COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS

Number 1005

Konkoly Observatory
Budapest
1975 June 9

ON THE PERIOD-LUMINOSITY RELATION OF THE DELTA SCUTI STARS

Taking into consideration 28 δ Scuti stars with known trigonometric or dynamic (or group) parallax the period-luminosity relation is discussed in this paper. This relation was obtained by Frolov (1969) on the basis of 6 δ Scuti stars with known trigonometric parallaxes for the first time.

A list of selected 28 δ Scuti stars is given in the Table which contains the name of the star, HD number, spectrum,mean <V> magnitude, logarithm of period P, trigonometric or dynamic (or group) parallax, observed absolute magnitude M_V with its mean error ε , weight estimated from the error ε of the observed absolute magnitude, absolute magnitude calculated from Eq. (1) and (2), subdivision and remark. The list was made using information included in papers given by Seeds and Yanchak (1972) , Baglin et al. (1973), Kukarkin et al. (1969, 1971, 1974), Broglia (1973), Jenkins (1952, 1963),Russell and Moore (1940). Only for two stars of this list, namely Y Cam and AB Cas, "photometric" parallaxes were determined using the new method which had been elaborated for the eclipsing binaries by one of us (Dworak 1974).

We discuss only such a sample of δ Scuti stars for which absolute magnitudes are known from geometric methods. We did not use absolute magnitudes obtained by Strömgren intermediate-band colours, Crawford's photoelectric H_β indices etc., because the absolute magnitudes determined in this way can be seriously erroneous for some δ Scuti stars with peculiar spectrum.

Table

Data for 28 selected δ Scuti Stars

Name	HD	Spectrum	<V>	log P	parallax		M_V obs.		weight	M_V cal.	subdiv.	Rem.
V1208 Aql	181333	F2 III (FO)	$5^m.55$	-0.803	0".002	±".007	$-2^M.9$	±($7^M.6$)	0	$-0^M.23$	bright	
UV Ari	17093	A7 IV	5.18	-1.432	0.024	.006	2.08	0.55	2	2.07	faint	
KW Aur	33959	A9 V	5.02	-1.058	0.007	d	-0.75		1	0.13	bright	SB
γ Boo	127762	A7 III	3.05	-0.538	0.016	.005	-0.93	0.70	2	-0.60	bright	
κ^2 Boo	124675	A7 IV (A8 IV)	4.56	-1.161	0.014	.006	0.29	0.95	2	0.28	bright	DS
Y Cam		A7 Vm	10.45	-1.2000	‡		0.70	0.60	2	0.33	bright	EB
AO CVn	115604	FO II (FO IIIp)	4.74	-0.914	0.014	.005	0.47	0.80	2	-0.07	bright	
AB Cas		A3	10.2	-1.237	‡		2.10	0.30	3	1.91	faint	EB
β Cas	432	F2 IV	2.28	-0.982	0.072	.007	1.57	0.25	3	1.69	faint	
ε Cep	211336	FO IV	4.19	-1.376	0.037	.005	2.03	0.30	3	2.02	faint	
FM Com	107131	A7 V	6.44	-1.260	0.012	g	1.84		1	1.92	faint	
γ CrB	149436	AO IV (A1 V)	3.86	-1.523	0.026	.005	0.94	0.45	3	0.79	bright	SB
τ Cyg	202444	FO IV (F5 IV)	3.70	-0.854	0.046	.004	2.01	0.20	3	1.58	faint	SB
δ Del	197461	A7 IIIp (FO IV)	4.45	-0.8655	0.008	.006	-1.03	1.65	1	-0.14	bright	SB
CL Dra	143466	FO IV	4.97	-1.161	0.019	.006	1.36	0.70	2	1.84	faint	
S Eri	32045	FO IV	4.79	-	0.015	.011	0.67	1.60	1	-	-	
o^1 Eri	26574	F2 II-III (F2)	4.05	-1.097	0.028	.007	1.30	0.55	2	1.79	faint	

