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A CRITICAL COMPILATION OF OSCILLATOR STRENGTHS FOR Fe II LINES

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RESUMEN

Presentamos una compilación de valores de oscilador gf para 848 líneas de Fe II de interés astrofísico. Se hace un análisis crítico de errores sistemáticos y azarosos de valores gf obtenidos de diversas formas tales como medidas de laboratorio, estimaciones semi-empíricas y aquellas que han sido calculadas usando líneas solares de Fe II. Encontramos que los errores en las determinaciones experimentales recientes y los valores solares son menores que en estimaciones semi-empíricas.

Después de omitir medidas con errores grandes (i.e., más del 25% de error) y aplicando las correcciones necesarias, hemos puesto en una escala única a los valores gf experimentales y solares. Posteriormente examinamos la extensa lista de valores gf semi-empíricos de Kurucz (1990a) y los de Fawcett (1987, 1988) por medio de comparaciones con valores experimentales.

RESUMEN

We have compiled oscillator strengths for 848 Fe II lines of astrophysical interest. The oscillator strengths from various sources like laboratory measurements, semi-empirical estimates and those derived using solar Fe II lines are critically examined for random and systematic errors. The errors of recent experimental determinations and also those of solar gf values are found to be lower compared to those of semi-empirical estimates. After omitting the measurements with large errors (i.e., more than 25% error) we have brought the oscillator strengths from the experimental and solar data to one scale by applying necessary corrections. Next, we have examined the semi-empirical gf values of Kurucz (1990a) which are overwhelmingly extensive and the gf values of Fawcett (1987, 1988) by comparing them with experimental values.

Key words: **ATOMIC DATA — STARS–ABUNDANCES**

1. INTRODUCTION

In the detailed spectroscopic investigation of intermediate spectral type stars the lines of neutral and singly ionised iron play a very important role. The spectrum of F-K spectral type stars contains a very large number of iron lines and the relative strengths of Fe II lines with respect to Fe I lines goes a long way in ascertaining the surface gravity of the star. Fe II lines are generally very prominent in yellow supergiants but they are also seen in the spectra of hotter stars like supernova of type II. Fe II lines are also present in spectra of Be stars and of quasars where they are seen in emission.

However, to relate these observed line strengths with atmospheric parameters of the star, one requires good model atmospheres for the star and equally important are the atomic parameters that affect the line transition. The oscillator strength, gf, is a very important atomic datum that is needed in the calculation of the line absorption coefficient. Even to develop a line-blanketed model atmosphere, one requires line opacity and hence the oscillator strength for all contributing lines. Further, abundance analyses also require gf values to be able to estimate the number densities of an element from the observed line strengths. Oscillator strengths of Fe II lines have been estimated using theoretical, semi-empirical, and experimental methods. However, it is found that the theoretical estimates of gf values are satisfactory for lighter elements like H, He, etc. but for the complex atoms better accuracy is attained by experimental means.

Fuhr, Martin, & Wiese (1988) compiled log gf values for 644 Fe II lines. It covers the published log gf values until 1987 and the list is very scanty in the ultraviolet. Many experimental and solar log gf values have been published after that. Further, revised semi-empirical log gf values of Kurucz(1990a) are more extensive and are of better accuracy compared to those published in Kurucz (1981) and Kurucz & Peytremann (1975). Hence we felt there was a strong need to prepare a compilation with the most recent estimates.

2. EMPIRICAL DETERMINATIONS OF OSCILLATOR STRENGTHS

Experimental determinations of Fe II gf values have been made by many workers (Grasdalen, Huber, & Parkinson 1969; Baschek et al. 1970; Wolnik, Berthel, & Wares 1971; Bridges 1973; Huber 1974, etc.) but these older estimates had large errors some possibly arising due to improperly controlled experimental conditions. Also, each work covered a small sample of lines. The gf values calculated by Bridges were perhaps the best ones among them. Recently Moity (1983) has measured gf values of 494 Fe II lines using a wall-stabilized arc operated in argon gas with a small admixture of iron corbonyl. Fe II emission lines in 2550–5320 A spectral region were recorded on IIaO plates and line strengths were measured following regular steps of converting densities on the photographic plates to intensity using an intensity calibration curve. The emission line strengths were then converted to relative gf values. An accuracy of 25% is claimed by Moity (1983), but uncertainties of these estimates are larger than that as we shall see later. Whaling (1985) derived gf values of 66 Fe II lines in 2253–4923 A region. Whaling (1985) measured emission branching ratios of fourteen levels on Fourier Transform Spectrometer (FTS) spectra of very high spectral resolution and transition probabilities were calculated using the known radiative lifetimes of these levels. An accuracy of 5% is attained for stronger lines but it may be lower (10%) for the weaker lines. Whaling compared his gf values with those of Moity (1983) and found that Moity's estimates were higher by about 20%.

Another important work reporting gf values of 124 lines is by Kroll & Kock (1987) (hereinafter KK) who employed the experimental lifetimes of 13 levels accurately determined by Hannaford & Lowe (1983). KK used a method that employs a combination of emission and anomalous dispersion measurements that does not depend upon the assumptions made about the plasma state in the experimental set up. The anomalous dispersion in the vicinity of an absorption line is measured by using spectral interferometry. The emission spectra were obtained using a hollow cathode lamp and the spectra were recorded photoelectrically using a photon counting system and a monochromator. They have attained an accuracy of 10–25%.

The gf values of 20 weak Fe II lines are measured by Heise & Kock (1990) using emission measurements on a high current hollow cathode after applying a magnetic field of desired strength. The measured branching ratios were calibrated to absolute values by means of the data of KK and they have obtained an accuracy of 10–27%. KK made comparison with the gf values of Moity (1983) and found large differences. We have compared the log gf values of Whaling (1985) with those of KK in Figure 1. In the upper panel we have plotted the difference log gf(Whaling)–log gf(KK) as a function of excitation potential. Since the differences do not show any dependence on excitation potentials, which was anyway expected since neither method depends on thermal equilibrium. We have plotted the difference as a function of log gf value itself in the lower panel and find that there is no dependence on the value of log gf, which is very encouraging since the log gf values of Moity (1983) are known to exhibit errors that become larger for the smaller values of log gf. It is likely that emission line measurements of Moity (1983) made using photographic spectra have larger errors for weak lines. For 63 lines that are common between the investigations of Whaling, and Kroll & Kock we got and average difference 0.004 with a standard error $\pm$ 0.07; only one line at 3285.41 A shows large deviation.

Pauls, Grevesse, & Huber (1990) (hereinafter PGH) derived gf values for 26 weak Fe II lines by measuring branching ratios and converting them to absolute transition probability with the aid of the lifetime of the upper level. They have used FTS along with narrow band filters to obtain very high S/N ratio that is needed to detect and measure weak lines. A hollow cathode discharge lamp with an iron electrode was used as light source to produce the spectra. They have 10 lines in common with KK

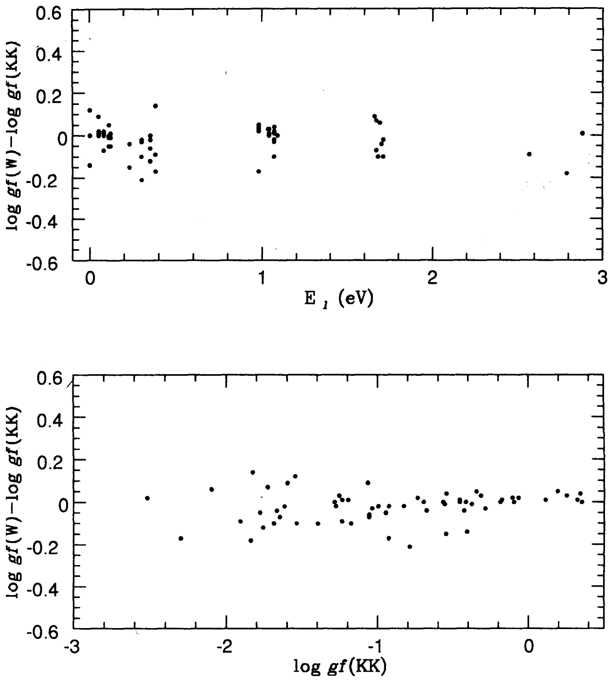

Fig. 1. Top panel shows the plot of log gf(Whaling) − log gf(KK) as a function of excitation potential in eV. The lower panel shows the plot of log gf(Whaling) − log gf(KK) as a function of log gf(KK).

and the agreement is generally good except for lines at 3213.309 and 4549.474 A for which surprisingly large deviations (−0.59 and 0.58 respectively) are seen. We get a mean deviation of +0.05 with standard error ± 0.02 between KK and PGH.

Hannaford et al. (1992) have determined new atomic lifetimes for eight quartet and ten sextet levels using the technique of laser-induced fluorescence from the sputtered metal vapour. Here the accuracy is improved by the use of β-barium borate crystal which enabled the exciting laser radiation to be emitted at wavelength such that low lying a^4F_j metastable levels near 3000 cm^{-1} can be used instead of higher levels at 8000 cm^{-1} (that was used in the earlier work of Hannaford & Lowe 1983) thereby increasing the S/N of the fluorescent decay curves. These new lifetimes are combined with the experimental branching functions of Heise & Kock (1990) and Pauls et al. (1990) to derive gf values for 15 Fe II lines. They have four lines common with Pauls et al. (1990) and the agreement is quite good though gf values of Hannaford et al. (1992) are slightly higher i.e., Hannaford et al. —PGH has an average value +0.07 with the standard error ± 0.02. We have brought the gf values of Pauls et al. (1990) to the scale of KK by applying a correction of +0.05 and that of Hannaford et al. (1992) to the scale of KK by applying a correction of −0.02.

Since the experimental gf values of Moity (1983) are very extensive, we have scrutinised it in more detail. We have compared log gf values of KK with those of Moity (1983) in Figure 2. The top panel shows the differences log gf(KK) − log gf(M) plotted as a function of excitation potential. The scatter is very large near 1.0 eV and towards 2.5–3.5 eV. There may be a mild dependence on excitation potential; the average deviation (KK–M) is −0.07 ± 0.05 (n = 14) at 0.0 eV, −0.09 ± 0.11 (n = 32) at 1.0 eV, −0.05 ± 0.06 (n = 16) at 1.7 eV which is essentially flat, but the trend is hazy after 2.0 eV due to the large scatter though one gets an average deviation nearly zero at 2.2 eV and +0.10 ± 0.09 near 2.8 eV. This further strengthens our suspicion that Moity's values are affected by temperature errors in the experimental setup. The lower panel shows the differences plotted as a function of log gf(KK). Here the trend is not very obvious since the scatter is very large. It was considered worthwhile correcting log gf values of Moity by splitting it into bins covering small range in excitation potential. Then for each data bin log gf values were corrected using the average deviations mentioned above. Such a procedure has been used in the past by us (Giridhar & Arellano Ferro 1988) to improve the accuracy of gf values.

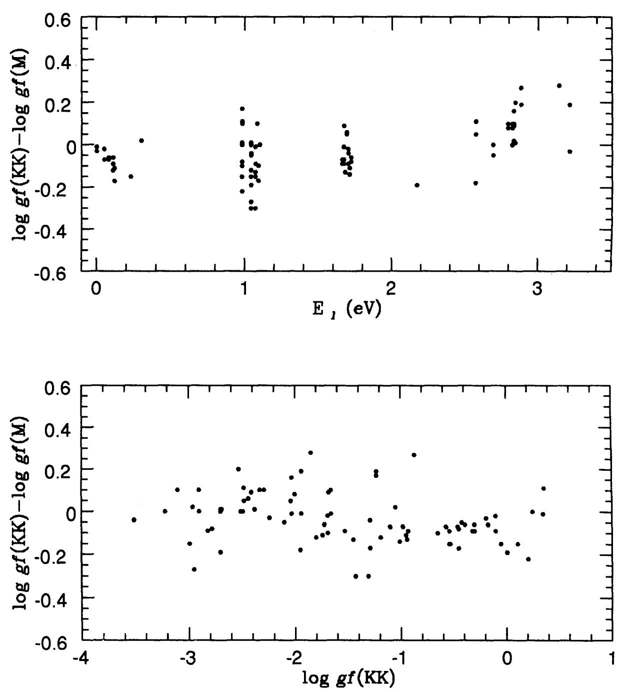

Fig. 2. Top panel shows the plot of log gf(KK) − log gf(Moity) as a function of excitation potential in eV. The lower panel shows the plot of log gf(KK) − log gf(Moity) as a function of log gf(KK).

