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Spectrographic Observations of Three Suspected Delta Scuti Variables

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Summary. We give a short review of some theoretical and observational problems regarding Delta Scuti variables. Three suspected A 2 Delta Scuti stars (σ And, θ Peg and 2 Lyn), of the survey begun in 1970 at the Milano-Merate Observatory, are analysed in this paper. These variables show radial velocity (RV) variations with large amplitudes and short periods, different from line to line of the Balmer series. Large equivalent width (W_λ) variations with longer averaged probable periods and small short-period variations, somehow phased with the RV variations, have been found. A tentative periodogram analysis shows possible chromospheric effects. Asymmetries of the Ca II K lines in the descending branch of the RV curves suggest also possible transient atmospheric phenomena. An estimation of pulsation constant, $Q>0.030$, suggests fundamental mode pulsation; however a tentative mode excitation analysis, taking the averaged long-period variations of W_λ as beat periods, seems to show simultaneous excitation of fundamental and overtone pulsation (up to the third overtone, for 2 Lyn). As σ And, θ Peg and 2 Lyn are stars progressively far from the hot limit of the instability strip of Delta Scuti variables, we may consider also these stars as a transition type of oscillating variables between giants and white dwarfs (Dziembowski, 1977). Moreover, σ And and θ Peg could be regarded as "unusual" Ap-variables (Baglin et al., 1973; Aslanov et al., 1976a, b). The variable 2 Lyn could be an Am-Delta Scuti variable test for the turbulent mixing theory of Vauclair (1976). More extended statistics and very high resolution spectrograms are requested.

Key words: Delta Scuti stars — cepheid variables — short-period pulsators

1. Introduction

In the last years the interest for Delta Scuti stars has grown for many unanswered theoretical and observational questions. Delta Scuti variables are Population I short-period pulsators (period less than one day), of spectral types between A 2 and F 5 and luminosity classes V to II (Baglin et al., 1973). Probably these stars belong to the most common and populated class of variables (Frolov, 1975; Percy, 1975); they are placed in the same region of the color magnitude diagram occupied by the dwarf cepheids, but dwarf cepheids with $P<0^{\mathrm{d}}.1$ are near the hot limit of Delta Scuti strip (Frolov, 1976).

The period differences among classical cepheids, Delta Scuti, RR Lyrae and dwarf cepheids may be caused not only by luminosity differences but also by large mass differences (Breger, 1969). By comparison of theoretical period ratios with the observational data, Peterson and Jørgensen (1972) derived the range $1.5 \leqq M/M_0 \leqq 2.7$ for the masses and $0.014 \leqq Q \leqq 0.036$ for the pulsation constant of Delta Scuti variables. These authors concluded that in these variables the excitation of both the fundamental mode and at least three overtones may be present. The pulsation constant varies with the mode of pulsation (Breger and Bregman, 1975). Moreover a possible correlation between the pulsation constant and the period, for *each* mode of pulsation, has been found by Antonello et al. (1977). This correlation could lessen the discrepancy between the theoretical and the empirical relation $M_{\mathrm{bol}}=M_{\mathrm{bol}}(P, T_e, \mathscr{M})$. However the Q values derived from the available observational data cannot provide clear indications regarding the mass, chemical composition and preferred mode of pulsation of Delta Scuti stars. The evidence of beat phenomena and variation of amplitude in the light and RV curves of several Delta Scuti stars could support the hypothesis of a mixture of modes and possibly of resonance terms (Baglin et al., 1973) The mode coupling is probably important also for Delta Scuti stars which, according to Dziembowski (1977), may be considered as a "transition type of oscillating variables between giants (Cepheids, RR Lyrae, etc.) and white dwarfs".