Table (concluded)

Name	HD	Spectrum	<V>	log P	parallax		M_V obs.		weight	M_V cal.	subdiv.	Rem.
HR 8666	215664	dA8	$5^m.76$	-1.284	0".018±	".007	$2^M.04$±	0.85	2	$1^M.95$	faint	Lac
V571 Mon	55057	A8n	5.46	-0.960	0.020	.005	1.96	0.55	2	1.67	faint	
τ Peg	220061	A5 IV (A5 V)	4.62	-1.252	0.031	.007	2.08	0.50	3	1.92	faint	
ρ Pup	67523	F6 IIp (F5 II)	2.75	-0.851	0.031	.007	0.21	0.50	3	-0.16	bright	DS
δ Sct	172748	F3 III-IV (F3)	4.72	-0.713	0.020	.005	1.22	0.55	2	1.46	faint	DS
δ Ser	138918	FO IV (dFO)	4.27	-0.866	0.015	.005	0.15	0.75	2	-0.14	bright	DS
ο Ser	160613	A2 V (A2 IV)	4.26	-1.276	0.003	.006	-3.35	(4.3)	0	0.44	bright	SB
V480 Tau	30780	dA5 (dF5)	5.11	-1.377	0.009	.006	-0.12	1.45	1	0.58	bright	
ν UMa	84999	F2 IV (FO IV)	3.76	-0.877	0.036	.005	1.54	0.30	3	1.60	faint	DS
FZ Vel	77140	FO III	5.18	-1.183	0.007	.009	-0.6	2.8	1	0.31	bright	DS
FG Vir	106384	dF3	6.55	-1.155	0.010	.011	1.56	2.4	1	1.83	faint	

Remarks: d - dynamic parallax, g - group parallax, * - photometric parallax, DS - double star, EB - eclipsing binary, SB - spectroscopic binary, Lac - in Lacerta.

Looking carefully on the data gathered in the Table it is easy to notice that all the stars can be divided into two distinct groups as regards their absolute magnitudes. Both groups are being delimited by the 1^M line. Stars more luminous than 1^M, called "bright δ Scuti" or "ρ Puppis stars", are more scattered in the log P - M_V diagram than the "faint δ Scuti stars" with $M_V > 1^M$. The mean values of the absolute magnitudes for both groups together with the standard deviations are as follows: Bright δ Scuti stars: $\langle M_V \rangle = +0\overset{M}{.}12 \pm 0\overset{M}{.}64$ (we reject two stars, namely V1208 Aql and o Ser, with the greatest errors in M_V). Faint δ Scuti stars: $\langle M_V \rangle = +1\overset{M}{.}79 \pm 0\overset{M}{.}32$.

Taking this into consideration we tried to find the period-luminosity relation separately for both groups, especially that one of bright δ Scuti stars, ρ Puppis, does not confirm the Frolov's (1969, 1970) period-luminosity relation.

Using the method of least squares we calculated for the stars presented in the Table the coefficients of regression lines expressing the array means of M_V as a function of log P. These calculations were carried out taking the weights of the absolute magnitudes into consideration. The weight for each star was defined according to the arbitrary rules:

$$w = 0 \text{ if the error in } M_V \ \varepsilon > 3^M,$$
$$w = 1 \text{ if } 1^M < \varepsilon \le 3^M,$$
$$w = 2 \text{ if } 0\overset{M}{.}5 < \varepsilon \le 1^M,$$
$$w = 3 \text{ if } \varepsilon \le 0\overset{M}{.}5.$$

Together with the parameters of the best regression lines we computed the areas of confidence overlapping the true regression line $M_V = a \log P + b$ with frequency 0.98 (see Fig.1).