3. SOLAR gf VALUES

It is noticed that the experimental data on gf values of Fe II are most abundant in the ultraviolet and blue spectral region but in the visual and near infrared very few estimates are available. For the visual spectral region the gf values derived from the use of solar data are the most important source of reasonably accurate gf values. Also the line blending in red spectral region is not very serious. Hence the solar gf values can be reasonably accurate if they are corrected for the systematic errors. Since most of the iron in the solar atmosphere is present as Fe II (95%), abundances derived using the Fe II lines are much less sensitive to the temperature structure of the chosen model atmosphere. Blackwell, Shallis, & Simmons (1980) investigated the difference in derived abundances for good unblended Fe I and Fe II lines which they got due to the use of two different solar models. They found for Fe I lines the solar model of Holweger & Müller (1974) to be better compared to that of Vernazza, Avrett, & Loeser (1976) but the abundances from Fe II lines were found to be insensitive to the chosen model. Hence the observed solar spectrum when used with a solar model can lead to accurate gf values of Fe II lines if they are unblended in the solar spectrum. Blackwell et al. (1980) used solar equivalent widths measured on Delbouille, Neven, & Rolland (1973) atlas of the solar spectrum with the Holweger & Müller (1974) model to calculate gf values for 42 Fe II lines. A comparison between Blackwell et al. and KK (they have 12 common lines) led to a correction of 0.10 to be applied to the log gf values of Blackwell et al. This difference might have been caused by the high solar Fe abundance of 7.69 adopted by Blackwell et al.

Thévenin (1989, 1990) derived solar gf values for a very large number of lines covering several elements (including Fe II lines) by matching the Delbouille et al. (1973) solar spectrum with the spectrum synthesized using the model atmosphere of the sun given in Gustafsson et al. (1975). Here the log gf values were varied until a satisfactory match was obtained between the observed and computed solar spectrum. Since this analysis uses a different model atmosphere and abundance table, we looked for systematic differences. We find that Thévenin's log gf values need a correction of +0.10 to bring them to the scale of Blackwell et al. (1980).

Ekberg & Feldman (1993) calculated solar gf values using photographic spectra obtained with the aid of Naval Research Laboratory normal incidence spectrometer on Skylab. Here using the experimental decay rates already existing in the literature and line intensities measured on Kodak 101 and 104 films gf values are estimated for 550 Fe II lines though many of the gf values are presented as upper or lower limits. We have taken only the lines with good measurements and have ignored the limits. They have 32 lines common with KK which enables one to compare these solar gf values with experimental ones. In Figure 3 we have plotted the differences between these log gf values as a function of excitation potential in the top panel and as a function of log gf value itself in lower panel. Both plots do not show any systematic trend above the scatter but a constant shift of 0.08 is needed to bring them to the scale of experimental gf values.

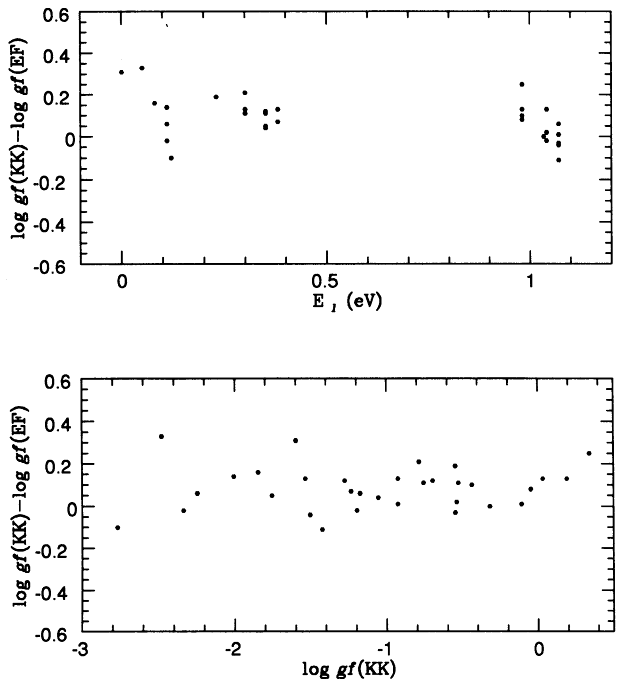

Fig. 3. Top panel shows the plot of log gf(KK) − log gf(EF) as a function of excitation potential in eV. The lower panel shows the plot of log gf(KK) − log gf(EF) as a function of log gf(KK).

Since Thévenin's work is rather extensive it is important to correct for the systematic errors and bring these values to the scale experimentally determined. Thévenin's list has 37 lines common with KK and lines cover an excitation potential range of 2.2 to 3.89 eV. Figure 4 shows the comparison KK log gf values with those of Thévenin. Three lines at 5169.02, 5325.55 and 6369.41 A show very large deviations of 0.62, 0.78 and 0.56 respectively. But it should be noted that differences of log gf values do not show any dependence on excitation potential. If we ignore those three lines with large deviations we get a systematic correction of +0.19 ± 0.20 which is reasonable, considering the fact that when compared to Blackwell et al. (1980), Thévenin log gf values needed a correction of +0.09 and log gf val-

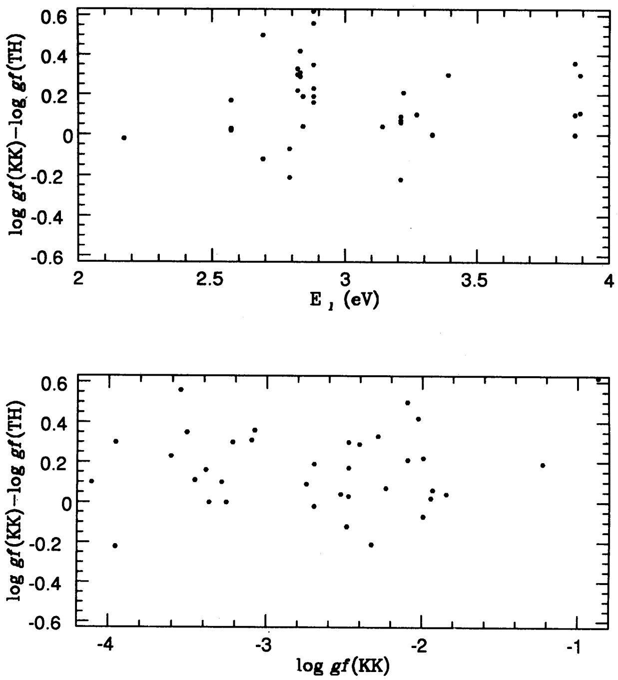

Fig. 4. Top panel shows the plot of log gf(KK) – log gf(Thévenin) as a function of excitation potential in eV. The lower panel shows the plot of log gf(KK) – log gf(Thévenin) as a function of log gf(KK).

ues of Blackwell et al. themselves needed a correction of +0.10 to bring them to the scale of KK. Obviously solar log gf values of Thévenin require a correction of the value mentioned above. It is not clear what is causing such a large shift since the Table 1 of Thévenin (1989) gives adopted Fe abundance as 7.46 which is nearer to the most recent estimate of solar Fe abundance given by Grevesse & Noels (1993). Further, the comparison of Thévenin with KK (Figure 4) shows large scatter indicating large random errors in log gf values of Thévenin. This is rather unfortunate since Thévenin (1989, 1990) are the largest single sources of solar log gf. Unfortunately, the data of KK does not cover excitation potential range above 3.8 eV and hence it is difficult to correct for Fe II lines with excitation potential above 3.8 eV.

Meylan et al. (1993) derived solar gf values for 22 Fe II lines using equivalent widths measured on Solar Flux Atlas of Kurucz et al. (1984). The gf values were estimated using solar model of Kurucz (1990b) that uses revised metal abundances of Anders & Grevesse (1989). Since the Fe abundance of 7.67 tabulated by Anders & Grevesse (1989) are very close to the value 7.69 adopted by Blackwell et al. (1980), we expected to see a good agreement between these two sets of log gf. But on the average, log gf values of Meylan et al. are larger by 0.17 compared to those of Blackwell et al. Meylan et al. have two lines in common with Pauls et al. and surprisingly these solar gf values are in good agreement with experimental ones.

4. SEMI-EMPIRICAL gf VALUES

Kurucz & Peytremann (1975) calculated gf values for a very large number of elements covering up to the first four ionised states. They used scaled Thomas-Fermi-Dirac wavefunctions and perfomed a least squares fit to the energy levels to determine the Slater parameters and eigenvectors. These are used to calculate electrostatic and spin orbit gf value matrices. Though the line list is very large (2×10^5 lines), the gf values suffer from large systematic errors as pointed out by Irwin (1983), Blackwell et al. (1983), Giridhar & Arellano Ferro (1989). Kurucz (1981) published another set of semi-empirical gf values this time only for Fe II lines. He used a very extensive list of the observed energy levels published by Johansson (1978) and Dobbie (1938) and with this extra knowledge of new energy levels the mixing in eigenvectors was better handled. The rest of the procedure using scaled Thomas-Fermi-Dirac wavefunctions is the same as that of Kurucz & Peytremann (1975). Kurucz (1981) has published gf values of 22547 Fe II lines. Although the gf values of Kurucz (1981) show a better agreement for low excitation potential lines with the empirical determinations, Kurucz (1981) gf values also suffer from large systematic errors. Fawcett (1987) calculated oscillator strengths for a large number of Fe II lines. The computational method involves the optimization of Slater parameters previously calculated with a Hartree-Fock-relativistic (HFR) program package which employs Blume-Watson method for spin-orbit interaction. Fawcett (1987) has included configuration interaction among the even and odd configurations. Fawcett (1988) has tabulated Fe II gf values for lines actually seen in the spectrum of the sun and the slow nova RR Tel. Kurucz (1990a) has made his table of gf values more extensive by adding missing iron group atomic lines that go to excited levels not yet observed in the laboratory but in actual stars these levels are easily populated and lines are seen in absorption. Inclusion of these lines up to several stages of ionisation has significantly altered the opacities and this in turn affects the calculation of stellar model atmospheres. The calculation of gf values seem to follow the procedure given in Kurucz (1981) but with larger interactions included and the gf values of 1990 agree slightly better with KK than those of Kurucz (1981). We have compared gf values of Fawcett (1988) with those of KK in Figure 5. The figure also shows the comparison of Kurucz (1990a) with KK. Interestingly, at 0.0 eV gf values of Kurucz (1990a) are in good agreement with those of KK but gf values of Fawcett (1988) are better in 0.2–0.3 eV range and also near 1.0 eV. The gf val-

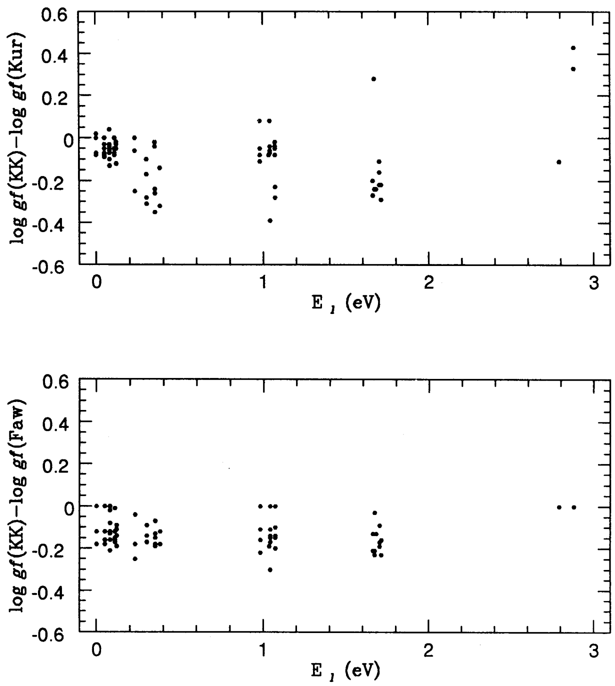

Fig. 5. Top panel shows the plot of log gf(KK) − log gf(Kurucz) as a function of excitation potential in eV. The lower panel shows the plot of log gf(KK) − log gf(Fawcett) as a function of excitation potential in eV.

ues of Kurucz (1990a) improve at 1.67 eV but get worse for higher excitation potential where the errors are random. However, Kurucz (1990a) lines are very extensive in all excitation potential ranges but those of Fawcett become very scarce after 3.5 eV.