The possible relations between Delta Scuti variables and some other groups of stars populating the same region of the HR diagram (Am, normal, dwarf cepheids,

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Table 1. Basic data for the stars σ And, θ Peg and 2 Lyn

Star	HR HD	V M_v (2)	T.S. (2) $V \sin i$	m_1 c_1 (2)	$(b-y)$ β (2)	$B-V$ $U-B$ (2)	RV π'' (3)	U V (2) W
σ And	68 1404	4.53 1.25	A2 *V* 150 (1)	0.192 1.035	0.026 2.893	0.05 0.06	−8*v* 0.015	−17 + 1 − 4
θ Peg	8450 210418	3.52 (3) 1.0	A2 *V* 122 (5)	0.169 (6) 1.081 (6)	0.047 (6) 2.886 (6)	0.09 (7) 0.08 (8)	−6*v* 0.042	− − −
2 Lyn	2238 43378	4.44 1.3	A2 *V* 20 (4)	0.177 1.059	0.008 2.913	0.02 0.03	−4 0.035	− 5 + 3 − 1

(1) Durrant, 1970; (2) Eggen, 1972; (3) Hoffleit, 1964; (4) Uesugi and Fukuda, 1970; (5) Levato, 1972; (6) Lindemann and Hauck, 1972; (7) Seeds and Yanchak, 1972; (8) Blanco et al., 1968.

Ap stars, Delta Del stars and unusual variables) were discussed by Baglin et al. (1973), Eggen (1976), Petersen and Jørgensen (1972), Hack (1975), Breger (1969), Baglin (1975), Kurtz (1976), Aslanov et al. (1976a, b). All these authors agree upon the need of theoretical models which can explain the presence of so many classes of stars in a restricted area of the HR diagram and of reliable observational criteria to characterize these classes.

In 1970 Frolov published a list of suspected Delta Scuti variables. In the same year we begun a spectrographic survey of some stars of this list for studying their type of variability. The results for three A 2 V stars are given in the present paper.

2. Observations and Reductions

The observed stars and their basic data are listed in Table 1.

The spectra were taken with the Zeiss prism spectrograph (dispersion 35 Å/mm at H_γ) on the 137 cm Ruths telescope of the Merate Observatory. Each star was observed for several hours (4^h–6^h) in the same night, with exposures of the spectra of 10–15 min. For the determination of the *RV* the spectrograms were measured with the visual digitized comparator of the Merate Observatory supplied with a Heidenhain grating (1 μ accuracy). The probable errors of the *RV* are about 5 km s^{-1} at H_γ. For the W_λ determinations the spectrograms and calibrations were traced on the Jenoptik Schnellphotometer and the microphotometric tracings were measured with the digitized coordinate gauge (0.1 mm accuracy) of the Merate Observatory. The computations were performed at the 1106 Univac Computer of the University of Milan. The equivalent widths were measured with the following cautions:

Having the spectra of each star equal exposure times and densities, the same parts of the calibration curves were used. Moreover the possible source of systematic discrepancies in the equivalent widths suggested by Mitton (1976), is eliminated.

Particular care was taken for the tracing of the continuum, which may be one of the most critical source of errors (Houtgast, 1966). All the continua were traced with the same criteria and comparing the spectra each other. With the same cautions were traced the line wings.

Moreover, for checking the errors of our measures, the standard star HD 163989 was observed with the same spectrograph and in the same conditions. The spectra were reduced with the instruments and methods utilised for the program stars. This star was also adopted in a classification paper (Casini and Pasinetti, 1970).

The variations of the equivalent widths and of the *RV* of the program stars are respectively 9–35 times and 2–8 times higher than the averaged errors of the standard star. Moreover the behaviour of these variations is clearly regular.

3. Results

The values of W_λ for σ And, θ Peg and 2 Lyn are listed in Tables 2a, 3a and 4a. The values of *RV* are listed respectively in Tables 2b, 3b and 4b.

In Figures 1, 2 and 3, we have plotted the W_λ and *RV* values of H_δ lines versus the julian days. The solid hand drawn lines show fairly regular curves with some well determined variations largely higher than the errors of measures.

