Spectral Atlas of Solar Absolute Disk-averaged and Disk-center Intensity from 3290 to 12510 Å

Preliminary Tape Version
(1987)

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1. Arrangement of Data

The atlas was prepared using tape-copies of the original FTS-scans obtained by J. Brault and his co-workers at Kitt Peak. As far as the disk-averaged spectrum is concerned, these tape copies are identical with those used by Kurucz et al. (1984) to prepare the NSO-Atlas No. 1 of the solar flux spectrum.

The atlas data are arranged in 20 files: files 1 - 10 contain the data-triplets (1. wavelength, 2. spectral intensity, 3. (quasi-)continuum intensity) for the disk-averaged spectrum, files 11 - 20 those for the disk-center spectrum. The wavelengths are given in Å, the intensities in Wcm^{-2} $ster^{-1}$ $Å^{-1}$. Using a FORTRAN-program, the triplets are read by FORMAT (F12.4, F9.6, F9.6). Table 2, which is the result of the FORTRAN-test-program presented in Table 1, yields for each file the following data: file number, number of data-triplets in the file, first data-triplet (LDA1, INT1, CONT1), last data-triplet (LDA2, INT2, CONT2). The numbers of the original FTS-scans, from which the primary spectral data were adopted for this atlas, are given in Table 3.

2. The wavelengths

The FTS scans provide the intensities for equidistant wavenumbers. The corresponding vacuum-wavelengths have been converted to air-wavelengths using the formula

$$\lambda_{air} = 0.999\ 726\ 83\ \lambda_{vac} + 0.0107 - 196.25/\lambda_{vac},$$

with the wavelengths measured in Å. The resulting air-wavelengths still have to be corrected for radial velocity and instrumental alignment errors. As the instrumental corrections can only be determined from the wavelength-shifts of atmospheric lines, we decided to determine the total corrections from the wavelength-shifts of solar lines. Actually, the wavelength-corrections followed from a comparison of the FTS-wavelengths of selected lines with the wavelengths given in the Kitt Peak Tables of Pierce and Breckinridge (1973). The results are compiled in the last two columns of Table 4. For the last three scans the λ-shifts of the atmospheric lines are given separately.

The mean errors of the corrections range between $0.06 \cdot 10^{-6}$ for $\lambda < 4000$ Å and $0.15 \cdot 10^{-6}$ in the infrared. Within these errors the atlas wavelengths are supposed to be in the system of the Kitt Peak Tables. For comparison, Table 4 includes also the radial velocities and instrumental corrections quoted in the NSO atlas as well as the corresponding total wavelength-corrections. Except for the last scan, there is good agreement between both determinations. The difference for the last scan can be explained by assuming that the instrumental correction is actually +0.30 km/sec as for the two preceding scans and not 0.0 km/sec (misprint in the NSO-atlas?). This conclusion is supported by the results of solar and terrestrial lines.

Further, for the full-disk scans we determined also the radial velocities, taking into account (a) the rotation of the Earth ($RV_{rot} = 0.394 \cdot \cos \delta_{\odot} \cdot \sin \theta_{\odot}$ km/sec) and (b) the variation of the radius vector Earth-Sun, which follows from the Tables in "The Astronomical Almanac". Possibly, the minor differences between our data and the NSO-values result from the inconsistencies of the start- and end-values of time and hour angle included in the headings of the FTS-scans.

3. The absolute spectral intensities

The absolute intensities follow from the Kitt Peak FTS-data as described by Neckel and Labs (1984a; for errata see 1984b). The precise wavelengths at which successive scans are linked are given in Table 3. Note that no zero point corrections have been made to any of the FTS intensities. Further we point to the fact that the absolute calibration of the disk-center spectrum is not reliable for wavelengths between 8800 and 9800 Å, in particular not near the linking wavelengths between scans 7 and 8 (8967.8452/8967.8545). In this spectral range the disk-center spectrum still needs a calibration by means of the well established continuum level. As soon as this calibration has been done, improved tapes will be provided on request. These improved tapes will then include also the 2960 to 3300 Å spectral region.

