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RADIAL MODES EXCITED IN THE DELTA SCUTI STAR 44 TAU

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RESUMEN

Se presentan observaciones fotoeléctricas en el filtro *B* de Johnson de la variable tipo δ Scuti 44 Tau. El análisis de períodos concluye que 44 Tau pulsa en el primer y segundo sobretonos con probablemente el modo fundamental excitado también. Los parámetros físicos se han redeterminado.

ABSTRACT

B -band photoelectric photometry and Fourier analysis of the δ Scuti type variable 44 Tau are presented. It appears that 44 Tau pulsates in the first and second overtones with probably the fundamental mode also excited. The physical parameters are redetermined.

Key words: STARS-PULSATION – STARS-δ SCUTI

I. INTRODUCTION

The star 44 Tau (HR 1287 = HD 26322) was first reported as being variable by Danziger and Dickens (1967), who proposed a period of about $0^{d}_{.}132$.

This star has been studied by several authors (see Gupta (1979); Breger (1979) and references therein), but there has not been unanimity about the pulsation periods. Some authors report that no periodicities are present in this star (Morguleff, Rutily and Terzan 1976) and others conclude that 44 Tau pulses with two stable periods (Wizinowich and Percy 1979), it even has been reported as a non-radial pulsator.

II. OBSERVATIONS

The star was observed on nine nights spanning two years, 1977 and 1978, with the 30-cm Cassegrain-reflector at the "Mojón del Trigo" Observatory in the Spanish Sierra Nevada using a standard *UBV* system.

The variable and both comparison stars (C1 = HR 1269 y C2 = HD 25768) were measured in filter *B*. The reduction procedure is described in Garrido *et al.* (1983), the magnitudes were corrected for extinction using nightly extinction coefficients. The standard deviation of the mean value for the magnitude differences between the two comparison stars was in no case more than about 5 mmag.

The light curves are shown in Figure 1. All the observations are listed in Table 1.

III. ANALYSIS

The Fourier analysis carried out for our data (López de Coca *et al.* 1984), showed two frequencies, 7.8613 c d^{-1} as the predominant one (Figure 2) and, once the data were prewhitened for this frequency, there appeared a maximum peak at 9.5387 c d^{-1} (Figure 3). After subtracting this secondary frequency, a third frequency emerged in the range of 4 to 7 c d^{-1} in the resulting power spectrum. The analysis of this range showed, two peaks of virtually the same power, centered respectively at 5.1421 c d^{-1} and 6.1450 c d^{-1} (Figure 4) where one of them is an "alias" of the other caused by the window of 1 c d^{-1} of the observations. The power spectrum after subtracting one or another frequency is practically white noise (Figures 5 and 6), hence the choice of the significant one will depend on the value of the pulsation constant Q and its ratio with respect to the two main frequencies. However, more data are needed to decide this point.

The results of the analysis are given in Table 2.

IV. DISCUSSION

The ratio of the two main periods is 0.824, which is in good agreement with the expected theoretical value for the ratio between the first overtone and the second one (Petersen 1976; Stellingwerf 1979). The third frequency either 5.142 c d^{-1} or 6.145 c d^{-1}, should correspond to the fundamental mode. If we take the first value, the ratios to the former frequencies are 0.65 and