In the hypothesis of periodic variations, a periodogram analysis (Lafler and Kinman, 1965) with our W_λ and *RV* values has been attempted. The corresponding results for reliable lines are the following:

Averaged probable periods of W_λ variations

	H_β	H_γ	H_δ	K	H_8
σ And	0.278	0.318	0.358	0.272	0.306
θ Peg	0.177	0.185	0.202	0.244	0.215
2 Lyn	0.306	0.298	0.298	0.284	0.326

Table 2a. Equivalent widths of σ And

N. Sp.	J. D.	H_β	H_γ	H_δ	H_8	K
2922	2440902.2479	10.91	14.68	16.15	12.28	2.12
2923	2440902.2597	11.53	13.60	16.86	11.62	2.00
2924	2440902.2715	11.04	13.29	15.46	12.04	2.21
2925	2440902.2833	10.60	13.90	16.29	11.84	2.06
2926	2440902.2972	12.42	17.07	17.96	13.69	2.50
2927	2440902.3097	11.17	17.02	19.14	13.40	2.53
2928	2440902.3222	12.37	16.10	18.30	13.17	2.20
2929	2440902.3347	13.63	15.86	18.97	13.45	2.37
2930	2440902.3462	10.51	14.15	19.85	13.04	2.21
2931	2440902.3597	13.53	16.45	20.37	14.22	2.33
2932	2440902.3715	14.23	19.34	20.41	13.63	2.75
2933	2440902.3833	12.73	17.78	20.46	14.03	2.59
2934	2440902.3958	13.90	20.59	21.16	14.47	2.92
2935	2440902.4097	14.38	19.93	20.63	14.33	2.23
2936	2440902.4222	13.64	22.05	20.35	13.70	2.41
2937	2440902.4347	12.85	18.62	21.34	12.75	2.26
2938	2440902.4472	15.93	21.31	21.02	13.74	2.25
2939	2440902.4645	13.15	19.93	18.48	14.10	2.24
2940	2440902.4708	12.39	19.06	18.98	13.70	2.42
2941	2440902.4909	13.48	20.50	21.45	14.18	2.35

Table 2b. Radial velocities of σ And

N. Sp.	H_γ	H_δ	H_8	K
2922	−13.0	−51.4	−20.1	−24.9
2923	−39.4	−50.2	−30.5	−29.0
2924	−17.0	−40.5	−15.5	−31.7
2925	−54.2	−16.5	−18.5	−24.8
2926	−10.5	+26.3	−10.2	−11.1
2927	−31.4	−39.4	−17.9	−24.5
2928	−36.6	−26.6	−13.7	−15.0
2929	−26.0	−46.4	−15.5	−19.2
2930	−15.0	−33.6	−27.5	−20.6
2931	−27.0	−34.6	−13.3	−19.9
2932	−10.1	− 4.0	+ 2.2	+ 8.2
2933	− 9.9	+15.3	− 6.2	− 9.8
2934	− 1.3	− 2.1	− 4.4	− 5.1
2935	−12.7	+ 8.2	−11.2	− 7.0
2936	−33.8	−13.8	−13.0	−15.5
2937	−34.3	−32.0	−15.1	−23.0
2938	−82.1	−38.7	−38.9	−31.0
2939	−22.0	−16.2	−36.5	−14.7
2940	−35.8	−15.4	−17.3	−16.0
2941	−31.6	−17.5	−16.2	−23.5

Table 3a. Equivalent widths of θ Peg

N. Sp.	J. D.	H_β	H_γ	H_δ	H_8	K
2905	2440889.2409	13.73	17.48	18.94	13.42	2.36
2906	2440889.2493	13.21	18.89	18.45	13.12	2.07
2907	2440889.2576	14.05	17.46	18.77	13.30	2.28
2908	2440889.2673	11.58	17.71	18.76	13.29	2.31
2909	2440889.2793	11.72	21.36	19.66	13.42	2.30
2910	2440889.2888	12.25	15.03	16.07	12.38	1.95
2911	2440889.3159	11.00	10.95	13.28	11.27	1.99
2912	2440889.3243	12.23	14.62	14.92	12.28	2.15
2913	2440889.3326	11.91	12.54	14.37	11.95	2.00
2914	2440889.3402	10.62	11.45	14.07	11.65	1.91
2915	2440889.3486	11.45	11.13	14.06	10.18	1.76
2916	2440889.3576	9.90	10.58	14.07	10.31	1.98
2917	2440889.3659	10.63	8.89	12.84	9.37	1.61
2918	2440889.3763	12.02	13.01	13.91	10.41	2.00
2919	2440889.3847	10.33	12.12	13.07	10.06	1.86
2920	2440889.3930	11.35	11.46	14.37	9.85	1.60
2921	2440889.4013	12.44	13.41	15.85	11.21	1.70