If the disk-averaged intensities are multiplied by 68.00, one gets the solar irradiance at 1 AU in 10^{-6} Wcm^{-2} Å^{-1}.

4. The 'continuum' level

The 'continuum' level follows from the polygonal tracks of the radiation temperatures defined in Table VII of Neckel and Labs (1984a). Its ambiguity at shorter wavelengths, in particular in the region near the Balmer-'jump', must not be emphasized.

References

Kurucz,R.L., Furenlid,I., Brault,J., Testermann,L.: 1984, Solar Flux Atlas from 296 to 1300 nm = National Solar Observatory Atlas No. 1, Office of the University Publisher, Harvard University

Neckel,H., Labs,D.: 1984a, Solar Phys. 90, 205

Neckel,H., Labs,D.: 1984b, Solar Phys. 92, 391

Pierce,A.K., Breckinridge,J.B.: 1973, The Kitt Peak Table of Photographic Solar Spectrum Wavelengths, Kitt Peak National Observatory Contribution No. 559

Table 1. FORTRAN-program to read data from tape

```
                FORTRAN 77      V10L31                  DATE 87.05.27  TIME 10.47.44

      C         TEST OF TAPE WITH ABSOLUTE SOLAR SPECTRUM DATA (1000 A FILES)

000001          INTEGER FILE,N,I
000002          DOUBLE PRECISION LDA,DATA,CONT,LDA1,DATA1,CONT1,LDAZ,DATAZ,CONTZ,
               1                 A,Z
000003          DIMENSION N(20)

000004          N(1)=164254
000005          N(2)=119581
000006          N(3)=149086
000007          N(4)=131127
000008          N(5)=110303
000009          N(6)= 97674
000010          N(7)= 78139
000011          N(8)= 74339
000012          N(9)= 65615
000013          N(10)=29424
000014          N(11)=156840
000015          N(12)=191426
000016          N(13)=147521
000017          N(14)=131128
000018          N(15)=111895
000019          N(16)= 99141
000020          N(17)= 96235
000021          N(18)= 78737
000022          N(19)= 65615
000023          N(20)= 29424

000024          A=3290.00
000025          Z=12510.00

000026          WRITE(6,1000) A,Z
000027  1000    FORMAT(1H1,'FTS-SPECTRA FROM ',F6.1,' TO ',F7.1,' A'/1X,'TEST DATA
               1 READ FROM WRITTEN TAPE'//1X,'FILE-NR.  NUMBER OF DATA    LDA1
               2   INT1       CONT1          LDAZ       INTZ       CONTZ'//)

000028          FILE=0
000029  5       FILE=FILE+1
000030          DO 10 I=1,N(FILE)+1
000031             READ(8,2000,END=5) LDA,DATA,CONT
000032  2000       FORMAT(F12.4,F9.6,F9.6)
000033             IF(I.EQ.1) THEN
000034                LDA1=LDA
000035                DATA1=DATA
000036                CONT1=CONT
000037             END IF
000038             IF(I.EQ.N(FILE)) THEN
000039                LDAZ=LDA
000040                DATAZ=DATA
000041                CONTZ=CONT
000042                WRITE(6,1010) FILE,N(FILE),LDA1,DATA1,CONT1,LDAZ,DATAZ,CONTZ
000043  1010          FORMAT(4X,I2,7X,I10,3X,F10.4,F10.6,F10.6,4X,F10.4,F10.6,
               1                F10.6)
000044                IF(FILE.EQ.20) GOTO 999
000045             END IF
000046  10      CONTINUE
000047  999     STOP
000048          END
```

Table 2. Number of data-triplets in files 1 to 20 and first and last data-triplet