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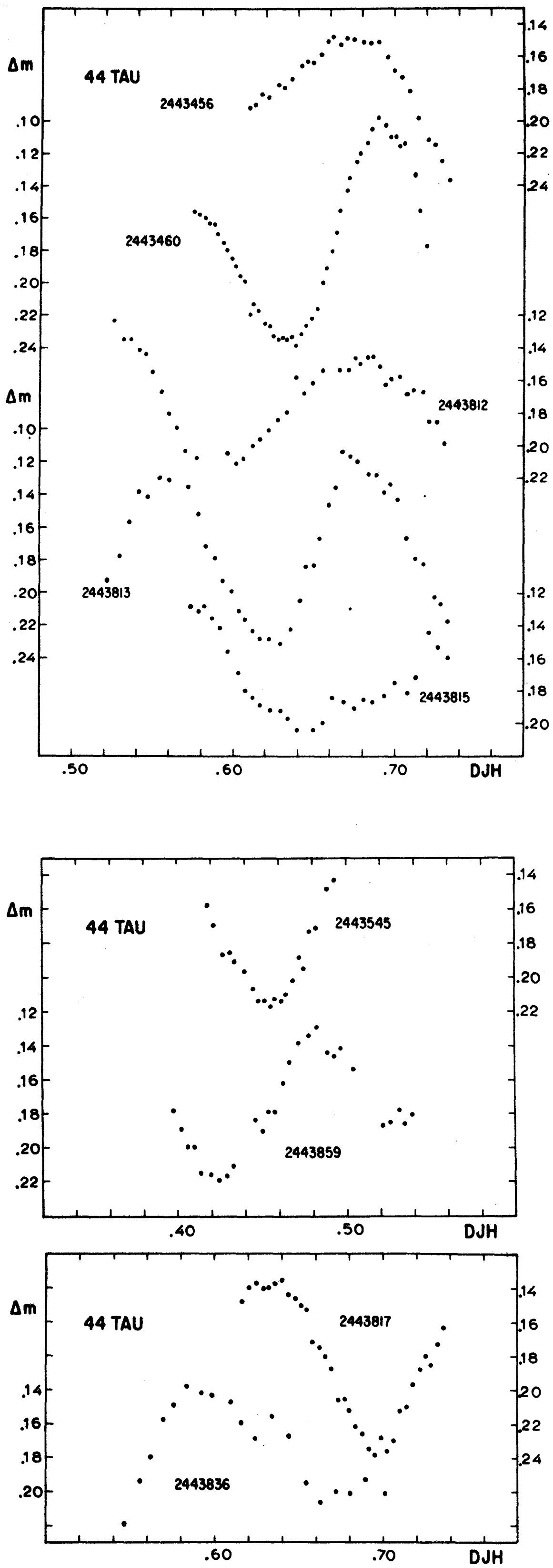

Fig. 1. Light curves of 44 Tau in 1977 and 1978, in filter *B*.

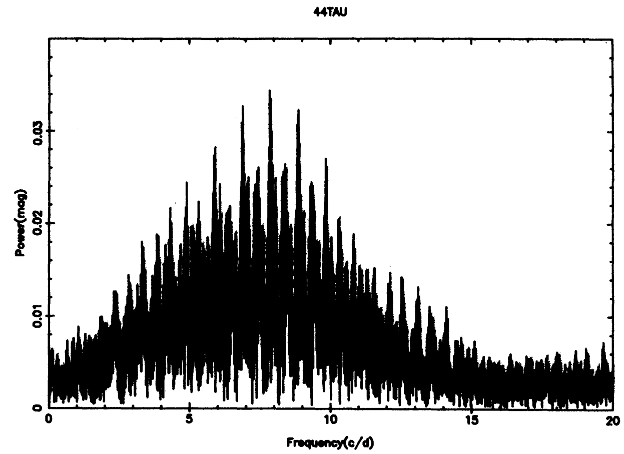

Fig. 2. Power spectrum for 1977 and 1978 seasons.

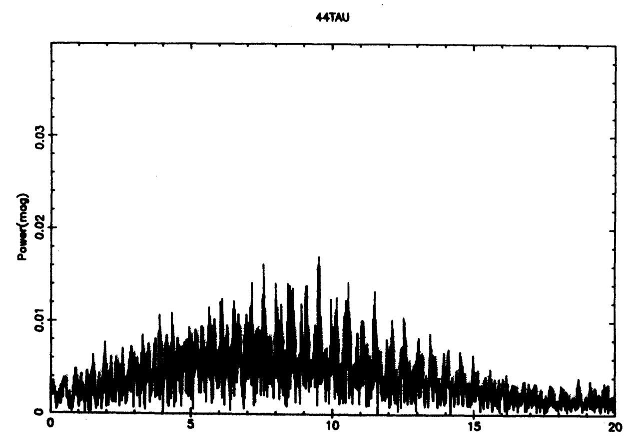

Fig. 3. Power spectrum for the residuals after prewhitening for ν_1 frequency.