Table 3b. Radial velocities of θ Peg

N. Sp.	H_β	H_γ	H_δ	K
2905	−18.4	−21.2	−19.3	−20.4
2906	−22.2	−22.0	−19.3	—
2907	−26.1	−26.9	−34.9	−27.6
2908	−31.1	−45.3	−32.9	−27.3
2909	−33.0	−59.7	−57.6	−34.8
2910	−31.0	−67.3	−35.4	−37.8
2911	—	−18.1	−10.5	−21.1
2912	−27.4	−43.1	−32.8	−32.4
2913	−24.9	− 5.2	−15.4	−11.3
2914	−49.7	−30.4	−48.2	−26.0
2915	−33.8	−42.1	−46.1	−41.1
2916	−56.1	−30.1	−66.4	−30.8
2917	—	−29.7	−50.7	−33.5
2918	−14.3	−22.4	−19.2	−24.4
2919	−18.5	− 7.3	− 2.9	− 6.9
2920	—	−15.8	−10.9	−15.3
2921	—	+ 5.1	−18.2	− 4.2

Averaged probable periods of RV variations

	H_β	H_γ	H_δ	K	H_8
σ And	—	—	0.102	0.088	0.094
θ Peg	—	0.087	0.081	0.071	0.071
2 Lyn	0.075	0.056	0.037	0.040	(0.269)

On account of the mean dispersion of our spectra, a qualitative analysis of possible asymmetries of the Ca II K line profiles has been attempted. For each star, two profiles of the Ca II K line have been compared: the profile corresponding to the phase close to the average RV value of the rising branch of the RV curve (maximum radius, points A of Figures 1, 2 and 3), and the profile corresponding to the phase close to the average RV value of descending branch of the RV curve (minimum radius, points B of Figures 1, 2 and 3). The results of these comparisons are shown in Figure 4.

Finally, an attempt to characterize σ And and θ Peg as spectroscopic binary stars has been made, confirming the negative results of Beardsley (1969) and Morbey and Brosterhus (1974).

4. Discussion

Radial Velocities

Tables 2b, ..., 4b and Figures 1–3 show large amplitudes (till 60 km s^{-1}) of the RV curves. It is rather un-

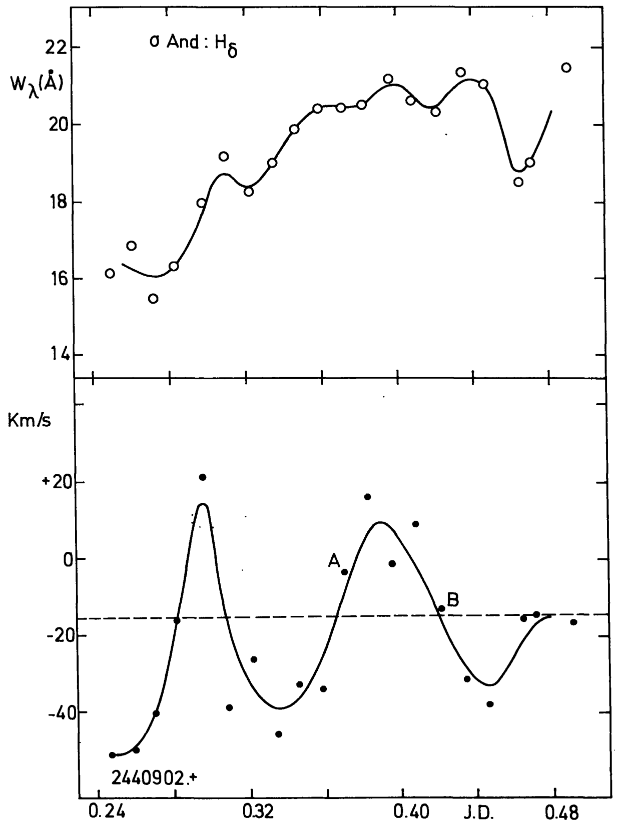

Fig. 1. Equivalent widths and radial velocities of H_δ line versus Julian Days for σ And. Points A, B see the text