5. PROPOSED SYSTEMATIC CORRECTIONS

We have presented in Table 1 the systematic corrections to be applied to the log gf values published by different experimental groups. However, calculation of systematic errors for semi-empirical gf values of Kurucz (1990a) and Fawcett (1988) is not as straightforward since errors arise from different sources depending upon the levels and interaction between various configurations and the way different couplings are handled. But it is very important to examine them to see if the errors are dependent upon any particular parameter and whether it is possible to find suitable corrections for them since they are the largest sets of log gf values. For many observed lines only log gf values from Kurucz (1990a) list are available. We therefore chose to compare the log gf values from Kurucz with the experimental ones after bringing them to one scale. However, we have restricted the comparison to the experimental log gf of accuracy better than 20%. In this way we had a large set of 180 lines covering a good range in excitation potential and log gf itself. Figure 6 shows the comparison of the normalised experimental log gf values (Nor) with those of Kurucz. The top panel has log gf(Kur) − log gf(Nor) plotted as a function of excitation potential in eV. It is obvious that the agreement is very good for low excitation potential

TABLE 1

SYSTEMATIC CORRECTIONS TO BE APPLIED TO log gf VALUES OF DIFFERENT INVESTIGATORS

Source	Correction in in log gf
Whaling (1985)	0.00
Pauls et al. (1990)	+0.05
Hannaford et al. (1992)	−0.02
Moity (1983)	−0.07 at 0.0 eV
	−0.09 at 1.0 eV
	−0.05 at 1.7 eV
	0.00 at 2.2 eV
Thévenin (1989, 1990)	+0.19
Blackwell et al. (1980)	+0.10
Ekberg & Feldman (1993)	+0.08

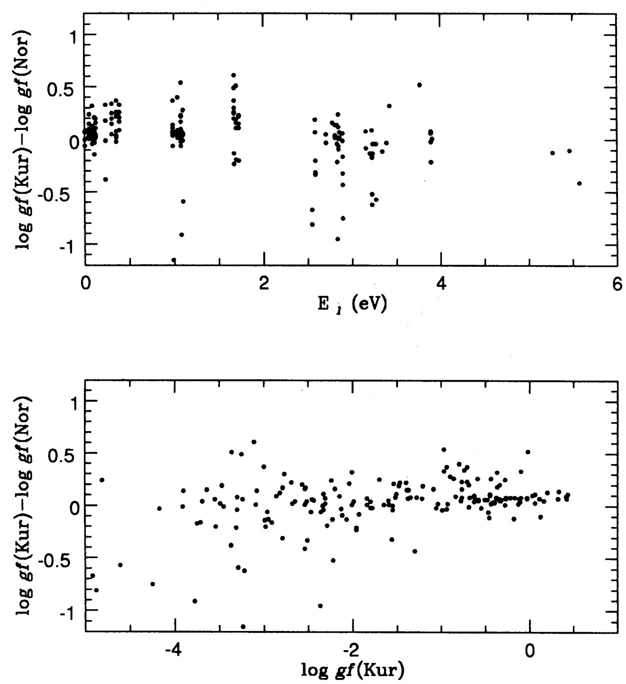

Fig. 6. Top panel shows the plot of log gf(Kur) − log gf(Nor) as a function of excitation potential in eV. The lower panel shows the plot of log gf(Kur) − log gf(Nor) as a function of log gf(Kur).

TABLE 2

COMPILATION OF log gf VALUES FOR Fe II LINES

λ	E_l	log gf				Mult.	Q
(Å)	(eV)	Kur	GAF	Exp [a]	Solar [b]	[c]	[d]
1055.262	0.000	−0.97	−0.84	...	...	21	C
1068.346	0.048	−0.46	−0.49	...	...	19	C
1071.584	0.083	−0.62	−0.69	...	...	19	C
1096.877	0.000	−0.25	−0.19	...	...	18	C
1099.132	0.107	−1.74	−1.10	...	...	18	C
1112.048	0.000	−1.08	−0.71	...	...	16	C
1121.975	0.000	−0.72	−0.54	...	...	12	C
1122.843	0.048	−0.82	−0.74	...	...	13	C
1128.046	0.121	−0.87	−0.96	...	...	14	C
1130.443	0.083	−1.04	−1.26	...	...	12	C
1133.405	0.048	−0.97	−1.05	...	...	50	C
1133.665	0.000	−0.90	−1.21	...	...	11	C
1138.632	0.048	−0.93	−1.14	...	...	11	C
1142.330	0.080	−1.14	−1.14	...	...	10	C
1143.226	0.000	−0.57	−0.69	...	...	10	C
1144.938	0.000	0.16	0.05	...	...	10	C
1635.401	0.986	−0.08	−0.27	...	...	68	C
1641.762	1.040	−0.37	−0.57	...	...	68	C
1647.163	1.040	−0.73	−0.90	...	...	68	C
2208.410	4.730	0.13	0.13	...	...	367	C
2213.655	2.635	−0.40	−0.34	...	...	168	C
2218.270	4.760	0.14	0.14	...	...	367	C
2220.381	2.522	−0.56	−0.59	...	−0.50E	118	C
2245.505	4.760	0.30	0.30	...	−0.69E	365	C
2249.180	0.000	−1.52	−1.60	−1.60K	−1.91E	5	A
2249.320	1.040	0.32	0.25	...	...	62	C
2249.480	1.090	−0.59	−0.55	...	...	63	C
2250.176	0.107	−2.34	−2.34	−2.34K	−2.32E	4	A
2250.936	0.083	−1.84	−1.85	−1.85K	−2.01E	4	A
2251.556	0.048	−2.24	−2.48	−2.53P	−2.46E	0	A
2253.127	0.048	−1.59	−1.60	−1.60K	−1.93E	4	A
2254.406	0.107	−2.99	−2.85	−2.90P	−2.86E	0	A
2255.766	2.544	−0.56	−0.74	...	−0.85E	133	C
2260.081	0.000	−1.55	−1.55	−1.55K	...	4	A
2260.240	0.121	−2.20	−2.36	−2.41P	...	0	A
2260.860	0.110	−2.01	−2.01	−2.01K	−2.15E	4	A
2262.688	0.107	−2.04	−2.25	−2.25K	−2.31E	5	A
2265.995	0.083	−2.01	−2.33	−2.38P	−2.45E	0	A
2267.587	0.083	−1.60	−1.65	−1.65K	−2.00E	4	A
2268.564	0.121	−2.57	−2.77	−2.77K	−2.67E	5	A
2279.916	0.048	−1.37	−1.52	−1.52W	−1.73E	4	A
2327.397	0.083	−0.63	−0.73	−0.74K	...	5	A
2331.307	0.232	−0.69	−0.68	−0.68K	−1.01E	35	A
2332.800	0.048	−0.19	−0.11	...	...	3	C
2338.008	0.107	−0.38	−0.46	−0.46K	...	3	A
2343.496	0.000	0.11	0.04	0.04K	...	3	A
2343.960	0.301	−0.78	−0.83	−0.83K	−0.85E	35	A
2344.283	0.121	−0.45	−0.56	−0.56K	...	3	A
2345.339	2.635	−0.08	−0.14	...	−0.51E	165	C
2348.115	0.232	−0.10	−0.43	−0.43K	...	36	A
2348.303	0.083	−0.25	−0.21	...	...	3	C
2351.202	2.657	−0.16	−0.10	...	−0.54E	165	C
2351.670	5.210	−0.07	−0.07	...	...	379	C
2352.310	5.230	0.14	0.14	...	...	379	C
2353.680	5.200	−0.07	−0.07	...	...	379	C
2354.479	2.676	−0.26	−0.25	...	−0.52E	165	C
2354.889	0.352	−1.04	−1.06	−1.06K	−1.10E	35	A
2359.598	2.676	−0.58	−0.59	...	...	165	C
2359.999	0.232	−0.37	−0.55	−0.55K	−0.74E	35	A
2360.293	0.301	−0.28	−0.53	−0.53K	−0.64E	36	A
2362.020	0.301	−0.74	−1.04	−1.04K	−1.28E	35	A
2363.860	5.200	0.64	0.63	...	...	379	C
2364.829	0.048	−0.34	−0.39	−0.39K	...	3	A
2366.593	0.352	−0.94	−1.29	−1.29K	−1.40E	35	A
2368.596	0.352	−0.44	−0.70	−0.70K	−0.82E	36	A
2369.950	5.190	0.76	0.76	...	...	379	C
2370.498	0.387	−0.97	−1.30	−1.24K	...	35	A
2373.736	0.000	−0.47	−0.41	−0.41K	...	2	A
2375.193	0.387	−0.59	−0.85	−0.90P	−0.87E	36	A
2379.276	0.301	−0.69	−0.79	−0.79K	−0.98E	36	A
2380.762	0.083	−0.63	−0.67	−0.67K	...	3	A
2382.039	0.000	0.56	0.62	...	...	2	C
2382.358	0.387	−1.54	−1.75	−1.83K	...	35	A
2382.901	2.522	−0.52	−0.59	...	...	117	C
2383.062	0.048	−1.34	−1.22	...	...	2	C
2383.245	0.352	−0.68	−0.76	−0.76K	−0.87E	36	A
2384.387	0.387	−0.84	−0.93	−0.93K	−1.06E	36	A
2385.005	0.352	−1.40	−1.62	−1.62K	−1.79E	35	A
2388.389	2.580	−0.58	−0.65	...	...	117	C
2388.630	0.035	−0.13	−0.15	−0.15K	...	2	A
2390.770	5.510	−0.42	−0.32	...	...	402	C
2391.478	0.301	−1.39	−1.54	−1.54K	−1.67E	35	A
2395.420	0.083	−0.99	−0.95	−0.95K	...	2	A
2395.626	0.048	0.41	0.32	0.32K	...	2	A
2396.719	3.199	−0.65	−0.72	...	−0.71E	211	C
2399.242	0.083	−0.11	−0.15	−0.15K	...	2	A
2401.290	5.510	0.24	0.24	...	...	402	C
2402.599	0.352	−1.78	−1.76	−1.76K	−1.81E	36	A
2404.432	0.107	−0.94	−0.91	−0.91K	...	2	A
2404.887	0.083	0.20	0.07	0.07K	...	2	A
2406.662	0.107	−0.17	−0.25	−0.25K	...	2	A
2406.993	3.903	−0.17	−0.06	...	...	302	C
2410.520	0.107	−0.03	−0.11	−0.11K	...	2	A
2411.069	0.121	−0.33	−0.38	−0.38K	...	2	A
2413.311	0.121	−0.40	−0.43	−0.43K	...	2	A
2416.450	5.510	0.14	0.14	...	...	396	C
2417.870	3.245	0.04	0.12	...	...	244	C
2418.440	5.550	0.05	0.05	...	−0.25E	396	C
2422.688	3.892	0.03	0.03	...	...	301	C
2423.210	3.889	−0.14	−0.12	...	...	301	C
2424.146	2.807	0.35	0.42	...	−0.12E	180	C
2424.392	2.583	−0.47	−0.28	...	−0.31E	149	C
2424.591	3.892	−0.14	−3.54	...	...	180	C
2428.293	3.903	−0.62	−0.73	...	...	301	C
2428.365	3.903	0.35	0.38	...	...	300	C
2428.799	3.889	−0.26	−0.22	...	...	301	C
2429.035	3.889	−0.38	−0.37	...	...	301	C
2429.387	2.704	−0.55	−0.52	...	...	146	C
2429.860	7.274	0.22	0.13	...	...	180	C
2430.079	2.828	0.21	0.26	...	...	180	C
2432.262	2.844	−0.03	0.01	...	−0.28E	180	C
2432.874	4.076	0.57	0.60	...	0.20E	321	C
2434.006	5.200	−0.43	−0.43	...	...	375	C
2434.240	5.270	0.24	0.24	...	−0.40E	384	C
2434.647	3.889	−0.31	−2.24	...	...	301	C
2434.730	4.080	0.51	0.53	...	0.22E	321	C
2434.952	2.856	−0.29	−0.14	...	−0.39E	180	C
2436.623	5.340	0.23	0.23	...	...	384	C
2439.302	3.153	0.49	0.57	...	0.12E	209	C
2440.423	3.892	−0.08	0.05	...	...	300	C

