SEARCH FOR PULSATING STARS IN MULTIPLE STELLAR SYSTEMS

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The importance of the search for pulsating stars of the δ Scuti type in multiple stellar systems is emphasized, in particular for the following objects: the evolutionary status of these systems, the interconnection between multiplicity and pulsation (Frolov et al., 1980), a verification of the theory of the turbulent mixing (Vauclair, 1976). A list of possible pulsating companions in visual and spectroscopic systems with foreseeable period and amplitude is given. Some preliminary results of a spectrophotometric survey begun at the Observatories of Milano - Merate and Bologna - Loiano are also given.

INTRODUCTION

Catalogues of variable visual binary stars were compiled by Plaut (1940), Baize (1962), Proust et al. (1981). The publication of uvbyβ photometry of wide visual binaries (Oblak, 1978; Oblak and Chareton, 1980) and of some spectroscopic binaries (Hauck and Mermilliod, 1980; Batten et al., 1978) gives us the opportunity to compile a first list of possible pulsating (δ Scuti) companions in multiple stellar systems. The search for pulsating stars in these systems is important, in particular, for the following subjects:

a. The evolutionary status of the stellar systems, as pointed out for some stars such as HD 15165 (BDS 1269, Rucinski, 1978) and 20 Leo (Fekel and Bopp, 1977).
b. A verification of the theory of the turbulent mixing (Vauclair, 1976; Michaud, 1980).
c. The interconnection between multiplicity and pulsation, as suggested recently by Frolov et al. (1980).

Surveys of several clusters have shown that pulsation is a common phenomenon, and it may occur in stars with different ages (Baglin et al., 1973). But it is not

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clear why only about 30% of the stars in the lower part of the instability strip are variable, and these stars are similar to nonvariable stars (with the exception of Am stars). The observation of multiple stellar systems such as double stars (wide visual systems), and particularly those with both the components in the instability strip, could give some clarification to these problems. Moreover, the survey of the spectroscopic binaries could give the incidence of variability within this group of stars (see Antonello, 1982) and verify the suggestion of Frolov et al. (1980).

LIST OF POSSIBLE DELTA SCUTI STARS

Two lists of possible δ Scuti stars have been compiled: one for the wide visual binaries, the other for the spectroscopic binaries in the catalogue of Batten et al. (1978). These two lists allow to observe two kinds of variable companions coeval with the stellar systems; those without interaction and those with some interaction with other stars of the system. By means of the uvbyβ photometry of wide visual binaries (Oblak, 1978; Oblak and Chareton, 1980) and of spectroscopic binaries (Hauck and Mermilliod, 1980), we have selected the companions with normal spectral type A, F belonging to the instability strip. Subsequent, by means of the relations:

$$\log P = -0.33\, M_V + 2.77\,(b-y) - 1.02 \qquad \text{(Breger, 1979)}$$

$$\log \Delta V = 2.08\, M_V\, \delta c_1 + 0.56 \log P - 1.09 \qquad \text{(Antonello et al., 1981)}$$

we have calculated the expected periods and maximum amplitudes of pulsation (only for visual binaries). These results are reported in Table 1, which contains 47 companions of wide visual binaries; 21 spectroscopic binaries are reported in Table 2 (several visual binaries are also spectroscopic binaries). The columns contain respectively: (1) and (2) the star identifications (HD and BD numbers); (3) apparent visual magnitude; (4) spectral type; (5) and (6) possible period P and maximum visual amplitude ΔV of pulsation; (7) separation of the components; (8) remarks.

The above mentioned subjects show the usefulness of a joint observational spectrophotometric study for companions in multiple stellar systems. A cooperation of this kind between the Observatories of Milano - Merate and Bologna - Loiano was begun with the following programme stars: HD 43525 (75 Ori A - B), HD 150100 - 150117 (16 - 17 Dra), HD 159541 - 159560 (ν^1 - ν^2 Dra), HD 173582 - 173607 (ζ^1 - ζ^2 Lyr)