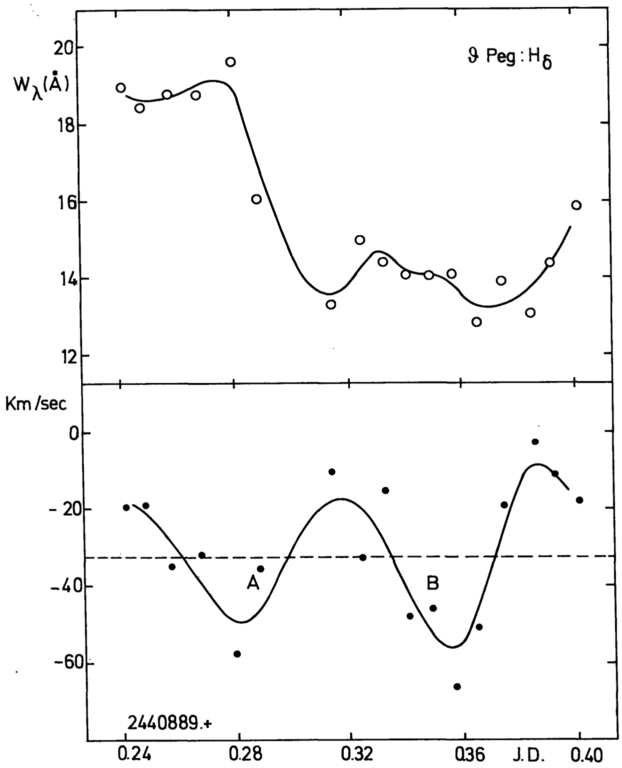

Fig. 2. Equivalent widths and radial velocities of H_δ line versus Julian Days for θ Peg. Points A, B see the text

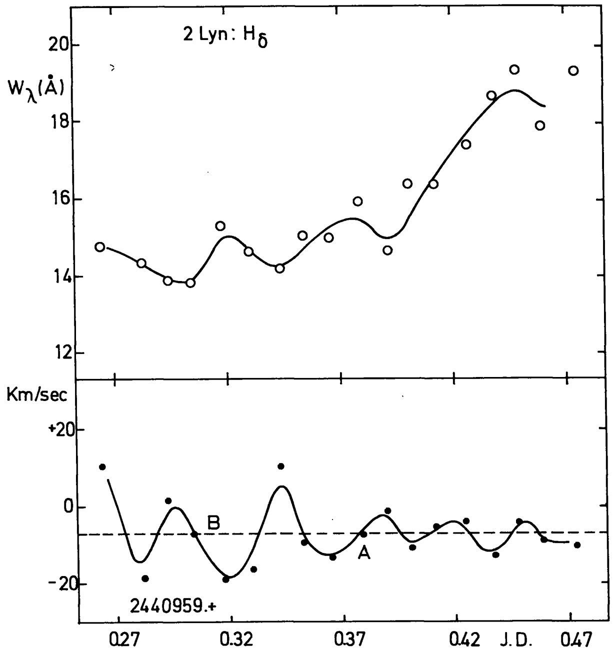

Fig. 3. Equivalent widths and radial velocities of H_δ line versus Julian Days for 2 Lyn. Points A, B see the text

common to find Delta Scuti stars with amplitudes of two, three tens of km s^{-1}. The *RV* curves differ from line to line, in amplitudes and averaged probable periods. Irregularities of amplitudes and periods also in the light curves of Delta Scuti variables have been observed (Valtier et al., 1975). Moreover, we can see a progressive decrement of amplitudes and periods, especially in 2 Lyn, which cannot exclude a "chromospheric level effect" (Buscombe, 1957; Frolov, 1975). Other weaker lines, not measurable in our spectra, should be necessary to confirm this level effect (Le Contel et al., 1970).