TABLE 2 (CONTINUED)

λ	E_l	log *gf*				Mult.	Q
(Å)	(eV)	Kur	GAF	Exp [a]	Solar [b]	[c]	[d]
2444.516	2.583	0.29	0.30	...	−0.08E	148	C
2445.110	5.170	0.31	0.31	...	...	375	C
2445.573	2.704	0.09	0.12	...	−0.14E	148	C
2445.798	3.889	−0.13	−0.09	...	...	300	C
2446.110	3.903	−0.14	−0.11	...	...	300	C
2446.472	2.657	−0.45	−0.45	...	−0.39E	164	C
2447.205	3.892	−0.23	−0.22	...	...	300	C
2447.327	3.889	−0.34	−1.58	...	...	290	C
2447.756	4.080	0.34	0.37	...	...	320	C
2449.965	3.889	−0.38	−0.58	...	...	300	C
2450.205	3.889	−0.46	−0.31	...	...	300	C
2453.980	5.470	−0.18	−0.18	...	...	400	C
2454.579	4.076	0.34	0.34	...	...	320	C
2455.710	5.510	−0.12	−0.12	...	...	395	C
2455.900	5.390	−0.04	−0.04	...	...	384	C
2457.112	3.387	−3.67	−3.67	...	...	269	C
2458.784	3.199	0.41	0.48	...	...	209	C
2458.973	3.892	−0.13	−0.14	...	...	209	C
2460.440	5.450	0.76	0.76	...	−0.22E	396	C
2461.284	3.230	0.23	0.27	...	−0.12E	209	C
2461.862	3.221	0.34	0.38	...	...	209	C
2463.282	3.153	−0.25	−0.15	...	−0.51E	208	C
2464.011	3.199	0.03	0.03	...	−0.40E	208	C
2464.906	3.230	−0.06	0.01	...	−0.38E	208	C
2465.913	3.221	−0.02	0.07	...	−0.43E	208	C
2466.673	2.856	−0.29	−0.28	...	...	179	C
2466.821	2.844	−0.15	−0.14	...	...	179	C
2469.516	3.903	0.17	0.19	...	...	299	C
2470.410	3.230	−0.43	−1.93	...	...	208	C
2470.670	2.828	−0.04	−0.02	...	...	179	C
2472.431	2.856	−0.49	−0.47	...	−0.81E	179	C
2472.610	5.510	0.53	0.53	...	...	395	C
2473.323	2.778	−0.28	−0.26	...	−0.71E	148	C
2475.120	5.550	0.33	0.33	...	...	395	C
2475.540	5.570	0.41	0.41	...	...	395	C
2476.266	2.692	−0.97	−0.96	...	−0.78E	163	C
2477.345	2.692	−0.76	−0.75	...	−0.93E	162	C
2478.573	2.844	−0.28	−0.25	...	...	179	C
2480.158	2.807	0.07	−0.05	...	−0.27E	179	C
2481.050	3.245	−0.65	−0.68	...	−0.93E	245	C
2482.118	2.635	0.05	0.06	...	...	161	C
2482.325	4.738	−0.66	−0.52	...	...	358	C
2482.658	3.153	0.17	0.15	...	−0.36E	207	C
2482.870	4.130	−1.65	−0.90	...	−0.27E	400	C
2483.720	4.154	−0.60	−0.51	...	−0.65E	331	C
2484.247	3.245	−0.21	−0.83	...	−0.17E	243	C
2484.440	5.470	0.23	0.23	...	...	400	C
2489.484	2.657	−0.15	−0.13	...	−0.49E	161	C
2489.831	3.153	−0.40	0.42	...	−0.03E	207	C
2490.713	4.149	−0.09	−0.03	...	...	331	C
2490.859	2.828	−0.24	−0.22	...	−0.43E	179	C
2491.398	3.199	−0.07	−0.11	...	−0.47E	207	C
2492.345	3.267	−0.68	−0.79	...	−0.81E	243	C
2493.184	2.657	0.40	0.47	...	...	161	C
2493.262	2.635	0.68	0.74	...	...	181	C
2493.880	5.530	0.01	0.01	...	...	400	C
2497.820	2.844	−2.26	−2.61	...	...	207	C
2500.924	4.732	0.31	0.33	...	−0.19E	357	C
2501.394	3.967	−3.57	−3.57	...	...	400	C
2502.393	3.221	0.01	...—	...	−0.33E	207	C
2503.327	3.153	0.43	−0.22	...	−0.08E	206	C
2503.571	2.856	−2.52	−0.55	...	−0 55E	161	C
2503.875	3.768	0.34	0.36	...	...	285	C
2506.094	3.199	−0.16	−0.08	...	−0.44E	207	C
2506.797	2.828	−2.94	−2.94	...	...	175	C
2511.761	2.692	0.31	0.37	...	0.23E	161	C
2514.383	3.814	0.20	0.22	...	...	285	C
2517.135	2.778	−0.55	−0.57	...	−0.35E	147	C
2519.048	3.387	0.13	0.18	...	−0.29E	268	C
2521.092	3.425	−0.06	−0.05	...	−0.43E	268	C
2521.816	4.154	0.23	0.26	...	...	330	C
2525.389	2.635	0.39	0.45	...	0.20E	159	C
2526.075	2.676	−0.24	0.06	...	−0.02E	159	C
2526.295	2.583	0.18	0.19	...	−0.11E	145	C
2527.104	2.657	−0.12	−0.19	...	−0.55E	159	C
2527.705	4.149	−0.12	−0.15	...	...	329	C
2529.078	4.738	0.05	0.07	...	...	357	C
2529.229	3.245	−0.53	−0.65	...	...	241	C
2529.546	2.807	0.33	−0.09	...	...	145	C
2530.111	2.828	−0.49	−0.40	...	...	178	C
2533.628	2.657	0.31	0.42	0.42M	0.20E	159	B
2534.419	2.692	0.03	0.19	0.19M	0.15E	159	B
2535.362	5.571	−0.01	0.34	0.34M	...	405	C
2535.486	2.807	−0.30	−0.14	−0.14M	−0.31E	177	B
2536.674	3.245	0.25	−0.09	−0.09M	...	241	B
2536.806	2.676	0.07	0.42	0.42M	...	159	B
2537.140	4.730	0.13	0.12	...	...	363	C
2538.204	3.245	−1.25	0.38	0.38M	...	319	B
2538.399	2.844	−1.60	−1.42	−1.42M	...	178	B
2538.501	2.692	−0.77	−0.48	−0.48M	...	160	B
2538.799	2.657	−0.03	0.14	0.14M	...	158	B
2538.911	2.676	−0.15	0.02	0.02M	...	158	B
2538.995	2.635	0.32	0.40	0.40M	0.18E	158	B
2539.806	2.828	−2.31	−1.48	−1.48M	...	176	B
2540.523	4.616	−0.42	−0.29	−0.29M	...	349	B
2540.661	4.495	0.18	0.20	...	...	177	B
2541.101	2.828	−0.30	−0.13	−0.13M	−0.51E	177	B
2541.836	2.692	−0.19	−0.11	−0.11M	−0.26E	158	B
2542.319	0.387	−2.79	−2.96	−2.89M	...	3	A
2542.736	3.339	−0.48	−0.20	−0.20M	−1.93E	223	B
2543.380	2.676	0.04	−0.05	−0.05M	...	159	B
2543.431	2.844	−0.57	−0.32	−0.32M	...	177	B
2544.973	2.704	−0.51	−0.39	−0.39M	−0.40E	147	B
2545.221	2.692	−0.19	−0.25	−0.25M	−0.41E	159	B
2545.444	3.387	−0.83	−0.63	−0.63M	−0.62E	267	B
2545.531	2.828	−1.82	−1.36	−1.36M	...	178	B
2546.671	2.828	−0.18	−0.08	−0.08M	−0.27E	177	B
2547.339	2.692	−0.34	−0.57	−0.57M	−0.93E	158	B
2548.325	2.704	−1.12	−0.70	−0.70M	−0.86E	146	B
2548.591	2.676	−0.16	−0.50	−0.50M	...	158	B
2548.744	2.704	−0.30	−0.25	−0.25M	...	145	B
2548.923	4.080	−0.49	−0.09	−0.09M	...	319	B
2549.084	3.768	0.17	0.32	0.32M	0.05E	284	B
2549.395	2.856	−0.25	−0.05	−0.05M	...	177	B
2549.461	2.844	−0.18	−0.09	−0.09M	...	177	B
2549.775	3.387	−0.96	−0.60	−0.60M	−0.52E	266	B
2550.026	3.267	0.26	0.32	0.32M	0.18E	240	B
2550.157	4.760	0.41	−0.41	...	...		C
2550.575	2.657	−0.76	−1.39	−1.39M	...	158	B
2550.684	3.245	−0.72	0.26	0.26M	...	240	B
2551.204	4.149	−0.34	−0.36	−0.36M	...	328	B
2554.945	3.221	−1.50	−1.52	−1.52M	...	205	B
2555.068	2.844	−0.74	−0.60	−0.60M	−0.80E	177	B
2555.454	2.856	−0.79	−0.60	−0.60M	−1.00E	177	B

TABLE 2 (CONTINUED)

