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The Calculation of Oscillator Strengths by the Arrangement of Width 6 Code

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Abstract:
In this work the WIDTH 6 code, which calculates the chemical abundances in the atmospheres of stars, has been changed to a form, so that it calculates the oscillator strengths by using solar chemical elemental abundance values, then the dippole oscillator strengths of 81 Fe I lines have been calculated.
Özet:
Yıldız atmosfer modellerinden itibaren atmosferlerinde kimyasal element bolluklarını hesaplıyan WIDTH 6 kodu yeniden düzenlenerek, atmosferinde kimyasal element bollukları iyi bilinen güneşin bolluk değerleri veri olarak girilerek 81 FeI çizgisinin ossilatör şiddetleri çıktı olarak elde edilmiştir.
Keywords: Oscillator strengths, abundances, model atmospheres.

Introduction

One of the main problems for analysing stellar atmosphere is to determine the oscillator strengths, which is an important parameter in calculating the chemical elemental abundances.

The oscillator strengths, as a measure of the transition probability between the energy levels of the atom or ions, are classified as theoretical, semi-theoreitical and experimental values. Some of the existing theoretical results are used by fitting to the experimental ones.

The main purpose of this study is to find consistent series of oscillator strengths reorganizing the computer code WIDTH 6, which calculates the chemical elemental abundance, in the form of GWIDTH, which calculates oscillator strengths using solar abundances as input data. Then Oscillator Strength of 81 FeI was calculated. The model atmosphere is calculated for Sun by using ATLAS 8 computer code.

This method leads to applicable consistent results for calculating oscillator strengths of all lines in the solar atmosphere.

Theory

In order to calculate the chemicaly elemental abundances for stellar atmospheres, program WIDTH is used with model atmosphere and physical parameters. Model parameters are effective temperature, gravity (log g) and turbulance velocity of stellar atmospheres. The physical parameters are excitation potentials and multiple coefficients of energy levels occurred atomic transitions between, equivalent-widths and oscillator strengths of absorbtionlines.

In this study, WIDTH 6 is reorganized in the form of GWIDTH so that chemical abundance value is given as an input value instead of oscillator strengts, with all other parameters, to calculate oscilator strengts of the line occurred in stellar atmosphere.

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The solar elemental abundances are almost definetely known values [1], and since Sun is the closest star very clear solar spectrum can be obtained.
Measurıng the equivalent widths of lines in solar spectrum and giving other parameters with well-determined elemental abundances for solar atmosphere, it is possible to calculate oscillator strength for each atomic transition with GWIDTH code.
In order to measure equivalent-widths of chosen Fe I lines, Automated Line Identification program was used. This computer program was developed to automate the intricate and tedious process of stellar line identification, [2]. The program also computes the equivalent width of the identified line.

Results and Discussıon

In this study, the solar spectra is taken from Jungfraujoch Astrophysical observatory. The clear 81 Fe I lines are identified in the wavelengths between $\lambda\lambda$ 4191.436-4377.326 $\overset{o}{A}$ to measure equivalenth widths. Model parameters are taken 5780 ^{o}K, 4.44, 1.35 km/s as effective temperature (Teff), Gravity(log g) and turbulance velocity, respectively [3]. The physical parameters and calculated oscillator strength of 81 Fe I lines are given in Table I . Table I also includes Kurucz-Peytreman's values.
Using calculated oscillator strengths (log gf_{DB}), Fe abundance (logN/H_{DB}) of HD 204411 iscalculated. Since HD 204411 has a hotter atmosphere (Teff =8400 ^{o}K) than solar atmosphere, only 9 lines are common in both atmospheres from 81 Fe lines which give (logN/H_{DB}) = –3.36 as a mean value. On the other hand, the mean value of Fe abundance computed from 9 Fe lines for HD 204411 are also given by Çalışkan [4] which is (logN/$H_{HÇ}$) =–3.96 . Çalışkan has taken Kurucz-Peytreman values as oscillator strengths (log gf_{KP}). The difference between the two values is 0.6dex which is an acceptable value. (Table 2)

