FRAUNHOFER LINES WITH LARGE ZEEMAN SPLITTING

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Abstract. A list of solar spectral lines having simple Zeeman triplet splitting with Landé g-factors equal to or greater than 2.5 is presented.

Fraunhofer lines with simple, large Zeeman splitting are useful for studies of solar magnetic fields. A list of such lines was given by von Klüber (1947) and references to these and other lines are found in the literature (e.g. Evershed, 1939; Babcock, 1962; Wiehr, 1970). Beckers (1969) presented a list of forbidden Fraunhofer lines produced by magnetic dipole and electric quadrupole transitions some of which have large Zeeman splitting. Blends in association with some of the well-known Zeeman triplets have been discussed by Kjeldseth Moe *et al.* (1970) and by Wittmann (1972). A list of Fraunhofer lines without Zeeman splitting was given by Sistla and Harvey (1970).

TABLE I
Simple Zeeman triplet transitions with large g-values

Number	g	Transition
1	$2\frac{1}{2}$	$^3P_0$–$^5P_1$
2		$^5P_1$–$^5P_1$
3		$^5P_1$–$^5D_0$
4		$^5P_1$–$^7F_0$
5	$2\frac{2}{3}$	$^4P_{1/2}$–$^4P_{1/2}$
6	$2\frac{4}{5}$	$^8D_{3/2}$–$^8D_{3/2}$
7	3	$^3P_0$–$^7D_1$
8		$^5D_0$–$^7D_1$
9		$^7D_1$–$^7D_1$
10		$^7D_1$–$^7F_0$
11		$^7D_1$–$^9G_0$
12	$3\frac{1}{3}$	$^6D_{1/2}$–$^6D_{1/2}$
13	$3\frac{1}{2}$	$^7F_0$–$^9F_1$
14	4	$^8F_{1/2}$–$^8F_{1/2}$

This note presents the results of a search for solar Fraunhofer lines with simple triplet patterns with g-values equal to or greater than 2.5.

Table I lists the transitions and their g-values which were sought in this work. Only transitions having at least one term with a multiplicity less than 9 were considered. The search for the transitions listed in Table I proceeded in three steps using

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TABLE II
Sources of data

Data	Wavelength (Å)	Source
Solar line identifications	2935–8770	Moore *et al.* (1966)
	7498–12016	Swensson *et al.* (1970)
	11355–24776	Ayres (1971)
	11984–25578	Mohler (1955)
	28000–237000	Migeotte *et al.* (1957)
Other line identifications	2951–13164	Moore (1945)
	> 3000	This work (Fe I only)
	>10000	Swensson (1951)
	11100–25000	Chauville *et al.* (1970)
Photospheric spectra	2942–10014	Brault and Testerman (1972)
	7498–12016	Delbouille and Roland (1963)
	11340–13524, 14872–18043, 19614–24779	Hall (1970)
	12187–30920	Bijl *et al.* (1969)
	28000–237000	Migeotte *et al.* (1956)
Solar wavelengths	2918– 9025	Pierce (1972)
Sunspot spectra		
(photographic)	3720–11400	Harvey (1971)
(photoelectric)	11340–13524, 14872–18043, 19614–24779	Hall (1970)

the data sources listed in Table II: (1) From solar and other line identification sources, a list of lines was prepared having the transitions in Table I. This list included predictions of the Fe I spectrum computed from energy level values tabulated by Moore (1952) and improved by Edlén (1955). (2) The list was compared with solar line identifications and photospheric spectrum records. Only reasonably good identifications were kept. (3) The remaining lines were examined on sunspot spectrum records, when possible, to insure that their behavior was consistent with the expected large Zeeman splitting.

Table III contains the final list of solar lines. Transition refers to the number listed in Table I. The product λg is listed as a relative measure of Zeeman sensitivity since the Zeeman effect varies as $\lambda^2 g$ but line widths vary roughly as λ. Line depth is measured in units of per cent of the continuum established from long wavelength intervals. Two numbers are listed; the first is the line depth referred to the continuum based on a long wavelength range and the second is estimated relative to the immediate wavelength range near the line. Blends are recorded as follows: 0 = no detectable blend, 1 = minor blending, 2 = significant blending, 3 = severe blend. The line strength in sunspots relative to the photosphere is listed, when possible, as: W = greatly weakened, w = slightly weakened, u = unchanged, s = slightly strengthened, S = greatly strengthened.

It has become obvious as a result of this work that many more line identifications