As a result of our calculations we obtained the following regression lines:

Bright δ Scuti stars: $$M_V = -1\overset{M}{.}41 \underset{\pm .39}{} \log P - 1\overset{M}{.}36 \underset{\pm .43}{} \qquad (1)$$

Faint δ Scuti stars: $$M_V = -0\overset{M}{.}84 \underset{\pm .22}{} \log P + 0\overset{M}{.}86 \underset{\pm .25}{} \qquad (2)$$

The scantiness of data did not allow us to explain, what was the reason for the division into bright and faint δ Scuti stars. However, on the basis of the available information we can make conjectures that the bright or ρ Puppis stars are rather unusual variables. For the majority of them the spectra belong to the II, III and V class of luminosity and very often emission lines are appearing. On the other hand, the lack of overtones is very probable for these stars as well as the gaps in variability. Some of the bright δ Scuti stars, namely ρ Pup, γ Boo, γ CrB, Y Cam, were already called untypical or unusual variables.

On the contrary, the faint δ Scuti variables seem to be typical subgiant stars and may be called normal δ Scuti stars.

Our suggestion that the δ Scuti stars may be divided into two distinct groups is confirmed by Elliott (1974).

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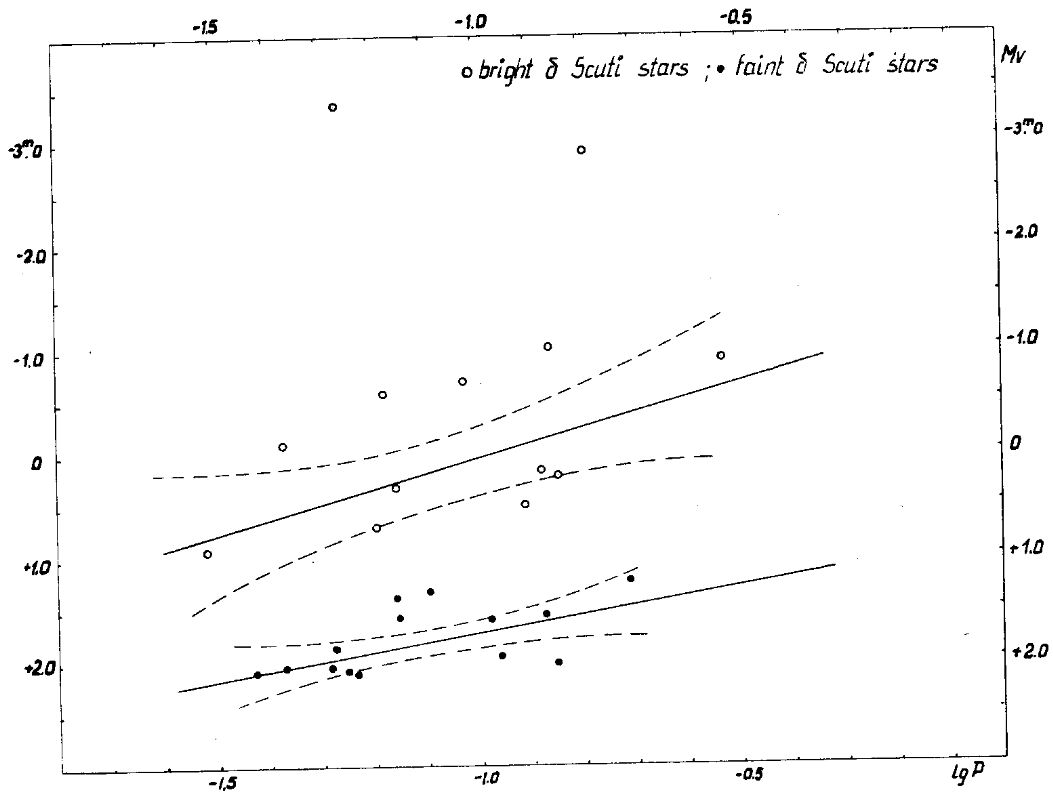

Fig. 1. The best regression lines together with their areas of confidence wich are to overlap the true regression lines with the frequency 98 % calculated for the δ Scuti stars.