Table 1. Calculated oscillator strengths and Kurucz-Peytreman values

λ	J_i	E_l	J_u	E_u	EW	Log gf_{D-B}	Log gf_{K-P}
4191.436	2.0	19912.486	1.0	43763.938	8.5	-2.306	-0.780
4191.680	0.0	23051.744	1.0	46901.808	6.2	-2.452	-2.460
4194.486	4.0	21999.132	4.0	45833.240	1.7	-3.526	-2.490
4195.318	5.0	26874.534	5.0	50703.912	13.9	-0.596	-0.730
4195.620	2.0	24335.764	2.0	48163.427	8.3	-1.824	-0.690
4196.198	3.0	27394.676	3.0	51219.059	9.6	-1.196	-0.590
4196.534	5.0	23783.617	5.0	47606.092	7.0	-2.188	-2.040
4197.098	2.0	7985.783	3.0	31805.059	5.9	-4.354	-8.020
4197.369	4.0	31307.235	3.0	55124.974	1.4	-2.550	-3.200
4198.624	2.0	27559.568	2.0	51370.184	13.3	-0.591	-0.760
4199.359	5.0	23783.617	4.0	47590.070	1.7	-3.316	-2.560
4199.986	2.0	704.003	2.0	24506.902	1.8	-6.102	-4.870
4200.780	2.0	12968.552	3.0	36766.950	5.2	-3.866	-3.780
4200.913	3.0	27394.676	4.0	51192.320	9.5	-1.227	-3.240
4202.746	4.0	24574.655	4.0	48361.920	3.7	-2.752	-2.420
4207.130	2.0	22838.320	1.0	46600.800	9.0	-1.854	-0.900