The occurrence of velocity fields (Le Contel et al., 1970) and transient phenomena like progressive sound waves (Baryłko, 1977) or shock waves (Dravins et al., 1977) seem to be shown by the asymmetries of Ca II K line profiles of Figure 4. Variations of the H_γ and Ca II K lines were observed with lower dispersion by Baglin et al. (1968). Steeper blue wings of the Ca II K profile at the descending branch of the *RV* curve were found with higher dispersion by Dravins et al. (1977). The asymmetry of Ca II K lines has been theoretically discussed by Baryłko (1977).

Finally, if we take in account the averaged probable periods $0^d.065$, $0^d.080$ and $0^d.095$ respectively for 2 Lyn, θ Peg and σ And, and their position in the HR diagram (see the last section) we could conclude that these stars are pulsating in the overtone modes. But an estimation of the pulsation constant by means of the formula reported by Petersen and Jørgensen (1972) gives $Q > 0.030$ which suggests fundamental mode pulsation.

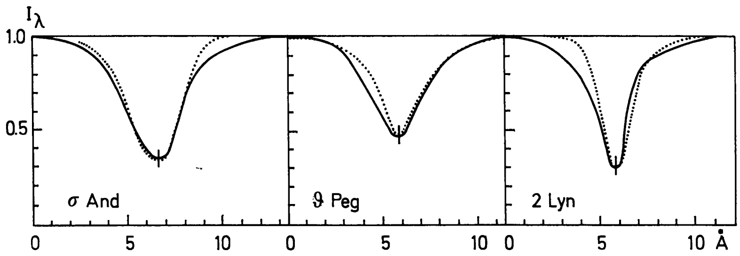

Fig. 4. Profiles of Ca II K: ——— *RV* incr. (point *A* of Figures 1, 2 and 3); ······ *RV* decr. (point *B* of Figures 1, 2 and 3); σ And, Sp. 2932 (*A*) and 2936 (*B*); θ Peg, Sp. 2910 (*A*) and 2915 (*B*); 2 Lyn, Sp. 2988 (*A*) and 2982 (*B*)

Table 4a. Equivalent widths of 2 Lyn

N. Sp.	J. D.	H_β	H_γ	H_δ	H_8	K
2979	2440959.2694	10.78	13.41	14.81	12.39	1.46
2980	2440959.2813	11.82	11.95	14.33	12.31	1.52
2981	2440959.2931	11.38	11.77	13.89	11.87	1.47
2982	2440959.3042	14.76	14.71	13.82	12.85	1.52
2983	2440959.3174	12.42	14.47	15.33	12.60	1.50
2984	2440959.3299	12.43	13.82	14.61	12.79	1.60
2985	2440959.3424	11.90	14.00	14.19	12.05	1.62
2986	2440959.3535	12.76	14.37	15.04	12.38	1.38
2987	2440959.3653	13.05	14.13	15.03	13.57	1.64
2988	2440959.3778	12.90	15.60	15.93	13.26	1.77
2989	2440959.3896	14.25	15.81	14.63	13.11	1.94
2990	2440959.4000	13.24	16.40	16.43	13.86	1.77
2991	2440959.4118	15.21	15.50	16.40	13.65	1.70
2992	2440959.4257	13.91	18.64	17.41	14.42	1.71
2993	2440959.4368	14.67	18.88	18.69	15.26	1.67
2994	2440959.4472	13.72	17.90	19.36	14.95	1.81
2995	2440959.4583	15.18	19.52	17.92	15.91	1.99
2996	2440959.4729	15.53	18.06	19.35	16.20	1.89