λ	E_l	log gf				Mult.	Q
(Å)	(eV)	Kur	GAF	Exp [a]	Solar [b]	[c]	[d]
557.084	2.692	−1.00	−1.45	−1.45M	...	158	B
557.506	2.807	−0.76	−0.74	−0.74M	−1.07E	175	B
559.242	3.387	−1.29	−1.04	−1.04M	...	266	B
559.773	3.230	−0.68	−0.49	−0.49M	−0.53E	205	B
559.926	3.425	−0.73	−0.49	−0.49M	...	267	B
560.283	3.197	−0.12	0.01	0.01M	−0.11E	221	B
561.586	3.199	−1.65	−1.76	−1.76M	−1.28E	205	B
562.093	3.197	−0.46	−0.30	−0.30M	−0.37E	221	B
562.536	0.986	0.06	−0.05	−0.05K	−0.13E	64	A
563.476	1.040	−0.22	−0.30	−0.32K	−0.32E	64	A
566.220	5.569	0.44	0.63	0.63M	0.51E	404	C
566.401	5.569	0.14	0.34	0.34M	0.31E	405	C
566.624	2.807	−0.98	−0.89	−0.89M	...	174	B
566.913	1.076	−0.62	−0.69	−0.69W	−0.56E	64	A
568.411	2.778	−0.65	−0.52	−0.52M	−0.76E	145	B
568.886	2.828	−1.01	−1.26	−1.26M	...	175	B
569.784	4.616	−0.16	−0.09	−0.09M	−0.43E	348	B
570.548	5.956	−2.87	0.23	0.23M	...	412	B
570.849	3.814	0.05	0.25	0.25M	0.06E	284	B
571.549	2.807	−1.32	−1.34	−1.34M	−1.20E	174	B
572.968	2.891	−1.75	−1.29	−1.29M	...	190	B
573.211	3.221	−0.78	−0.61	−0.61M	...	205	B
573.757	3.814	−1.34	−1.56	−1.56M	...	284	B
574.367	2.583	0.01	0.03	0.03M	−0.04E	144	B
574.540	2.790	−1.70	−1.34	...	...	174	B
576.862	4.149	0.41	0.36	0.36M	...	326	B
577.430	2.844	−1.58	−1.90	−1.90M	...	175	B
577.923	1.097	−0.58	−0.63	−0.54M	−0.53E	64	A
580.721	4.154	−2.18	−1.67	−1.67M	...	327	B
581.112	2.891	−2.14	−1.46	−1.46M	...	190	B
582.413	3.944	−0.53	−0.47	−0.47M	...	310	B
582.584	1.076	−0.45	−0.55	−0.55K	−0.52E	64	A
583.054	2.828	−1.89	−1.42	−1.42M	−1.25E	174	B
583.351	3.387	−1.69	−1.89	−1.89M	...	266	B
585.616	4.149	−0.61	−0.20	−0.20M	...	326	B
585.876	0.000	−0.12	−0.19	−0.19K	...	1	A
587.945	4.154	0.34	0.40	0.40M	...	336	B
588.193	2.778	−1.45	−1.26	−1.26M	−1.23E	145	B
588.798	3.387	−1.32	−0.97	−0.97M	−1.09E	265	B
590.551	2.704	−1.20	−1.02	−1.02M	−1.14E	145	B
591.543	1.040	−0.48	−0.54	−0.54K	−0.56E	64	A
592.780	4.060	0.76	0.77	0.77M	...	318	B
593.730	1.090	−1.22	−1.29	−1.29K	...	64	A
594.960	3.930	−1.05	−0.85	−0.85M	...	310	B
595.280	2.790	−1.72	−1.52	−1.52M	...	172	B
598.370	0.050	−0.03	−0.10	−0.10K	...	1	A
599.396	0.000	0.42	0.35	0.35K	...	1	A
604.053	5.569	−0.89	−0.79	−0.79M	...	404	C
604.670	3.387	−1.52	−1.79	−1.79M	...	265	B
605.037	5.571	0.31	0.47	0.47M	0.32E	404	B
605.311	4.479	−0.05	0.06	0.06M	...	342	B
605.425	3.230	−0.76	−0.56	−0.56M	...	204	B
605.902	4.738	−1.05	−0.37	−0.37M	...	356	B
606.517	4.495	0.18	0.28	0.28M	0.00E	342	B
607.088	0.083	−0.10	−0.18	−0.18K	...	1	A
608.853	2.807	−1.17	−1.20	−1.20M	−1.26E	171	B
609.127	3.967	−0.30	−0.28	−0.28M	...	310	B
609.442	3.425	−1.06	−0.96	−0.96M	...	265	B
609.865	3.221	−1.01	−0.60	−0.60M	−0.69E	204	B
611.074	1.076	−1.35	−1.43	−1.43K	−1.32E	64	A
611.342	2.828	−2.37	−1.42	−1.42M	...	173	A
611.874	0.048	0.03	−0.07	0.07K	...	1	A
2613.572	2.807	−3.99	−1.18	−1.18M	...	172	B
2613.825	0.107	−0.32	−0.38	−0.38K	...	1	A
2614.189	3.387	−1.76	−0.96	−0.96M	...	264	B
2614.871	2.828	−1.44	−1.40	−1.40M	...	171	B
2617.618	0.083	−0.51	−0.57	−0.57K	...	1	A
2619.075	2.807	−0.49	−0.31	−0.31M	...	171	B
2620.172	2.844	−1.45	−0.84	−0.84M	...	173	B
2620.409	0.107	−1.80	−1.78	−1.78K	...	1	A
2620.696	2.828	−0.45	−0.32	−0.32M	−0.61E	171	B
2621.670	0.121	−0.93	−0.95	−0.95K	...	1	A
2623.130	4.076	−0.88	−0.54	−0.54M	...	318	B
2623.725	2.844	−0.70	−0.62	−0.62M	−0.87E	171	B
2625.490	4.080	0.60	0.50	0.50W	...	318	B
2625.668	0.048	−0.44	−0.46	−0.46K	...	1	A
2626.501	2.856	−0.93	−0.44	−0.44M	−0.55E	173	B
2626.698	3.221	−1.94	−1.56	−1.56M	...	203	B
2628.294	0.121	−0.43	−0.46	−0.46K	...	1	A
2628.581	3.230	−1.30	−1.17	−1.17M	...	203	B
2629.589	2.844	−0.21	−0.05	−0.05M	−0.36E	171	B
2630.071	2.856	−0.33	−0.21	−0.21M	−0.47E	171	B
2631.048	0.107	−0.27	−0.35	−0.35K	...	1	A
2631.324	0.083	−0.27	−0.34	−0.34K	...	1	A
2631.609	2.807	−0.02	0.06	0.06M	...	171	B
2633.203	4.732	−0.62	0.08	0.08M	−0.17E	356	B
2636.697	4.738	−1.62	−1.07	−1.07M	...	356	C
2637.520	5.800	−0.49	−0.25	−0.25M	...	410	C
2637.644	3.339	−0.53	−0.22	−0.22M	−0.45E	221	B
2639.565	3.339	−0.77	−0.41	−0.41M	−0.61E	221	B
2641.123	2.704	−1.62	−1.41	−1.41M	−1.32E	144	B
2642.012	3.944	−0.63	−0.41	−0.41M	−0.51E	309	B
2646.212	3.245	−2.02	−1.60	−1.60M	...	410	B
2651.299	3.245	−1.92	−2.03	−2.03M	...	237	B
2652.566	3.267	−1.20	−1.17	−1.17M	−1.16E	237	B
2654.640	5.850	−0.56	−0.25	−0.25M	...	410	C
2657.918	3.768	−1.45	−1.13	−1.13M	−1.00E	283	B
2658.253	3.967	−0.56	−0.32	−0.32M	−0.41E	309	B
2662.560	5.880	−0.64	−0.45	−0.45M	...	410	B
2664.664	3.387	0.34	0.45	0.45M	0.50E	263	B
2666.637	3.425	0.24	0.41	0.41M	0.30E	263	B
2667.220	5.850	−0.29	0.01	0.01M	...	410	C
2669.933	6.088	−0.62	−0.46	−0.46M	...	416	C
2670.379	4.732	−1.79	−1.05	−1.05M	...	355	C
2671.400	5.880	−0.36	−0.38	−0.38M	...	410	C
2682.507	6.807	0.22	0.12	0.12M	...	425	C
2683.000	6.138	−0.34	−0.14	−0.14M	...	416	C
2684.754	3.814	0.26	0.43	0.43M	0.30E	283	B
2684.959	3.153	−2.11	−1.66	−1.66M	...	201	B
2686.387	3.425	−1.97	−1.76	−1.76M	−1.25E	262	B
2686.800	3.220	−2.04	−1.94	−1.94M	...	202	B
2691.737	3.199	−1.50	−1.15	−1.15M	...	202	B
2692.601	3.768	0.28	0.45	0.45M	0.35E	283	B
2692.834	0.986	−3.24	−2.09	−2.09W	...	62	A
2693.857	3.387	−1.70	−1.23	−1.23M	−0.92E	261	B
2697.328	4.479	−1.01	−0.69	−0.69M	...	341	B
2697.462	4.479	−0.47	−0.16	−0.16M	...	341	B
2697.727	4.149	−1.19	−1.00	−1.00M	...	325	C
2699.199	6.138	−0.54	−0.30	−0.30M	...	416	C
2703.990	3.387	−0.03	0.27	0.27M	0.21E	261	B
2704.576	3.221	−1.90	−1.71	−1.71M	...	202	B
2707.133	4.479	−0.41	−0.01	−0.01M	...	339	B
2709.056	3.197	−0.57	−0.37	−0.37M	−0.59E	218	B
2709.381	1.040	−2.86	−2.95	−2.95K	...	62	A

TABLE 2 (CONTINUED)

