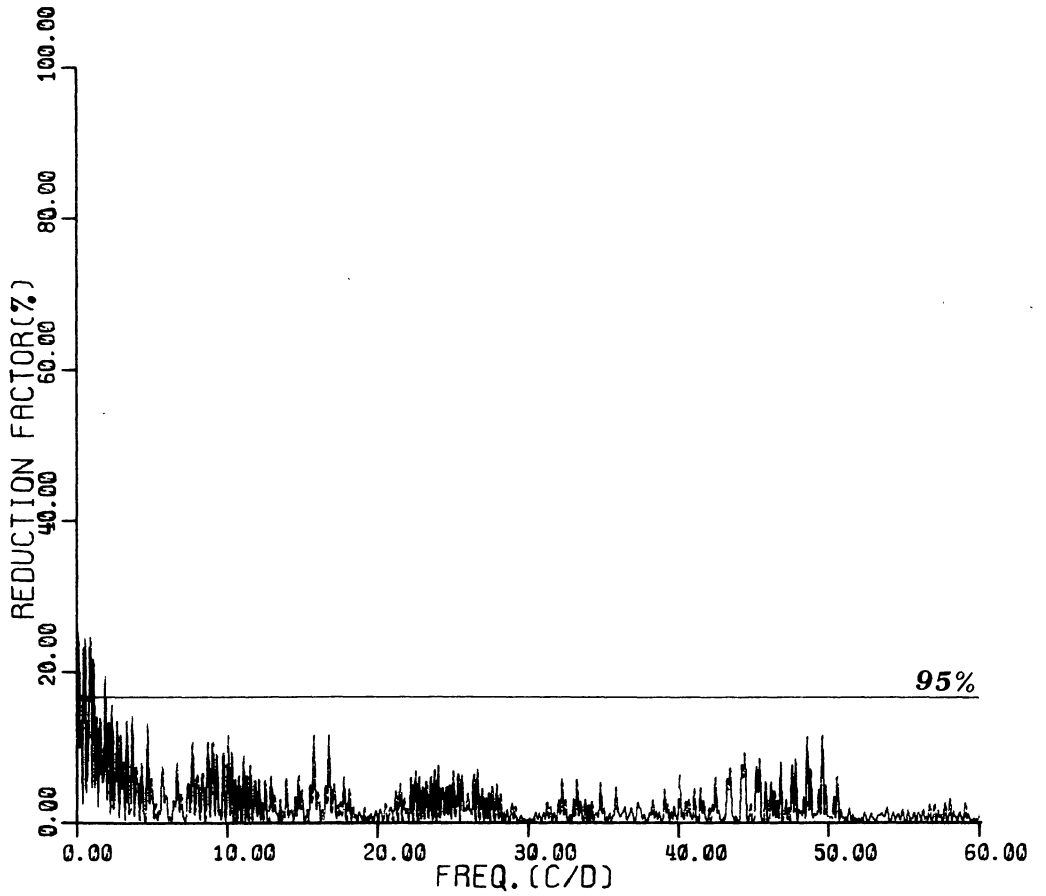

FIGURE 4. — Individual power spectrum computed with the ΔV data of four quasi-adjacent nights ; the horizontal line gives the 95 % confidence level.