Table 4b. Radial velocities of 2 Lyn

N. Sp.	H_β	H_γ	H_δ	K	H_8	λ 4481
2979	+ 2.0	−25.8	+10.6	− 6.1	−12.6	−11.2
2980	− 9.9	+15.2	−18.7	−15.7	−20.4	+12.8
2981	+40.4	+ 1.9	+ 1.7	+ 3.0	−21.6	+ 0.8
2982	+13.2	− 2.8	− 6.9	−15.4	−25.2	−18.1
2983	− 1.6	−25.6	−18.4	−17.3	−26.0	+ 5.0
2984	−33.0	−35.6	−16.0	−10.0	−23.0	−41.0
2985	−15.9	−21.0	+10.5	− 5.5	−20.7	−19.1
2986	− 1.4	− 3.3	− 8.9	− 9.0	− 6.0	+ 6.6
2987	+14.3	−40.1	−12.9	−12.4	− 8.2	− 2.7
2988	+15.7	− 7.3	− 6.9	− 4.4	− 5.1	+ 8.3
2989	—	− 8.4	− 1.3	−12.3	−23.9	+ 7.5
2990	—	− 0.2	−10.4	−13.2	−19.7	+11.5
2991	—	+ 2.7	− 5.4	− 9.2	− 6.7	+10.8
2992	+ 2.1	—	− 4.1	− 2.3	− 6.4	− 3.2
2993	+ 0.2	− 6.7	−12.3	−10.8	− 9.2	+33.1
2994	—	− 7.7	− 4.1	−11.3	− 7.3	+18.2
2995	—	− 3.4	− 9.1	− 7.6	− 2.6	−12.6
2996	—	−12.8	−10.1	−15.7	+ 3.1	−39.0

Equivalent Widths

Tables 2a, ..., 4a and Figures 1–3 show clear, large and small variations of W_λ, somehow phased (sometimes specular?) with the *RV* variations. The large variations have amplitudes of about ±20% and reach the value of ±40% in the H_γ of θ Peg. Nevertheless, our observations are not sufficient to establish a possible periodicity of these variations, therefore the periods reported above are only indicative.

At our knowledge W_λ curves of Delta Scuti stars are missing in the literature, therefore no comparison with our results is possible. Only the profile and the equivalent width of H_β of δ Del were determined by Williams et al. (1974) but no fast (few minutes) variation, as expected, was found.

The W_λ and *RV* curves may suggest two models of radial pulsation simultaneously excited. Indeed, if we assume the period of W_λ as the beat period P_m and the period of *RV* as the basic period P_b we can determine the average ratio $\bar{B}$ of fundamental and overtone periods as follows:

θ Peg, H_γ, H_δ, H_8 and K lines: $\bar{B}=0.626$ with the theoretical value $P_2/P_0=Q_2/Q_0=0.020/0.033=0.61$. This result could indicate that the fundamental $P_0 \equiv P_b$ and second overtone P_2 are simultaneously excited, and P_0 bears the main variation (Christy, 1966).

σ And, H_δ, K and H_8 lines: $\bar{B}=0.766$ with the theoretical value $P_1/P_0=Q_1/Q_0=0.025/0.033=0.76$. P_0 and P_1 are simultaneously excited and P_0 bears the main variation.

2 Lyn, H_γ, H_δ, H_8 and K lines: $\bar{B}=0.853$ with the theoretical value $P_3/P_2=Q_3/Q_2=0.017/0.020=0.85$. P_2 and P_3 are simultaneously excited, and P_2 bears the main variation. For all these stars the ratio P_m/P_b is about 3.2.

Although these results agree with the theory of radial pulsation (Petersen and Jørgensen, 1972) nevertheless they must be taken with care. The *RV* curves show evident irregularities, the W_λ curves are inadequately determined and show short-period variations clearly in phase with the *RV* curves (especially σ And and θ Peg). On the other hand, if our results shall be confirmed by other observations it would be interesting to explain the influence of the beat periods on the atmospheric parameters.

Further Remarks and Comparison with Ap, Am *Stars*

The $b-y$ indices of σ And, θ Peg and 2 Lyn show that these stars are progressively far from the hot limit of the instability strip of Delta Scuti stars (Baglin et al., 1973). Some "unusual variables" are in a similar situation (Baglin et al., 1973 Sect. 6.4). However, the main difference between our variables and the classical Delta Scuti stars are the large amplitudes of the *RV* curves, as remarked above. If we consider the ratio $2K/\Delta m_v$ of the amplitudes of the *RV* curves and of the light curves, varying from 50 to 125 km s^{-1}/mag for classical Delta Scuti stars (Breger et al., 1976), we found a value of $\Delta m_v \sim 0^m.3$ ten times higher than the values commonly estimated for our stars.