λ (Å)	E_l (eV)	log *gf* Kur	GAF	Exp [a]	Solar [b]	Mult. [c]	Q [d]	λ (Å)	E_l (eV)	log *gf* Kur	GAF	Exp.[a]	Solar [b]	Mult. [c]	Q [d]
2711.842	3.153	−0.27	0.01	0.01M	−0.03E	201	B	2784.277	3.889	−1.86	−1.60	−1.60M	...	295	B
2712.391	3.199	−0.89	−0.52	−0.52M	...	201	B	2785.210	5.180	0.22	0.31	0.31M	...	373	B
2714.413	0.986	−0.40	−0.44	−0.44K	−0.57E	63	A	2787.260	5.270	−0.97	−0.81	−0.81M	...	380	C
2716.218	3.425	−0.28	0.10	0.10M	0.10E	261	B	2790.561	3.814	−1.62	−1.44	−1.44M	...	282	B
2716.441	4.495	−1.75	−1.26	−1.26M	...	339	C	2793.886	3.199	−0.65	−0.63	−0.63M	−0.81E	199	B
2716.537	7.118	0.28	0.58	0.58M	...	434	C	2796.640	5.200	−0.79	−0.68	−0.68M	...	373	B
2716.697	0.986	−1.48	−2.07	−3.07K	...	62	B	2797.917	3.267	−1.35	−1.24	−1.24M	...	234	B
2717.890	7.570	0.36	0.57	0.57M	...	431	C	2799.295	3.267	−1.13	−0.76	−0.76M	−0.85E	233	B
2718.640	6.219	0.05	0.30	0.30M	...	417	C	2799.722	3.199	−2.22	−2.14	−2.14M	...	198	C
2719.304	4.495	−0.84	−0.24	−0.24M	...	339	B	2804.021	3.425	−1.48	−1.80	−1.80M	...	259	B
2721.814	3.153	−1.35	−1.19	−1.19M	−0.96E	199	B	2805.318	3.889	−1.80	−1.53	−1.53M	...	295	B
2722.063	3.387	−0.54	−0.78	−0.78M	−0.72E	260	B	2805.788	3.387	−1.48	−1.44	−1.44M	...	259	B
2722.741	6.226	−0.10	0.08	0.08M	...	416	C	2809.800	5.270	−0.66	−0.57	−0.57M	...	380	C
2724.884	1.040	−0.80	−1.20	−1.20K	−1.18E	62	A	2811.268	3.153	−2.38	−1.62	−1.62M	...	196	B
2726.520	3.425	−1.34	−1.15	−1.15M	−0.82E	261	B	2812.494	3.197	−1.81	−1.71	−1.71M	...	215	B
2727.383	3.153	−0.57	−0.21	−0.21M	...	200	B	2813.615	3.221	−1.09	−1.15	−1.15M	...	198	B
2727.539	1.040	−0.35	−0.42	−0.42K	−0.49E	63	A	2817.110	5.340	−0.86	−0.76	−0.76M	...	380	C
2728.906	3.387	−0.84	−0.77	−0.77M	...	260	B	2819.343	3.153	−2.39	−1.63	−1.63M	...	196	B
2730.734	1.076	−0.71	−0.94	−0.93K	−0.94E	62	A	2826.027	3.387	−1.43	−1.31	−1.31M	...	256	B
2732.009	3.267	−0.96	−1.06	−1.06M	...	236	B	2827.427	3.245	−1.48	−1.15	−1.15M	...	231	B
2732.446	0.232	−3.37	−2.99	−2.99K	−2.39E	32	A	2831.562	3.197	−0.09	−0.14	−0.14M	...	217	B
2732.943	6.223	−0.19	−0.04	−0.04M	...	417	B	2833.100	5.340	−0.55	−0.47	−0.47M	...	380	B
2736.489	3.339	−2.51	−2.04	−2.04M	...	220	B	2835.711	3.197	−0.70	−0.41	−0.41M	...	216	B
2736.966	1.076	−0.55	−0.53	−0.58P	−0.63E	63	A	2836.185	3.814	−1.75	−1.31	−1.31M	...	294	B
2739.548	0.986	0.33	0.19	0.19K	0.07E	63	A	2836.512	3.889	−1.22	−1.19	−1.19M	...	294	B
2741.394	3.425	−0.37	−0.69	−0.69M	−0.81E	260	A	2837.297	3.267	−1.60	−1.33	−1.33M	...	231	B
2743.197	1.097	−0.05	−0.11	−0.11K	−0.12E	62	B	2838.240	5.390	0.75	−0.75	−0.75M	...	380	C
2746.484	1.076	0.16	0.11	0.11K	−0.06E	62	A	2839.540	5.460	0.12	0.22	0.22M	...	391	B
2746.982	1.040	0.06	0.03	0.03K	−0.10K	63	A	2839.800	5.270	−0.18	−0.06	−0.06M	...	380	B
2749.181	1.076	−0.28	−0.29	−0.29K	...	63	A	2840.343	3.153	−0.77	−0.85	−0.85M	...	195	B
2749.321	1.040	0.32	0.25	0.25K	...	62	A	2840.651	3.339	−0.46	−0.35	−0.35M	...	217	B
2749.486	1.097	−0.58	−0.64	−0.69P	...	63	A	2840.760	3.768	−0.02	−0.54	−0.54M	...	280	B
2750.008	3.199	−1.50	−1.63	−1.63M	...	199	C	2841.356	3.199	−8.29	−2.09	−2.09M	...	196	C
2751.127	3.197	−0.91	−0.79	...	−0.64E	217	B	2842.076	3.221	−2.22	−1.70	−1.70M	...	196	B
2752.150	5.230	−0.50	−0.46	...	...	373	B	2843.316	3.267	−1.55	−1.51	−1.51M	...	231	B
2753.288	3.267	0.46	0.45	0.45M	0.51E	235	C	2843.478	3.889	−1.06	−1.04	−1.04M	...	294	B
2754.910	3.250	0.47	−0.09	0.00M	...	373	B	2844.970	5.580	−0.92	−0.72	−0.72M	...	399	C
2755.737	0.986	0.43	0.34	0.34K	0.09E	62	A	2847.210	3.221	−3.72	−1.62	−1.62M	...	197	B
2756.512	3.230	−1.06	−1.01	−1.01M	−0.72E	200	B	2847.793	5.390	−0.69	−0.56	−0.56M	...	380	B
2757.030	3.199	−1.55	−1.07	−1.07M	−0.83E	199	B	2848.110	5.510	−0.29	−0.21	...	...	399	C
2759.332	0.301	−3.37	−3.28	−3.28M	−2.56K	32	B	2848.330	5.570	−0.16	−0.04	−0.04M	...	391	C
2761.813	1.097	−0.90	−1.18	−1.18K	−1.24E	63	A	2848.906	4.080	−1.20	−0.94	−0.94M	...	317	B
2762.340	5.230	−0.44	−0.35	−0.35M	...	373	B	2849.605	3.199	−1.01	−0.98	−0.98M	...	196	B
2762.447	3.230	−2.46	−1.61	−1.61M	...	199	B	2853.207	3.230	−1.89	−2.04	−2.04M	...	197	B
2763.660	8.170	0.24	0.24	...	...	440	C	2855.666	3.221	−0.88	−0.66	−0.66M	...	196	B
2763.911	3.221	−1.83	−1.42	−1.42M	−1.07E	199	B	2856.149	3.199	−1.06	−1.09	−1.09M	...	195	B
2764.790	3.153	−1.70	−1.71	−1.71M	−1.00E	199	B	2856.390	5.340	−0.48	−0.34	−0.34M	...	380	B
2768.935	1.076	−0.97	−1.51	−1.51K	−1.47E	63	A	2856.939	5.490	−0.01	0.17	0.17M	...	399	B
2769.152	3.221	−1.03	−0.99	−0.99M	...	200	B	2857.170	3.870	−0.86	−0.79	−0.79M	...	294	B
2769.355	3.153	−0.39	−0.35	−0.35M	−0.52E	198	B	2857.420	3.220	−1.38	−1.44	−1.44M	...	195	B
2771.186	3.768	−1.36	−1.06	−1.06M	...	282	B	2858.333	3.221	−1.19	−1.23	...	...	195	C
2771.555	3.230	−1.73	−1.85	−1.85M	...	197	C	2861.168	1.076	−2.93	−3.06	−2.97M	...	61	B
2772.726	1.040	−1.53	−3.35	−3.26M	...	63	C	2864.972	3.903	−1.27	−1.22	−1.22M	...	294	B
2774.688	3.339	−0.94	−0.72	−0.72M	−0.86E	218	B	2868.874	1.040	−2.09	−2.32	−2.23M	...	61	B
2775.338	0.352	−3.69	−3.73	−3.66M	...	32	A	2869.159	3.387	−1.74	−1.41	−1.41M	...	257	B
2776.179	3.230	−1.54	−1.49	−1.49M	−1.14E	199	B	2869.699	3.387	−2.28	−2.03	−2.03M	...	257	B
2776.920	5.210	−0.47	−0.32	−0.32M	...	373	B	2870.608	3.221	−3.23	−1.82	−1.82M	...	195	B
2779.300	3.267	−0.02	0.09	0.09M	0.12E	234	B	2871.060	3.199	−1.65	−1.26	−1.26M	...	195	B
2779.909	4.616	−0.77	−0.73	−0.73M	...	348	B	2871.131	3.245	−1.32	−1.24	−1.24K	...	230	B
2780.051	4.616	−1.02	−0.93	−0.93M	...	348	B	2872.384	3.267	−0.62	−0.60	−0.60M	...	230	B
2783.691	3.245	0.14	0.15	0.15M	0.20E	234	B	2873.398	3.814	−0.20	−0.13	−0.13M	...	279	B

TABLE 2 (CONTINUED)

λ (Å)	E_l (eV)	log *gf* Kur	log *gf* GAF	log *gf* Exp [a]	log *gf* Solar [b]	Mult. [c]	Q [d]
2875.349	3.387	−0.83	−0.69	−0.69M	...	258	B
2876.804	3.387	−1.02	−0.99	−0.99M	...	257	B
2879.245	3.768	−1.56	−1.36	−1.36M	...	278	B
2880.756	0.986	−1.52	−1.76	−1.76M	...	61	C
2883.710	3.245	−0.61	−0.52	−0.52M	...	230	B
2884.780	5.530	−0.73	−0.60	−0.60M	...	399	C
2885.933	4.076	−1.31	−1.04	−1.04M	...	317	B
2886.236	3.245	−3.54	−1.92	−1.92M	...	229	B
2887.314	3.425	−1.32	−1.79	−1.79M	...	257	B
2888.090	3.180	−1.36	−1.33	−1.33M	...	215	B
2892.827	1.076	−2.69	−2.91	−2.82M	...	61	A
2894.779	3.267	−1.07	−0.98	−0.98M	...	230	B
2895.220	3.903	−0.83	−0.76	−0.76M	...	294	B
2897.226	3.425	−1.21	−0.90	−0.90M	...	254	B
2902.319	3.425	−2.28	−2.06	−2.06M	...	257	B
2902.460	3.768	−1.52	−1.32	−1.32M	...	278	B
2906.124	3.339	−1.65	−1.59	−1.59M	...	215	B
2907.856	0.986	−2.88	−3.05	−2.98M	...	60	B
2910.763	3.814	−2.19	−1.84	−1.84M	...	278	B
2916.151	0.986	−3.00	−3.37	−3.30M	...	60	A
2917.083	4.495	−1.24	−1.47	−1.47M	...	336	C
2917.466	1.040	−2.63	−2.82	−2.75M	...	61	B
2922.022	3.903	−1.10	−1.21	−1.21M	...	293	B
2926.585	0.986	−1.28	−1.20	−1.20K	...	60	A
2934.494	3.814	−2.31	−1.91	−1.91M	...	278	B
2939.510	1.040	−2.57	−2.78	−2.69M	...	60	B
2944.396	1.695	−0.74	−0.93	−0.86M	...	78	B
2947.654	1.671	−0.71	−1.07	−1.07K	...	78	A
2949.182	3.768	−0.61	−0.44	−0.49M	...	277	B
2953.775	1.040	−1.38	−1.31	−1.31K	...	2	A
2954.052	3.387	−1.45	−1.76	−1.76M	...	61	C
2959.599	3.387	−0.98	−1.06	−1.06M	...	62	B
2959.835	5.569	−0.76	−0.66	−0.66M	...	180	C
2961.276	1.076	−2.53	−2.70	−2.63M	...	2	A
2964.133	3.387	−1.81	−1.17	−1.17M	...	60	B
2964.623	1.724	−1.47	−1.60	−1.55M	...	78	B
2965.033	1.695	−1.21	−1.40	−1.40K	...	8	A
2965.406	3.425	−2.25	−2.10	−2.10M	...	59	B
2968.737	3.370	−2.46	−2.30	−2.30M	...	61	C
2969.930	3.814	−0.84	−0.61	−0.61M	...	70	B
2970.520	1.070	−1.65	−1.66	−1.66K	...	2	A
2970.694	3.768	−1.03	−1.39	−1.39M	...	69	B
2975.937	1.097	−2.52	−2.62	−2.58M	...	2	A
2979.354	1.097	−1.99	−2.03	−2.03K	...	2	A
2980.963	3.425	−1.93	−1.77	−1.77M	...	61	B
2982.059	4.479	−0.60	−0.54	−0.54M	...	130	B
2984.825	1.671	−0.34	−0.54	−0.54K	...	8	A
2985.545	1.724	−0.77	−1.00	−1.00K	...	8	A
2997.300	4.495	−0.80	−0.81	−0.81M	...	139	B
2998.060	3.425	−2.59	−2.19	−2.19M	...	60	B
3000.062	3.814	−1.04	−1.39	−1.39M	...	69	B
3002.321	3.944	−1.84	−1.37	−1.37M	...	98	B
3002.646	1.695	−0.77	−0.93	−0.93K	...	8	A
3021.417	3.387	−2.62	−2.51	−2.51M	...	59	B
3036.990	5.800	−0.83	−0.63	−0.63M	...	181	B
3044.840	3.967	−1.96	−1.48	−1.48M	...	98	B
3049.010	5.850	−0.78	−0.56	−0.56M	...	181	C
3056.804	4.076	−0.68	−1.28	−1.28M	...	109	B
3062.237	4.080	−0.69	−0.54	−0.54M	...	108	B
3065.316	3.944	−1.69	−1.26	−1.26M	...	97	B
3070.691	3.768	−1.74	−1.83	−1.83M	...	68	B
3071.140	5.880	−0.95	−0.74	−0.74M	...	181	B
3076.460	5.850	−0.56	−0.38	−0.38M	...	181	B
3077.171	4.076	−1.16	−0.48	−0.48M	...	108	B
3078.700	5.800	−0.28	−0.08	−0.08M	...	181	B
3089.384	4.732	−1.50	−1.36	−1.36M	...	158	C
3096.295	3.967	−1.82	−1.31	−1.31M	...	97	B
3105.167	3.889	−1.63	−1.40	−1.40M	...	82	B
3105.554	3.889	−1.66	−1.42	−1.42M	...	82	B
3106.566	3.814	−1.56	−1.60	−1.60M	...	68	B
3114.297	3.889	−1.40	−1.19	−1.19M	...	82	B
3114.686	3.889	−1.77	−1.55	−1.55M	...	82	B
3116.579	3.892	−1.46	−1.15	−1.15M	...	82	B
3131.724	4.080	−2.10	−1.62	−1.62M	...	107	B
3133.050	3.889	−1.83	−1.61	−1.61M	...	82	B
3135.360	3.892	−1.08	−0.89	−0.89M	...	82	B
3144.752	3.903	−1.59	−1.50	−1.50M	...	82	B
3146.755	3.768	−5.04	−2.58	−2.58M	...	67	C
3154.202	3.768	−0.46	−0.42	−0.42M	...	66	B
3162.798	4.154	−1.10	−1.09	−1.09M	...	120	B
3163.094	1.671	−2.95	−2.82	−2.82K	...	7	A
3166.672	1.671	−2.77	−3.07	−3.02M	...	6	A
3167.857	3.814	−0.69	−0.58	−0.58M	...	66	B
3170.337	1.695	−2.33	−2.44	−2.49P	...	6	A
3177.532	3.903	−0.88	−0.77	−0.77M	...	82	B
3179.503	4.732	−0.89	−0.68	−0.68M	...	157	B
3180.149	4.738	−1.09	−0.95	−0.95M	...	157	B
3183.114	1.695	−2.29	−2.10	−2.10K	...	7	A
3185.317	1.724	−2.98	−2.78	−2.78K	...	7	A
3186.738	1.695	−1.48	−1.67	−1.67K	...	6	A
3187.297	4.149	−1.01	−1.03	−1.03M	...	120	B
3192.066	3.814	−2.07	−1.95	−1.95K	...	66	B
3192.909	1.671	−1.70	−1.95	−1.95K	...	6	A
3193.799	1.724	−1.51	−1.66	−1.66K	...	6	A
3196.070	1.671	−1.96	−1.73	−1.73K	...	7	A
3210.444	1.724	−1.47	−1.69	−1.69K	...	6	A
3213.309	1.695	−1.09	−1.27	−1.27K	...	6	A
3227.742	1.671	−0.86	−1.06	−1.06K	...	6	A
3230.504	3.967	−3.80	−3.17	...	...	95	C
3231.706	3.892	−1.82	−1.59	−1.59M	...	80	B
3232.785	4.154	−1.43	−1.20	−1.20M	...	119	B
3237.399	3.889	−2.06	−1.75	−1.75M	...	81	B
3237.820	3.889	−1.32	−1.14	−1.14M	...	81	B
3241.685	3.903	−2.27	−2.33	−2.33M	...	80	B
3243.723	4.149	−1.24	−1.06	−1.06M	...	119	B
3247.175	3.889	−1.13	−0.98	−0.98M	...	81	B
3247.389	4.154	−1.88	−1.91	−1.91M	...	119	B
3249.656	3.892	−1.97	−1.83	−1.83M	...	81	B
3255.887	0.986	−2.46	−2.52	−2.52K	...	1	A
3257.363	3.967	−2.80	−2.39	−2.39M	...	94	C
3258.771	3.892	−1.11	−0.94	−0.94M	...	81	B
3259.051	3.903	−0.91	−0.80	−0.80M	...	81	B
3266.936	3.768	−2.11	−1.92	−1.92M	...	65	B
3267.039	3.903	−3.71	−2.26	−2.26M	...	80	B
3268.510	4.154	−1.65	−1.98	−1.98M	...	118	B
3269.765	4.149	−1.81	−2.17	−2.17M	...	118	B
3273.490	4.154	−1.77	−2.08	−2.08M	...	118	B
3276.604	3.944	−1.61	−1.59	−1.59M	...	92	B
3277.348	0.986	−2.36	−2.30	−2.30K	...	1	A
3279.644	4.149	−2.09	−2.10	−2.10M	...	118	B
3281.292	1.040	−2.65	−2.69	−2.69H	...	1	A
3285.408	1.076	−3.78	−2.87	−2.87K	...	1	A