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Table 1. Visual binaries

HD	BD	m_v	S.T.	P	ΔV	Sep	R
2358A	+15.00059	6.4	A5	0.10	0.06	96".3	
2885B	-63.00050	4.5	A2V	0.03	0.01	37.7	
3369B	+32.00101	8.6	A6V	0.03	0.01	36.1	
6288A	+ 0.00174	6.1	FOV	0.04	0.02	16.6	
11973A	+22.00288	4.8	FOIV			37.0	1,2,S
15695B	+ 0.00415	7.7	A7V	0.04	0.02	13.5	
20313A	-79.00091	5.7	FOII			15.2	S
22077A	-10.00694	7.3	F2	0.23	0.12	80.4	
23630B	+23.00541	8.3	FO	0.06	0.04	85.6	
24398B	+31.00666	9.9	A2	0.04	0.03	12.6	
27934A	+21.00642	4.2	A7V	0.06	0.04	39.5	3
27946B	+21.00643	5.3	A7V	0.06	0.04	39.5	
29172B	-10.00958	7.7	AO	0.03	0.01	12.8	
31203A	-53.00760	5.7	FOIV			12.4	S
42955B	+14.01211	7.9	FO	0.04	0.02	69.8	
257937B	+20.01441	7.9	A1V	0.03	0.02	112.	
71663A	- 2.02581	6.4	FO			18.0	*
76644A	+48.01707	3.1	A7V			10.7	*
81029A	+ 4.02178	7.3	FO	0.07	0.05	21.2	
83023A	+15.02077	6.3	A1V	0.04	0.03	42.4	
91312A	+41.02101	4.8	A7IV			24.6	*,3
286295C	+14.00797	10.	A5	0.03	0.01	89.3	
118349A	-25.09900	5.8	A7III	0.09	0.05	10.1	
118349B	-25.09900	6.7	A7IV	0.06	0.04	10.1	
120641B	-52.06787	7.6	A3	0.03	0.01	18.3	
120955B	-31.10729	8.5	FO	0.03	0.01	14.9	
124620A	-56.06215	7.2	AO	0.03	0.01	30.2	
138268A	-19.04128	6.3	A5V			11.6	S
138362A	-47.10092	7.1	FO	0.04	0.02	28.3	
148638A	-60.06560	7.9	AO	0.10	0.03	27.4	
151431A	+ 2.03175	6.1	A2			23.2	S
159480B	+ 9.03424	7.8	FOIV	0.03	0.02	41.3	
159876A	-15.04621	3.5	FOIV			24.9	*,2
161270A	+ 2.03390	6.1	AOV			20.8	S
165910A	+13.03529	6.6	A2V	0.29	0.01	42.7	
174005A	- 6.04913	6.5	A2	0.10	0.06	37.9	
175638A	+ 4.03916	4.6	A5V	0.05	0.03	22.3	
175639B	+ 4.03917	5.0	A5n	0.06	0.04	22.3	
178449A	+32.03326	5.0	A7			128.	*,1
231195B	+14.03879	8.8	A5	0.12	0.06	80.8	
188557A	-52.11589	7.6	FO	0.04	0.02	80.5	
190849A	+ 7.04367	7.1	A1V	0.07	0.04	65.1	
191709B	+ 0.03937	7.9	AO	0.03	0.02	55.3	
192461A	- 3.04825	7.0	FO	0.05	0.03	14.2	
193281A	-29.16981	6.6	A2III	0.11	0.04	27.4	
193281B	-29.16981	7.7	A2IV	0.08	0.05	27.4	
195093B	-19.05830	6.7	A8V	0.03	0.01	22.2	

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Remarks: 1. constant (Breger, 1969)
2. constant (Millis, 1967)
3. variable? (Millis, 1967)
S. spectroscopic binary
*. spectroscopic binary with known orbital elements

Table 2. Spectroscopic binaries (*)

HD	BD	m	S.T.	R
1826	+28.00049	6.9	A5	
4058	+46.00146	4.9	A5V	
12111	+70.00153	4.7	A4V	
13161	+34.00381	3.0	A5III	1
17094	+ 9.00359	4.2	FOIV	2
27176	+21.00618	5.6	A8	2
31109	- 5.01068	4.4	A9IV	2
37507	- 7.01142	4.8	A4IV	3
82610	-28.07373	6.4	F0	
104321	+ 7.02502	4.6	A4V	
104350	+13.02481	8.6	A7	
107259	+ 0.02926	3.9	A2V	
139319	+64.01077	7.3	A5	
151676	-15.04395	6.1	A3	
179950	-25.13866	4.9	F5	
187949	-14.05578	6.5	F	
196362	+25.04299	6.2	A4III	
199603	-15.05848	6.0	A3	
205767	- 8.05701	4.7	A7V	
209278	-17.06422	7.1	A2V	
217792	-35.15630	5.1	FOIV	

(*) the known δ Scuti stars (12 systems) are excluded.
Remarks: 1. constant (Breger, 1969)
2. constant (Millis, 1967)
3. constant (Jorgensen et al., 1971)

and HD 173648 - 173649 ($\varepsilon^1 - \varepsilon^2$ Lyr). The photometric observations of the systems $\zeta^1 - \zeta^2$ Lyr and $\nu^1 - \nu^2$ Dra show probable variations for the former, and no variations for the latter, according to Gonzalez et al. (1974). Possible small variations were found in ζ^1, ζ^2, ε^1, ε^2 Lyr also by Percy (1978).

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