λ	J_i	E_l	J_u	E_u	EW	Log gf_{D-B}	Log gf_{K-P}
4212.055	2.0	27559.568	3.0	51294.262	4.4	-2.273	-3.690
4213.649	1.0	22946.810	0.0	46672.523	9.1	-1.822	-1.040
4216.185	4.0	0.000	4.0	23711.443	10.1	-4.391	-3.440
4217.536	1.0	27666.334	2.0	51370.184	11.4	-0.847	-0.200
4219.364	5.0	28819.966	6.0	52513.546	15.5	-0.196	-0.130
4219.583	2.0	28604.610	2.0	52296.960	1.0	-3.022	-2.120
4222.218	3.0	19757.020	3.0	43434.585	17.5	-1.043	-1.040
4223.731	5.0	23783.617	4.0	47452.702	2.5	-3.112	-4.660
4224.160	4.0	27166.804	5.0	50833.485	13.2	-0.653	-3.200
4224.503	1.0	27666.334	2.0	51331.090	10.0	-1.105	-4.120
4225.444	2.0	27559.568	3.0	51219.059	12.2	-0.736	-0.060
4225.693	4.0	34039.495	4.0	57697.590	6.1	-1.196	-2.530
4228.704	4.0	27166.804	4.0	50808.053	2.7	-2.669	-3.820
4229.507	1.0	26406.490	1.0	50043.250	2.5	-2.796	-2.020
4229.536	5.0	23783.617	5.0	47420.215	6.6	-2.289	-3.780
4229.756	4.0	11976.239	3.0	35611.608	11.2	-2.723	-5.980
4231.599	2.0	21038.987	2.0	44664.061	2.1	-3.530	-3.120
4232.729	1.0	888.132	2.0	24506.902	2.7	-5.858	-4.960
4237.673	3.0	24338.766	4.0	47929.981	2.6	-3.025	-3.030
4238.798	3.0	27394.676	4.0	50979.627	9.3	-1.269	0.080
4241.119	2.0	22838.320	1.0	46410.366	0.7	-3.862	-1.620
4245.259	0.0	23051.744	1.0	46600.800	4.5	-2.785	-1.140
4246.014	1.0	26406.490	0.0	49951.360	4.3	-2.433	-2.740
4246.096	3.0	29371.860	2.0	52916.278	5.9	-1.764	-0.970
4246.789	3.0	20874.482	4.0	44415.057	3.6	-3.227	-4.350
4248.403	1.0	8154.713	2.0	31686.342	6.5	-4.224	-4.970
4249.577	4.0	20641.110	3.0	44166.240	6.6	-2.663	-2.590
4256.199	2.0	27559.568	1.0	51048.100	5.1	-2.145	-4.960
4256.796	3.0	34328.733	3.0	57813.970	3.5	-1.673	-3.170
4258.317	2.0	704.003	3.0	24180.848	8.1	-4.781	-4.380
4258.954	3.0	24338.766	4.0	47812.104	4.7	-2.595	-2.340
4269.861	3.0	27394.676	4.0	50808.053	7.6	-1.640	-4.920
4270.303	3.0	20874.482	2.0	44285.436	4.7	-3.020	-3.060
4275.699	4.0	20641.110	4.0	44022.518	6.1	-2.779	-3.460
4276.704	5.0	26351.049	4.0	49726.964	6.8	-1.951	-3.430
4277.393	2.0	21038.987	1.0	44411.137	3.0	-3.324	-3.250
4277.677	3.0	33412.706	3.0	56783.306	1.0	-2.475	-1.540
4278.220	4.0	27166.804	3.0	50534.435	6.8	-1.846	-1.380
4292.288	2.0	17726.985	2.0	41018.029	5.5	-3.253	-3.690
4294.040	4.0	20641.110	3.0	43922.652	8.7	-2.215	-2.540
4299.625	3.0	24338.766	4.0	47590.070	8.6	-1.798	-1.910
4300.816	2.0	32133.977	2.0	55378.842	8.8	-0.859	-1.710
4302.188	4.0	24574.655	4.0	47812.104	8.7	-1.750	-1.750
4304.865	4.0	26627.612	3.0	49850.610	5.3	-2.224	-2.780
4305.137	4.0	21999.132	3.0	45220.662	7.5	-2.329	-3.190
4305.208	2.0	28604.610	3.0	51825.758	3.3	-2.370	-2.110
4305.455	2.0	24335.764	1.0	47555.584	10.5	-1.419	-1.740
4319.444	2.0	21038.987	2.0	44183.607	7.5	-2.448	-3.550
4324.952	2.0	17726.985	3.0	40842.130	7.7	-2.791	-3.740
4327.091	2.0	28604.610	2.0	51708.330	8.1	-1.408	-1.420
4329.540	1.0	17927.378	2.0	41018.029	0.3	-4.844	-4.840
4330.743	2.0	24335.764	2.0	47420.000	1.6	-3.296	-1.920
4330.957	5.0	26351.049	6.0	49434.142	4.2	-2.470	-2.850
4335.461	1.0	24772.019	2.0	47831.132	1.0	-3.489	-4.830
4337.048	3.0	12560.933	3.0	35611.608	4.5	-4.070	-2.970
4338.261	3.0	17550.180	4.0	40594.413	4.5	-3.470	-3.530
4343.222	3.0	26224.961	3.0	49242.872	4.2	-2.486	-3.300
4343.693	4.0	24574.655	4.0	47590.070	5.6	-2.408	-0.990
4346.557	4.0	26627.612	4.0	49627.861	5.6	-2.172	-3.160
4357.515	1.0	31937.308	2.0	54879.720	3.8	-1.896	-3.190
4377.326	3.0	31322.603	3.0	54161.182	3.9	-1.949	-3.020

Table 2.The Comparison of abundance results

	Log Fe/H $_{DB}$	Log Fe/H $_{HÇ}$
	-3.380	-3.920
	-3.260	-3.760
	-3.370	-4.260
	-3.730	-4.060
	-3.030	-3.960
	-3.650	-4.090
	-4.020	-4.050
	-3.370	-3.710
	-2.450	-4.250
Mean Values	**-3.360**	**-3.960**

As a conclusion, the method will help to calculate consistent series of oscillator strengths by using solar spectrum and solar chemically elemental abundances.

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