TABLE 2 (CONTINUED)

λ (Å)	E_l (eV)	log gf Kur	GAF	Exp [a]	Solar [b]	Mult. [c]	Q [d]
3289.354	3.814	−1.42	−1.38	−1.38M	...	65	B
3295.233	3.892	−1.83	−2.02	−2.02M	...	79	B
3295.817	1.076	−2.96	−2.90	−2.90K	...	1	A
3297.880	3.944	−2.17	−1.83	−1.83M	...	91	B
3302.857	1.040	−3.49	−3.51	−3.51K	...	1	A
3303.464	1.097	−3.29	−2.70	−2.70K	...	1	A
3313.988	1.097	−3.91	−3.92	−3.92K	...	1	A
3323.063	3.967	−1.31	−1.39	−1.39M	...	92	B
3360.115	4.080	−2.33	−2.43	−2.43M	...	105	B
3366.967	5.569	−1.63	−1.47	−1.47M	...	177	C
3381.006	5.571	−1.63	−1.63	−1.63M	...	177	C
3388.138	3.903	−3.20	−3.27	...	...	77	C
3395.328	4.154	−2.06	−2.43	−2.43M	...	117	C
3398.360	4.076	−2.14	−2.24	−2.24M	...	105	B
3416.021	2.276	−2.82	−2.89	−2.89M	...	16	B
3425.575	1.671	−3.11	−3.72	−3.67M	...	5	A
3434.305	4.732	−3.53	−2.03	−2.03M	...	91	B
3442.220	3.967	−2.70	−2.21	−2.21M	...	89	B
3456.924	3.903	−1.94	−2.04	−2.04M	...	76	B
3463.962	1.671	−3.72	−4.27	−4.22M	...	4	C
3464.495	4.149	−2.18	−2.35	−2.35M	...	114	C
3468.678	4.154	−1.48	−1.45	−1.45M	...	114	B
3475.739	1.671	−3.25	−3.74	−3.69M	...	4	A
3487.986	1.695	−3.36	−3.87	−3.83M	...	4	A
3493.470	4.149	−1.10	−1.12	−1.12M	...	114	B
3494.673	2.276	−2.88	−3.02	−3.02M	...	16	B
3495.618	4.149	−2.37	−2.37	−2.37M	...	115	C
3499.876	4.154	−2.76	−2.17	−2.17M	...	115	C
3503.466	1.724	−3.64	−3.79	−3.74M	...	4	A
3507.395	6.223	−4.01	−3.27	−3.27M	...	16	B
3508.202	1.724	−3.69	−4.20	−4.15M	...	4	C
3614.876	4.154	−2.00	−2.10	−2.10M	...	112	B
3621.270	4.616	−1.52	−1.75	−1.75M	...	144	B
3624.893	4.616	−1.79	−1.92	−1.92M	...	144	B
3632.292	4.149	−2.51	−2.45	−2.45M	...	112	B
3711.170	5.890	−2.74	−1.68	−1.68M	...	192	B
3748.483	4.732	−1.57	−1.22	−1.22M	...	154	B
3759.464	4.738	−1.89	−1.92	−1.92M	...	154	B
3814.124	4.738	−2.27	−2.17	−2.17M	...	153	B
3824.929	2.583	−3.09	−3.35	−3.35M	...	29	B
3827.083	4.732	−2.35	−2.40	−2.40M	...	153	B
3906.035	5.571	−1.67	−1.59	−1.59M	...	173	B
3914.503	1.671	−4.10	−4.04	−3.99M	...	3	B
3935.962	5.569	−1.68	−1.62	−1.62M	...	173	B
3938.290	1.671	−3.77	−3.88	−3.83M	...	3	B
3938.970	5.911	−1.52	−1.61	−1.61M	...	190	B
3945.210	1.695	−4.12	−4.24	−4.19M	...	3	B
3969.373	1.695	−4.71	−3.84	−3.84M	...	3	C
3974.167	2.704	−3.30	−3.45	−3.45M	...	29	B
4002.083	2.778	−3.47	−3.65	...	...	29	C
4018.490	2.276	−5.74	−5.40	...	−5.59T	13	B
4024.547	4.495	−2.12	−2.24	−2.24M	−3.57T	127	B
4031.442	4.732	−3.12	−3.08	...	−3.26T	151	B
4032.935	4.495	−2.70	−2.69	...	−2.88T	126	B
4064.756	2.856	−5.53	−4.89	...	−5.08T	39	B
4075.954	2.544	−4.85	−3.32	−3.32M	...	21	B
4084.586	4.738	−5.36	−3.91	...	−4.10T	151	B
4087.284	2.583	−4.80	−4.43	...	−4.62T	28	B
4088.755	2.844	−4.81	−4.57	...	−4.76T	39	B
4119.524	2.544	−4.92	−4.27	...	−4.46T	21	B
4122.668	2.583	−3.54	−3.34	−3.32M	−3.53T	28	B
4124.787	2.544	−4.88	−4.07	...	−4.20B	22	B
4128.748	2.583	−3.47	−3.66	−3.71M	−3.85T	27	B
4151.795	2.276	−6.83	−4.21	...	−4.40T	12	B
4153.008	2.891	−5.47	−4.82	...	−5.01T	45	B
4158.448	2.276	−5.67	−5.23	...	−5.42T	12	B
4160.290	4.738	−4.45	−2.40	...	−2.59T	149	B
4169.979	2.276	−5.41	−5.40	...	−5.59T	12	B
4173.461	2.583	−2.51	−2.18	−2.18K	−2.51T	27	A
4176.446	4.738	−4.59	−2.68	...	−2.87T	149	B
4177.692	2.544	−3.75	−3.40	...	−3.58T	22	B
4178.862	2.583	−2.79	−2.48	−2.48K	−2.71B	28	A
4180.981	4.738	−3.76	−1.60	−1.60M	...	148	B
4227.173	2.891	−5.20	−4.69	...	−4.88T	45	B
4233.172	2.583	−1.84	−1.91	−1.91H	−1.97T	27	A
4244.541	2.342	−6.21	−5.81	...	−6.00T	12	B
4251.494	2.342	−6.06	−5.23	...	−5.42T	12	B
4258.154	2.704	−3.80	−3.38	−3.34M	−3.58T	28	B
4273.326	2.704	−3.26	−3.31	−3.28M	−3.31T	27	B
4278.159	2.692	−3.82	−3.84	...	−4.03T	32	B
4296.572	2.704	−3.20	−2.59	−2.95M	−2.78T	28	B
4303.176	2.704	−2.44	−2.49	−2.49K	−2.37T	27	A
4314.310	2.676	−3.48	−3.44	...	−3.63T	32	B
4338.703	2.692	−4.10	...	...	−4.25	32	B
4351.769	2.704	−2.13	−2.10	−2.10K	−2.61T	27	A
4369.411	2.778	−3.92	−3.62	−3.61M	−3.82T	28	B
4384.319	2.657	−3.53	−3.61	−3.44M	−3.80T	32	B
4385.387	2.778	−2.54	−2.70	−2.75P	−2.68T	27	A
4386.585	2.583	−4.95	−5.06	...	−5.25T	26	B
4413.601	2.676	−3.93	−3.86	...	−3.87B	32	B
4416.830	2.778	−2.53	−2.55	−2.54M	−2.61B	27	B
4439.134	2.692	−5.27	−4.50	...	−4.69T	32	B
4461.439	2.583	−4.11	−4.37	...	−4.56T	26	B
4472.929	2.844	−4.30	−3.50	−3.37M	−3.69T	37	B
4489.183	2.828	−3.42	−2.96	−2.91M	−3.15T	37	B
4491.405	2.856	−2.68	−2.70	−2.70K	−2.70B	37	A
4508.288	2.856	−2.31	−2.38	−2.33M	−2.43B	38	A
4515.339	2.844	−2.47	−2.41	−2.41K	−2.70T	37	A
4520.224	2.807	−2.98	−2.68	−2.55M	−2.88T	37	B
4522.634	2.844	−2.12	−2.03	−2.03K	−2.45T	38	A
4534.168	2.856	−3.25	−3.44	−3.41M	−3.53T	37	B
4541.524	2.856	−2.85	−3.06	−2.99M	−2.99B	38	B
4549.192	5.911	−1.47	−1.59	−1.63M	−1.78T	186	B
4549.474	2.828	−1.96	−1.75	−1.75K	−2.22T	38	A
4555.893	2.828	−2.33	−2.29	−2.29K	−2.36B	37	A
4574.790	3.220	−3.51	...	...	...	48	B
4576.340	2.844	−2.82	−2.94	−2.94H	−3.08B	38	A
4580.063	2.583	−3.73	−3.76	...	...	26	B
4582.835	2.844	−3.09	−3.10	−3.10K	−3.30B	37	A
4583.837	2.807	−1.80	−1.84	−1.84K	−1.93T	38	A
4595.682	2.856	−4.26	−4.59	...	−4.79T	38	B
4601.378	2.891	−4.43	−4.38	...	−4.57T	43	B
4602.747	2.544	−6.08	−5.21	...	−5.41T	19	B
4620.521	2.828	−3.08	−3.22	−3.29H	−3.21H	38	A
4629.339	2.807	−2.31	−2.33	−2.33K	−2.12T	37	A
4635.316	5.956	−1.27	−1.41	−1.41M	−1.60T	186	B
4648.235	2.844	−4.85	−4.43	...	...	25	B
4656.981	2.891	−3.55	−3.61	−3.61H	−3.59H	43	A
4663.708	2.891	−4.26	−3.85	...	−4.06T	44	B
4665.805	2.704	−4.92	−4.55	...	−4.74T	0	B
4666.758	2.828	−3.22	−3.34	−3.27M	−3.53T	37	B
4670.182	2.583	−3.90	−4.07	...	−4.22B	25	B
4713.193	2.778	−4.93	−4.46	...	−4.65T	26	B
4720.149	3.197	−4.53	−4.55	...	−4.74T	54	B