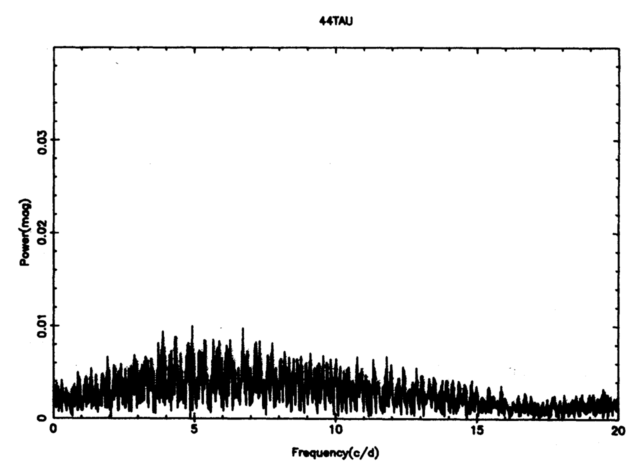

Fig. 4. Same as Figure 3 after prewhitening for ν_1 and ν_2 frequencies.

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TABLE 1

PHOTOELECTRIC PHOTOMETRY OF 44 Tau

DJH	ΔM	DJH	ΔM	DJH	ΔM	DJH	ΔM	DJH	ΔM	DJH	ΔM
2443400. +		60.6096	0.220	45.4400	0.196	12.6944	0.163	13.7018	0.143	17.6446	0.144
		60.6125	0.213	45.4448	0.207	12.6982	0.159	13.7075	0.167	17.6479	0.147
58.6094	0.192	60.6154	0.217	45.4485	0.214	12.7034	0.158	13.7131	0.179	17.6514	0.151
58.6132	0.190	60.6195	0.225	45.4519	0.214	12.7079	0.168	13.7193	0.183	17.6548	0.153
58.6173	0.184	60.6224	0.227	45.4556	0.217	12.7123	0.166	13.7252	0.203	17.6582	0.172
58.6217	0.185	60.6250	0.233	45.4586	0.213	12.7179	0.167	13.7292	0.207	17.6619	0.175
58.6277	0.178	60.6276	0.235	45.4616	0.214	12.7222	0.185	13.7336	0.218	17.6655	0.181
58.6315	0.180	60.6302	0.234	45.4646	0.210	12.7269	0.186			17.6695	0.188
58.6363	0.174	60.6329	0.235	45.4681	0.202	12.7308	0.199	15.5736	0.129	17.6732	0.206
58.6421	0.166	60.6358	0.233	45.4718	0.188			15.5781	0.132	17.6768	0.206
58.6455	0.163	60.6387	0.239	45.4749	0.195	13.5214	0.192	15.5823	0.129	17.6801	0.212
58.6496	0.164	60.6417	0.232	45.4782	0.173	13.5289	0.178	15.5873	0.136	17.6837	0.222
58.6544	0.159	60.6450	0.226	45.4824	0.171	13.5349	0.157	15.5920	0.142	17.6881	0.226
58.6580	0.151	60.6486	0.222	45.4891	0.148	13.5407	0.138	15.5971	0.157	17.6915	0.235
58.6612	0.148	60.6515	0.216	45.4932	0.143	13.5469	0.141	15.6032	0.170	17.6955	0.238
58.6659	0.153	60.6552	0.200			13.5539	0.130	15.6081	0.181	17.6989	0.228
58.6704	0.149	60.6579	0.191	2443800. +		13.5601	0.131	15.6125	0.185	17.7022	0.236
58.6742	0.150	60.6612	0.180			13.5721	0.135	15.6171	0.190	17.7063	0.230
58.6810	0.151	60.6638	0.169	12.5260	0.123	13.5785	0.152	15.6228	0.193	17.7103	0.212
58.6850	0.152	60.6666	0.155	12.5314	0.135	13.5830	0.172	15.6295	0.193	17.7137	0.210
58.6897	0.151	60.6698	0.143	12.5359	0.135	13.5884	0.179	15.6343	0.198	17.7177	0.197
58.6951	0.161	60.6726	0.135	12.5409	0.142	13.5932	0.193	15.6398	0.205	17.7214	0.188
58.6994	0.169	60.6764	0.125	12.5453	0.144	13.5988	0.200	15.6496	0.205	17.7248	0.180
