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Probable additional Swan band lines in the solar spectrum

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Abstract. Several unidentified spectral features in the solar spectrum are listed by Moore *et al.* (1966). They are traceable in the atlas by Delbouille *et al.* (1973). We attempt to identify some of these features in the region λ4800–5200 Å as the lines due to the (0–0) band of the Swan system of the C_2 molecules.

Key words: Swan bands—C_2 molecules—solar spectrum

1. Introduction

Ever since the dawn of solar spectroscopy, detection and identification of Fraunhofer lines has remained an important area of study. Over the years, it has resulted in the identification of numerous atomic and molecular contributors to the solar spectrum (Moore *et al.* 1966; Swensson *et al.* 1970). However, still there are hundreds of lines awaiting identification. It is pertinent to check if some of the lines can be identified with the already known molecular species. One such study led to the identification of new CN lines (Porfireiva 1982). Here, we present the results of our study based on the identification of the (0–0) band of the Swan system of the C_2 molecules.

2. Formulations and calculations

The presence of the Swan bands in the solar spectrum is well known (Grevesse & Sauval 1973). The availability of a high quality solar atlas (Delbouille *et al.* 1973) makes it possible to detect weak features in the solar spectrum. Also available is a highly accurate table of wavelengths extending over large values of rotational quantum numbers J for the Swan bands (Phillips & Davis 1968; Amiot 1983). This favourable circumstance prompted us to look for new features of the Swan bands in the solar spectrum. The FTS study of wavelengths by Amiot (1983) is in remarkable agreement with that due to Phillips & Davis (1968). We compared the C_2 wavelengths (Phillips & Davis 1968) with the list of line identifications (Moore *et al.*

1966). Such lines for which no identification is given were noted for a check in the photospheric atlases by Delbouille *et al.* (1973) and by Brault & Testerman (1972). The latter atlas gives the near limb spectrum also.

The equivalent widths of the newly identified lines were calculated for the centre of the solar disc ($\mu = 1.0$) and for a near limb position ($\mu = 0.2$). It may be pointed out that for such weak lines as the Swan bands, equivalent widths may be calculated which do not depart more than 30% from observations (sinha 1984). The photospheric model of Holweger & Müller (1974) was used for the calculations.

3. Results and discussions

Molecular lines are known to strengthen towards the solar limb (Sotirovski 1971). A cursory inspection of the atlas (Brault & Testerman 1972) suggests that the lines listed in table 1 do strengthen towards the limb (*cf.* Fig. 1). Since the lines were extremely weak, equivalent widths were not measured. Further, to deblend the lines one would need atlases with a better signal-to-noise ratio such as the one obtainable with an FTS.

In table 1 the equivalent widths measured by Moore *et al.* (1966) are given for the newly identified features. Also given are the results of the present calculations for $\mu = 1.0$ and $\mu = 0.2$. Coincidences within $|\Delta\lambda| = 0.05$ Å were taken as

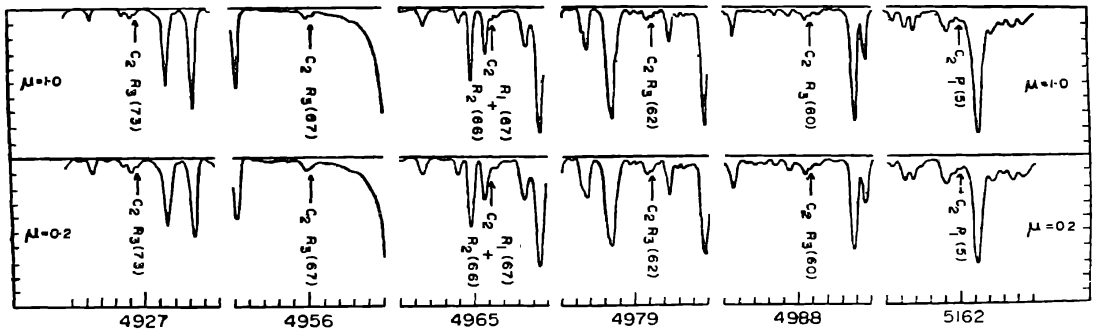

Figure 1. The newly identified Swan features, at $\mu = 1.0$ and $\mu = 0.2$ (Brault & Testerman 1972).