Taking into account these discrepancies and possible pulsations of Ap-stars, reported by Baglin et al. (1973), we have looked up in the literature other stars with characteristics similar to those of our variables. Therefore we have considered the Ap-stars 21 Com, 17 Com A and HD 224801 observed by Aslanov et al. (1976a, b). In 21 Com these Authors found variations of the W_λ of the hydrogen lines with a period of about $1^d.03$. In 17 Com A, *RV* variations of H_δ were found with a period of about 71^m, in good agreement with the photometric period of 75^m observed by Shenaikh (1975). In HD 224801, *RV* variations of H_γ, H_δ and H_ε with a period of 6^h were observed. Both 17 Com A and HD 224801 show large amplitude (40–50 km s^{-1}) of *RV* variations, but very small variations in the light curve (< 0.01 mag). Therefore, the small amplitude of light variations and the large amplitude of *RV* variations both with short periods, and the large amplitude and period of variations of W_λ, observed in σ And, θ Peg and 2 Lyn, seem to be characteristics of Ap-stars. Nevertheless we cannot say that σ And, θ Peg and 2 Lyn are Ap-stars. Indeed σ And is reported in the list by Durrant (1970) but none of these stars is reported in the Ap and Am stars catalogue of Bertaud and Floquet (1974).

The star 2 Lyn requires a further discussion. It was classified A 0 V by Campbell and Moore (1928) and by Harper (1937), and was reported as a normal A 2 V star by Hoffleit (1964). Harper (1937) remarked that its spectrum shows additional and sharp metallic lines. Moreover it is a slow rotator (Uesugi and Fukuda, 1970). Figure 3 shows that its *RV* amplitudes (10–20 km s^{-1}) are smaller than those of σ And and θ Peg and the computations reported above show that the second and third overtones should be excited in this star. 2 Lyn show some Am characteristics but is outside the classical Am region. The above mentioned phenomena could suggest to consider this star as a candidate test for the theory of the turbulent mixing according to which every Am-star could become a normal A-star or a Delta Scuti variable (Vauclair, 1976)[1].

[1] On this subject the anonymous referee suggests to take into account also the paper of Smith (1977) about the incidence of non radial pulsations in B stars and possibly in stars outside the customary Delta Scuti stars region

5. Conclusions

Three suspected A 2 V Delta Scuti stars, σ And, θ Peg and 2 Lyn show large amplitude and short period variations of *RV* different from line to line, definite and regular variations of the W_λ with probable larger periods and smaller short-period variations of the W_λ, somehow phased with the *RV* variations. Tentative periodogram analyses of the hydrogen lines seem to show possible chromospheric level effects. The asymmetry of the Ca II K lines in the descending branch of the *RV* curves suggests also transient phenomena. An estimation of the pulsation constant $Q > 0.030$ suggests fundamental mode pulsation for these stars; however a tentative analysis of mode excitation taking the averaged probable periods of W_λ as beat periods, could show simultaneous excitation of fundamentals and overtones (up to the third one). As σ And, θ Peg and 2 Lyn are stars progressively far from the hot limit of the instability strip of Delta Scuti stars, the following questions arise:

Multiperiodicity and rapid amplitude changes found in white dwarfs may indicate that the mode coupling is probably also important in the case of Delta Scuti variables, which may be considered as a transition type of oscillating variables between giants and white dwarfs (Dziembowski, 1977).

Our stars seem to show some characteristics similar to those of "unusual" and Ap variables (Baglin et al., 1973; Aslanov et al., 1976a, b).

Moreover, 2 Lyn shows also some Am characteristics which could indicate the crossing from Am to Delta Scuti zones, predicted by the turbulent mixing theory (Vauclair, 1976).

Our results suggest to extend the statistic to other suspected Delta Scuti stars, not peculiar and outside the hot limit of Delta Scuti strip. Also for these stars, as remarked by Hack (1975), there is a need for very high resolution spectra, both in the visible and far UV range.

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