58.7037	0.173	60.6792	0.120	12.5502	0.155	13.6032	0.212	15.6559	0.200	17.7284	0.185
58.7092	0.181	60.6828	0.113	12.5550	0.167	13.6076	0.217	15.6620	0.185	17.7321	0.173
58.7146	0.198	60.6862	0.105	12.5601	0.180	13.6125	0.224	15.6690	0.188	17.7359	0.163
58.7211	0.212	60.6892	0.098	12.5649	0.189	13.6169	0.229	15.6751	0.191		
58.7252	0.215	60.6934	0.103	12.5698	0.203	13.6226	0.229	15.6807	0.186	36.5472	0.219
58.7295	0.225	60.6974	0.110	12.5769	0.207	13.6289	0.232	15.6861	0.188	36.5561	0.194
58.7348	0.237	60.7005	0.110	12.5968	0.205	13.6352	0.223	15.6943	0.184	36.5633	0.179
		60.7032	0.116	12.6021	0.211	13.6417	0.205	15.7004	0.176	36.5701	0.157
60.5749	0.156	60.7063	0.114	12.6066	0.208	13.6456	0.184	15.7078	0.182	36.5766	0.148
60.5790	0.158	60.7129	0.133	12.6118	0.200	13.6499	0.184	15.7137	0.172	36.5840	0.137
60.5820	0.160	60.7162	0.155	12.6168	0.196	13.6539	0.167	15.7210	0.145	36.5921	0.141
60.5848	0.163	60.7204	0.177	12.6222	0.190	13.6588	0.147	15.7274	0.154	36.5993	0.143
60.5875	0.164			12.6278	0.184	13.6635	0.136	15.7334	0.160	36.6097	0.147
60.5904	0.170	2443500. +		12.6336	0.179	2443800. +		59.4026	0.189	59.4726	0.139
60.5934	0.175			12.6388	0.159			59.4063	0.200	59.4777	0.134
60.5962	0.180	45.4181	0.158	12.6438	0.168	36.6169	0.159	59.4099	0.200	59.4829	0.129
60.5992	0.185	45.4223	0.170	12.6489	0.162	36.6252	0.168	59.4137	0.215	59.4891	0.144
60.6017	0.190	45.4270	0.187	12.6557	0.154	36.6345	0.155	59.4201	0.216	59.4931	0.146
60.6044	0.196	45.4307	0.186	12.6659	0.154	36.6443	0.167	59.4250	0.219	59.4969	0.142
60.6070	0.199	45.4342	0.191	12.6711	0.154	36.6546	0.195	59.4288	0.217	59.5052	0.154
2443800. +		13.6681	0.114	17.6166	0.148	36.6630	0.206	59.4332	0.211	59.5215	0.187
		13.6727	0.117	17.6207	0.140	36.6726	0.200	59.4463	0.184	59.5266	0.185
12.6755	0.147	13.6772	0.120	17.6248	0.138	36.6801	0.201	59.4500	0.190	59.5308	0.178
12.6791	0.150	13.6837	0.128	17.6292	0.140	36.6893	0.193	59.4542	0.179	59.5345	0.186
12.6836	0.146	13.6889	0.128	17.6325	0.140	36.7009	0.201	59.4578	0.179	59.5389	0.181
12.6872	0.146	13.6934	0.139	17.6363	0.138			59.4625	0.162		
12.6909	0.152	13.6976	0.134	17.6402	0.136	59.3982	0.178	59.4673	0.150		