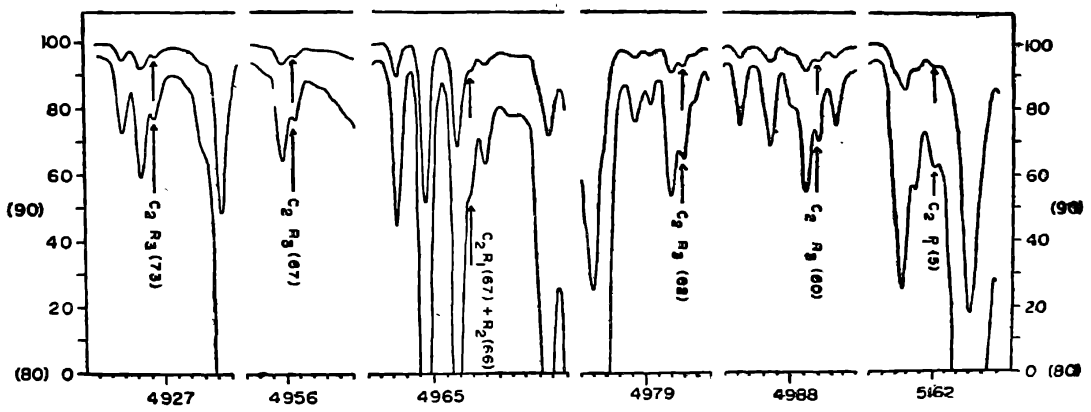

Figure 2. Portions of the solar atlas (Delbouille *et al.* 1973) showing the Swan features.

Table 1. The new C_2 lines in the solar spectrum

Branch (J)	Wavelength (Å)		| Δλ |	Equivalent weight (mÅ)		
	Phillips & Davis (1968)	Moore *et al.* (1966)		Moore *et al.* (1966)	Present study $\mu = 1.0$	Present study $\mu = 0.2$
P_1 (5)	5162.037	5161.987	0.050	12	3.57	7.49
P_2 (4)	5161.984		0.003			
P_2 (3)	5161.285	5161.28	0.005	4.5	1.05	2.26
+*P_3 (26)	5159.600	5159.605	0.005	6	7.66	13.9
P_2 (2)	5160.576	5160.568	0.008	2.5	0.50	1.08
*R_3 (30)	5098.296	5098.318	0.022	7.5	8.08	14.59
P_3 (65)	5078.427	5078.455	0.028	3.5	3.93	7.75
P_3 (74)	5047.383	5047.404	0.021	4	2.63	5.35
P_3 (77)	5035.743	5035.733	0.010	13	2.26	4.54
P_1 (85)	5011.547	5011.37 to 5011.70	—	5	4.69	8.75
P_2 (84)						
P_3 (83)						
P_1 (88)	4999.216	4999.264	0.048	6	3.95	7.60
P_2 (87)						
P_3 (86)						
R_3 (58)	4996.944	4996.979	0.035	3.5	5.06	9.72
P_1 (89)	4994.578	4994.60	0.022	2.5	3.72	7.24
P_2 (88)						
P_3 (87)						
R_3 (60)	4988.209	4988.24	0.031	3.5	4.72	9.16
P_1 (91)	4985.796	4985.758	0.038	11	3.30	6.57
P_2 (90)						
P_3 (89)						
R_3 (61)	4983.553	4983.603	0.050	10	4.55	8.89
R_3 (62)	4979.301	4980.177 to 4980.296	—	—	4.38	8.61
P_1 (95)	4967.786	4967.80	0.014	2.5	2.56	5.41
P_2 (94)						
P_3 (93)						
R_1 (67)	4965.273	4965.30	0.027	2	7.65	13.60
R_2 (66)						
+R_3 (67)	4956.076	4956.09	0.014	2	3.58	7.30
R_3 (68)	4951.521	4951.52	0.001	2.5	3.43	7.04
R_3 (73)	4926.926	4926.947	0.021	3	2.72	5.65
+R_3 (75)	4916.940	4916.959	0.018	2.5	2.47	5.08
R_3 (76)	4912.144	4912.185	0.041	4.5	2.35	4.81
R_1 (79)	4906.701	4906.706	0.005	3	4.38	8.48
R_2 (78)						
R_3 (78)	4901.949	4901.91	0.039	3	6.07	11.06
R_1 (80)	4901.876		0.034			
R_2 (79)						
R_3 (82)	4881.092	4881.08	0.012	3	4.88	9.21
R_1 (84)	4881.034		0.046			
R_2 (83)						
R_1 (95)	4820.768	4820.78	0.012	1.5	2.51	5.02
R_2 (94)						
R_3 (93)						
R_1 (96)	4815.529	4815.491	0.038	2	2.35	4.68
R_2 (95)						
R_3 (94)						
R_1 (98)	4804.222	4804.23	0.008	1.5	2.05	4.06
R_2 (97)						
R_3 (96)						

*Also identified by Schadee (1964).
+Also identified by Grevesse & Sauval (1973).

true. The lines for which coincidences are found are of detectible intensity. In figure 2 we present some of the portions of the solar atlas by Delbouille *et al.* (1973) to show the new features.

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Note added in proof

There is one more feature which should be identified as a C_2 line of the Swan band as given below :

Branch	Wavelength (Å)			Equivalent width (MÅ)		
J	Phillips & Davis (1968)	Moore *et al.* (1966)	Δλ	Moore *et al.* (1966)	Present study $\mu = 1.0$	$\mu = 0.2$
$R_1(99)$	4798.063	4798.107	0.04	2.5	1.93	4.47
$R_2(98)$						
$R_3(97)$						