TABLE 2 (CONTINUED)

λ	E_l	log gf				Mult.	Q
(Å)	(eV)	Kur	GAF	Exp [a]	Solar [b]	[c]	[d]
4731.453	2.891	−3.05	−2.92	−3.30M	−2.92T	43	B
4818.242	2.276	−6.00	−5.39	...	−5.58T	11	B
4825.736	2.635	−4.83	−4.82	...	−5.01T	30	B
4833.197	2.657	−4.60	−4.59	...	−4.78T	30	B
4840.662	2.276	−6.24	−4.69	...	−4.88T	30	B
4847.623	2.692	−5.29	−5.01	...	−5.20T	30	B
4868.806	2.676	−5.16	−5.29	...	...	30	B
4893.820	2.828	−4.06	−4.27	...	−4.46T	36	B
4923.927	2.891	−1.56	−1.24	−1.24K	−1.43T	42	A
4991.390	2.840	−3.71	−2.89	...	...	37	B
4993.358	2.807	−3.49	−3.68	...	−3.82B	36	B
5000.743	2.778	−4.40	−4.49	...	−4.74B	25	B
5018.440	2.891	−1.40	−1.24	−1.23M	−1.24T	42	B
5036.920	2.828	−4.52	−4.21	...	−4.40T	36	B
5100.664	2.807	−4.14	−4.16	...	−4.37B	35	B
5100.852	5.911	−1.78	−1.64	...	−1.83T	185	B
5120.346	2.830	−4.35	−4.18	...	−4.37T	35	B
5127.866	5.571	−2.54	−2.13	...	−2.32T	167	B
5132.669	2.807	−3.90	−4.04	...	−4.18B	35	B
5136.802	2.844	−4.32	−4.33	...	−4.49B	35	B
5146.127	2.828	−3.91	−3.93	...	−4.23T	35	B
5150.941	2.856	−4.45	−4.47	...	−4.66T	35	B
5154.409	2.844	−4.14	−4.13	...	−4.32T	35	B
5160.839	5.569	−2.64	−2.13	...	−2.33T	167	B
5161.184	2.856	−4.48	−4.30	...	−4.49T	35	B
5169.033	2.891	−1.30	−0.87	−0.87K	−1.42T	42	A
5191.587	3.197	−4.86	−4.79	...	−4.98T	52	B
5197.577	3.230	−2.23	−2.10	−2.10K	−2.31T	49	A
5234.625	3.221	−2.15	−2.24	−2.27K	−2.23H	49	A
5256.938	2.891	−4.25	−4.13	...	−4.32T	41	B
5262.479	3.197	−5.61	−3.06	−3.06H	−4.96T	52	B
5264.812	3.230	−3.30	−3.26	−3.27H	−3.25H	48	A
5272.397	5.956	−1.62	−1.70	...	−1.89T	185	B
5276.002	3.199	−2.07	−1.94	−1.94K	−2.00T	49	A
5284.109	2.891	−3.30	−3.12	...	−3.31T	41	B
5316.615	3.153	−1.93	−1.85	−1.85K	−1.89T	49	A
5316.784	3.221	−2.91	−2.75	−2.80P	−2.84T	48	A
5325.553	3.221	−3.22	−2.60	−2.60K	−3.32B	49	A
5337.732	3.230	−3.89	−3.79	...	−3.98T	48	B
5346.571	3.230	−5.07	−4.32	...	−4.51T	49	B
5362.869	3.199	−2.74	−2.61	...	−2.80T	48	B
5375.990	3.190	−2.22	−2.22	...	...	49	B
5408.811	5.956	−2.39	−2.00	...	−2.19T	184	B
5414.073	3.221	−3.75	−3.58	−3.58H	−3.50H	48	A
5425.257	3.199	−3.37	−3.50	...	−3.36B	49	B
5445.984	3.339	−5.30	−4.74	...	−4.93T	53	B
5498.229	2.583	−7.63	−5.43	...	−5.62T	24	B
5519.845	3.339	−5.62	−4.56	...	−4.75T	52	B
5525.125	3.267	−4.61	−4.04	−4.04H	−3.95H	56	A
5534.847	3.245	−3.00	−2.77	...	−2.93B	55	B
5544.774	5.569	−4.10	...	...	...	166	C
5545.271	2.583	−5.91	−5.25	...	−5.44T	24	B
5627.497	3.387	−4.17	−4.14	−4.14H	−4.10H	57	A
5696.127	2.642	−7.65	−4.82	...	−5.01T	18	B
5725.963	3.425	−4.83	−4.45	...	−4.64T	57	B
5732.724	3.387	−4.67	−4.29	...	−4.48T	57	B
5737.699	3.425	−5.57	−4.61	...	−4.80T	58	B
5813.677	5.571	−2.82	−2.50	...	−2.69T	163	B
5823.155	5.569	−3.01	−2.81	...	−3.00T	164	B
5824.415	3.425	−6.04	−4.40	...	−4.59T	58	B
5826.111	5.911	−2.89	−2.72	...	−2.91T	182	B
5864.543	2.704	−5.76	−5.15	...	−5.34T	24	B
5891.328	7.269	−2.03	−1.33	...	−1.52T	0	B
5952.510	5.956	−2.03	−2.00	...	−2.18T	182	B
5991.376	3.153	−3.56	−3.64	...	−3.74B	46	B
6084.111	3.199	−3.81	−3.88	...	−3.98B	46	B
6113.322	3.221	−4.16	−4.21	...	−4.31B	46	B
6116.057	3.230	−4.69	−4.47	...	−4.56T	46	B
6129.703	3.199	−4.66	−4.44	...	−4.63T	46	B
6147.741	3.889	−2.72	−2.73	...	−2.92T	74	B
6149.258	3.889	−2.72	−2.75	...	−2.85B	74	B
6155.254	5.569	−4.26	−2.53	...	−2.72T	161	B
6175.146	6.223	−1.98	−2.11	...	−2.30T	200	B
6179.384	5.569	−2.60	−2.51	...	−2.70T	163	B
6196.688	3.221	−5.78	−5.00	...	−5.19T	46	B
6233.534	5.480	−2.94	−2.51	...	−2.70T	0	C
6238.392	3.889	−2.63	−2.68	...	−2.87T	74	B
6239.953	3.889	−3.44	−3.40	...	−3.59T	74	B
6247.557	3.892	−2.33	−2.41	...	−2.51B	74	B
6248.897	5.510	−2.70	−2.43	...	−2.62T	0	B
6305.296	6.219	−2.04	−1.80	...	−1.99T	200	B
6331.954	6.217	−1.98	−1.63	...	−1.82T	199	B
6369.462	2.891	−4.25	−3.55	−3.55H	−4.36B	40	A
6383.722	5.550	−2.27	−2.17	...	−2.27B	0	B
6385.451	5.550	−2.62	−2.66	...	−2.85T	0	B
6407.251	3.889	−3.70	−3.30	...	−3.49T	74	C
6416.919	3.892	−2.74	−2.75	...	−2.85B	74	B
6432.680	2.891	−3.71	−3.55	−3.55H	−3.74B	40	A
6442.955	5.553	−2.89	−2.45	...	−2.64T	0	B
6446.410	6.223	−2.07	−2.07	...	−2.16B	199	B
6456.383	3.903	−2.08	−2.20	...	−2.30B	74	B
6482.204	6.219	−2.27	−1.70	...	−1.89T	199	B
6491.246	5.580	−2.79	−2.66	...	−2.85T	0	B
6493.035	5.580	−2.58	−2.43	...	−2.62T	0	B
6516.080	2.891	−3.45	−3.44	−3.44H	−3.38H	40	A
6627.261	7.274	−1.61	−1.12	...	−1.31T	210	B
7222.394	3.889	−3.30	−3.38	−3.43P	−3.36H	73	A
7224.487	3.889	−3.24	−3.30	−3.35P	−3.29H	73	A
7301.560	3.892	−4.52	−3.63	...	−3.88B	72	B
7308.073	3.889	−3.02	−3.25	...	...	73	C
7310.216	3.889	−3.36	−3.63	...	...	73	C
7320.654	3.892	−3.22	−3.46	...	...	73	C
7449.335	3.889	−3.31	−3.10	−3.10H	−3.09H	63	A
7462.407	3.892	−2.73	−2.96	...	...	73	C
7479.693	3.892	−3.59	−3.68	...	−3.88B	72	B
7515.831	3.903	−3.43	−3.41	−3.41H	−3.44H	73	B
7533.367	3.903	−3.99	−4.57	...	...	72	C
7534.824	3.944	−5.98	−4.14	...	−4.33T	87	B
7655.488	3.892	−3.55	−3.85	...	...	73	C
7711.723	3.903	−2.54	−2.55	−2.55H	−2.47H	73	A
7841.388	3.903	−3.72	−4.03	...	−4.22T	73	B

[a] K: Kroll & Kock (1987); W: Whaling (1985); P: Pauls et al. (1990); H: Hiese & Koch (1990); M: Moity (1983).

[b] E: Ekberg & Feldman (1993); B: Blackwell et al. (1980); T: Thévenin (1989, 1990).

[c] For $\lambda < 2950$ A multiplet numbers are from Moore (1952), otherwise from Moore (1972).

[d] A: error 10 – 15%; B: error 15 – 25%; C: error > 25% .

lines. Particularly in the range 0.0 eV to 0.4 eV the scatter is small but it increases after 1 eV and beyond 2.2 eV it is rather large. The same difference is plotted as a function of log gf(Kur) in lower panel. It appears that in the log gf range -1.0 to $+0.5$ the scatter is smaller but for log gf smaller than -2.0 it becomes very large. Hence the log gf values of Kurucz (1990a) are quite good for low excitation potential lines of large and moderate strengths but suffer from large random errors for high excitation lines of small strength.

6. PRESENT COMPILATION AND FUTURE PROSPECTS

The line list of Kurucz (1990a) is overwhelmingly large and though all lines may be necessary while calculating opacities for model atmospheres, a relatively small fraction of these lines individualy contribute to the observed spectrum . We decided to restrict our compilation to well established lines existing in the multiplet table of Moore (1972) for visual and Moore (1952) for ultraviolet. Our compilation of 848 Fe II lines is presented in Table 2. Column 1 gives the wavelength in A; column 2 excitation potential of lower level in eV; column 3 gives log gf values of Kurucz (1990a); column 4, labeled GAF, contains our compilation of log gf values and generally contains values that have been brought to the scale of KK by applying corrections given in Table 1. Such lines are of better accuracy and are indicated by letters A or B in the last column. However there are lines for which only semi-empirical estimates were available. We have seen in the last section that the standard errors are comparable for log gf values of Kurucz and Fawcett in the excitation potential range 0.0–3.0 eV hence for such lines we chose to take the mean of these two log gf values. But for lines of excitation potential higher than 3.0 eV we have used log gf value of Kurucz itself since the standard error for Fawcett log gf values are much larger for higher excitation lines and also very few lines are available. Column 5 gives log gf derived experimentally by different workers. In this column the log gf values are followed by a letter indicating the source of the data as coded in the botom of the table. Column 6 gives solar log gf values derived by different workers, here also the values are followed by a letter as coded in the bottom of the table. Column 7 gives the muliplet number taken either from Moore (1952) (for $\lambda < 2950$ A) or from Moore (1972) for visual and red spectral regions. A few lines existed in Moore's tables with no multiplet number, such lines have a blank in column 7. Column 8 has letters indicating the quality of log gf estimates as coded at the end of the table.

We believe our compilation will help abundance workers in deriving abundances at better accuracy. We plan to prepare similar compilations for other Fe-group elements like Ti I, Ti II, Cr I and Cr II.

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