TABLE III

Solar Fraunhofer lines with large Zeeman splitting

λ(Å)	Element	Transition (Table I)	Lower excitation potential (eV)	λg	Photosphere		Sunspot umbra	
					Line depth	Blends	Behavior	Blends
2964.634	Fe II	5	1.72	79	97–30	3		
2982.762	V II	3	1.67	75	69–35	1		
3007.291	V II	2	1.67	75	93–30	2		
3013.033	Cr I	3	0.96	75	84–48	1		
3022.586	V II	1	1.67	76	68–25	3		
3063.497	Ti II	5	1.16	82	90–27	3		
3112.077	Ti II	5	1.22	83	94–43	3		
3121.784	Fe I	1	2.22	78	88–39	2		
3175.986	Fe I	10	2.88	95	86–75	1		
3222.075	Fe I	9	2.48	97	97–60	2		
3228.901	Fe I	8	2.48	97	93–45	2		
3274.227	Fe I	1	2.22	82	70–55	1		
3282.239	Co I	5	1.78	88	52–18	3		
3292.593	Fe I	2	2.22	82	94–85	2		
3298.013	Ni I	3	3.50	82	13–3	3		
3370.974	Co II	3	2.27	84	69–16	2		
3418.512	Fe I	3	2.22	85	95–80	1		
3426.091	Fe I	1	3.11	86	24–9	3		
3470.729	Cr I	3	2.71	87	29–22	2		
3476.705	Fe I	3	0.12	87	97–80	2		
3477.860	Fe I	1	2.22	87	89–70	1		
3495.841	Mn II	3	1.85	87	92–50	3		
3509.852	Fe I	2	2.22	88	94–55	3		
3538.556	Fe I	1	2.48	88	81–70	3		
3598.982	Fe I	10	2.88	108	82–75	3		
3604.931	Cr I	2	2.71	90	42–20	2		
3626.016	Co I	5	1.78	97	8–3	3		
3712.948	Cr II	5	2.71	99	86–70	3	s	3
3748.014	V I	5	1.86	100	81–13	3	?	3
3768.033	Fe I	3	2.22	94	89–62	2	u	2
3790.763	Fe I	1	2.48	95	80–45	3	u	3
3925.207	Fe I	3	3.29	98	83–55	1	u	1
3949.610	Cr I	3	3.01	99	14–8	2	u	2
3961.146	Fe I	1	2.86	99	83–30	2	u	2
3972.684	Cr I	2	2.71	99	56–2	2	w	1
3974.759	Fe I	2	2.22	99	80–45	3	u	3
4070.278	Mn I	12	2.19	136	79–73	1	u	1
4080.880	Fe I	8	3.29	122	76–74	1	w	1
4116.477	V I	12	0.26	137	38–15	3	S	3
4190.135	Cr I	1	2.87	105	27–20	2	?	3
4210.355	Fe I	9	2.48	126	93–85	3	s	3
4220.051	V II	3	1.67	106	53–47	3	?	3
4279.870	Fe I	1	2.86	107	72–55	2	u	1
4309.458	Fe I	1	3.11	108	78–25	3	w	3
4338.839	Fe I	1	2.48	108	43–6	3	u?	3
4430.621	Fe I	3	2.22	111	88–65	2	u	3
4438.346	Fe I	3	3.69	111	64–61	2	w	3
4479.700	Ti I	2	1.73	112	36–30	3	s	3
4485.682	Fe I	2	3.69	112	80–78	1	w	3

Table III (Continued)

λ(Å)	Element	Transition (Table I)	Lower excitation potential (eV)	λg	Photosphere		Sunspot umbra	
					Line depth	Blends	Behavior	Blends
4613.363	Cr I	3	0.96	115	80–75	2	s	3
4645.191	Ti I	3	1.73	116	32–26	1	s	1
4654.730	Cr I	10	3.10	140	37–5	3	s	3
4704.952	Fe I	3	3.69	118	72–70	0	u	1
4838.219	Mn I	5	3.86	129	4–2	3	?	3
4878.216	Fe I	10	2.88	146	82–60	3	w	3
5131.475	Fe I	2	2.22	128	76–74	2	u	3
5161.78	Cr I	3	2.71	129	15–5	3	s	3
5220.894	Cr I	9	3.38	157	13–12	2	s	3
5241.462	Cr I	2	2.71	131	5–5	1	s	3
5247.574	Cr I	3	0.96	131	76–75	1	s	2
5250.217	Fe I	8	0.12	158	73–72	1	s	3
5557.913	Fe I	1	3.11	139	36–20	3	u	3
5724.466	Fe I	1	4.28	143	6–6	0	u?	3
5755.15	Fe I	1	2.48	144	3–2	1	s	3
5781.755	Cr I	3	3.32	145	19–15	1	s	1
5807.787	Fe I	8	3.29	174	8–7	1	u	3
6173.344	Fe I	3	2.22	154	63–62	1	s	1
6258.585	V I	12	0.26	209	16–7	3	S	3
6302.502	Fe I	3	3.69	158	65–64	0	u	2
6565.90	V I	5	1.18	175	16–1	?	s	3
6733.157	Fe I	3	4.64	168	24–23	1	w	3
6842.691	Fe I	2	4.64	171	33–33	1	u	3
7305.885	Ti I	2	1.73	183	3–2	3	s	3
7366.382	Fe I	3	4.64	184	12–11	2	s	2
8200.40	N I	5	10.33	219	5–1	3	?	3
8468.418	Fe I	2	2.22	212	63–60	2	S	3
8601.03	Ti I	3	1.73	215	2–1	3	S	3
8670.19	S I	3	7.86	217	7–3	1	w?	2
8671.869	Fe I	3	5.02	217	13–9	2	w	2
8707.40	Cr I	3	2.71	218	2–1	3	s	2
9260.81	O I	3	10.74	232	12–2	3	W	3
11310.76	Cr I	3	3.32	282	17–15	3	S	2
11593.56	Fe I	3	2.22	289	39–18	3	w	3
12213.3	Fe I	3	5.65	305	17–4	3	u	2
13216.9	Cr I	2	2.71	330	4–1	2	s	2
15343.85	Fe I	3	5.65	383	17–12	2	s	2
15835.33	Ti I	2	4.50	396	34–29	2	s	2
16587.44	S I	3	8.42	414	3–3	2	W	3
17098.4	Fe I	3	5.72	426	2–1	1	s	2
17740.30	Fe I	2	5.99	444	?	3	s?	3
17822.74	Fe I	2	5.75	445	8–7	2	u	3
21874.1	Fe I	3	5.72	546	13–11	1	w	2
22310.6	Ti I	3	1.73	556	8–0	3	S	2

in the region between 1–2 μ are needed. It is likely that several lines which should be listed in Table III are missing owing to a lack of identifications.

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