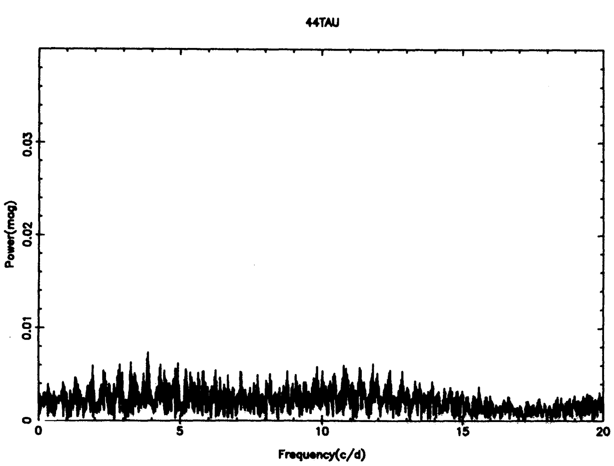

Fig. 5. Same as Figure 3 after prewhitening for ν_1, ν_2 and ν_3 frequencies.

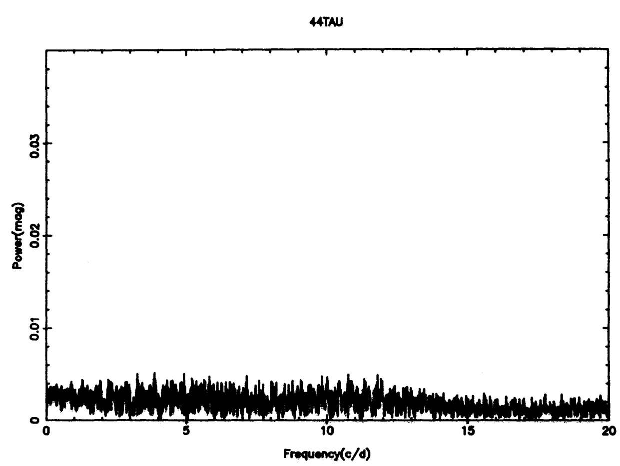

Fig. 6. Same as Figure 5 but prewhitening for υ_3' instead of υ_3'. (See text).

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TABLE 2

PARAMETERS OF THE SYNTHETIC LIGHT CURVE OF 44 Tau

H_i	$Freq_i (c\ d^{-1})$	P_i(d)	A_i(mag)	ψ_i(rad)
ν_1	7.8613	0.127205	0.0363	2.330
	37	6	16	44
$2\nu_1$	...	...	0.0045	0.807
	...	...	16	356
ν_2	9.5387	0.104836	0.0184	6.003
	37	4	12	63
ν_3	:6.1450	0.162734	0.0108	5.687
	37	10	10	90

$T_0 = 2443458^d\!.6094$, mean value of the magnitude difference 44 Tau minus HR $1269 = 0^m\!.176$, standard deviation before analysis $= 0^m\!.032$ and after analysis $= 0^m\!.011$.

0.54 respectively, while the second value gives ratios of 0.78 and 0.63 in good agreement with the expected theoretical values. Therefore, we take the value 6.145 c d^{-1} as the one corresponding to the fundamental mode.

For the photometric calibration, we have used the indices given by Hauck and Mermilliod (1980). We obtained the following physical parameters for this star: $M_V = 1.39$, $\log T_e = 3.849$ and $\log g = 3.628$. The pulsational constant, Q_{ob}, deduced from a narrow band photometric calibration, was obtained through the formula

$$\log Q_{ob} = -6.454 + \log P + 0.5 \log g + 0.1 M_{bol} + \log T_e$$

given by Petersen and Jorgensen (1972). For the $0^d\!.127205$ period a pulsational constant of 0.028 was obtained; for the $0^d\!.104836$ period the value was 0.023 and for the $0^d\!.162734$ period, 0.036, while the expected values were 0.025, 0.020, and 0.033.

More observations are needed to be sure of the value of the third frequency. We therefore conclude that 44 Tau pulsates in the first and second overtones, probably with the fundamental mode also excited.

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