FTS-SPECTRA FROM 3290.0 TO 12510.0 A
TEST DATA READ FROM WRITTEN TAPE

FILE-NR.	NUMBER OF DATA	LDA1	INT1	CONT1	LDAZ	INTZ	CONTZ
1	164254	3290.0002	0.218948	0.229413	3999.9997	0.300062	0.335083
2	119581	4000.0044	0.297489	0.335084	4999.9969	0.311790	0.320217
3	149086	5000.0029	0.311943	0.320217	5999.9996	0.266235	0.266839
4	131127	6000.0061	0.266241	0.266839	6999.9913	0.192963	0.212930
5	110303	7000.0002	0.196547	0.212930	7999.9966	0.167945	0.170616
6	97674	8000.0057	0.167827	0.170616	8999.9968	0.077254	0.138707
7	78139	9000.0083	0.078732	0.138707	9999.9927	0.111253	0.111851
8	74339	10000.0069	0.111188	0.111850	10999.9884	0.089095	0.090105
9	65615	11000.0024	0.089128	0.090105	11999.9909	0.074709	0.075614
10	29424	12000.0075	0.074649	0.075613	12509.9836	0.067742	0.069042
11	156840	3290.0013	0.309212	0.322246	3999.9995	0.413085	0.457836
12	191426	4000.0041	0.408334	0.457837	4999.9984	0.397402	0.407710
13	147521	5000.0044	0.397815	0.407709	5999.9960	0.323753	0.324082
14	131128	6000.0026	0.323742	0.324081	6999.9948	0.235709	0.252391
15	111895	7000.0037	0.238606	0.252391	7999.9916	0.195101	0.197061
16	99141	8000.0006	0.195015	0.197060	8999.9948	0.098114	0.158027
17	96235	9000.0041	0.098185	0.158027	9999.9964	0.125368	0.125973
18	78737	10000.0080	0.125404	0.125973	10999.9873	0.099855	0.100889
19	65615	11000.0013	0.099871	0.100889	11999.9897	0.083387	0.084226
20	29424	12000.0063	0.083290	0.084226	12509.9824	0.074575	0.076212

Table 3. Numbers of original FTS-scans, from which the primary spectral data are taken (NL-No. = number used by Neckel and Labs, 1984; NSO-No. = number used by Kurucz et al., 1984)

NL-No.	NSO-No.		wavelength - limits		
(a) disk-averaged spectrum					
2	3		3290.0002	-	3678.9508
3	5		3678.9556	-	4038.8477
4	7		4038.8525	-	4748.6628
5	9		4748.6684	-	5758.4471
6	11		5758.4551	-	7527.8813
7	13	(a)	7527.8894	-	8847.5354
		(b)	8847.5466	-	10277.5470
8	15		10277.5620	-	12509.9824
(b) disk-center spectrum					
2	-		3290.0013	-	3908.9474
3	-		3908.9527	-	4138.6607
4	-		4138.6655	-	4558.6693
5	-		4558.6750	-	5798.3672
6	-		5798.3750	-	7488.1516
7	-		7488.1595	-	8967.8452
8	-		8967.8545	-	12509.9824

Table 4. Wavelength corrections for radial velocity and FTS-alignment
(a) from RV and FTS-correction given in the NSO-atlas (only for full disk spectrum)
(b) from comparison with Kitt Peak Wavelength Table of Pierce and Breckinridge

		f u l l d i s k					disk-center
NL-No.	NSO-No.	our result	NSO - atlas			this atlas adjusted to Kitt Peak Table	
		RV km/sec	RV km/sec	FTS-corr. km/sec	$\Delta\lambda/\lambda$ 10^{-6}	$\Delta\lambda/\lambda$ 10^{-6}	$\Delta\lambda/\lambda$ 10^{-6}
2	3	+ 0.216	+ 0.203	- 0.75	+ 1.8	+ 1.7	+ 1.3
3	5	- 0.054	- 0.070	- 0.75	+ 2.7	+ 2.9	- 2.1
4	7	- 0.391	- 0.398	+ 0.25	+ 0.5	+ 0.6	- 1.6
5	9	+ 0.607	+ 0.598	+ 0.15	- 2.5	- 2.5	- 1.7
6	11 SUN	+ 0.414	+ 0.406	+ 0.30	- 2.4	- 2.4	- 1.9
	ATM			+ 0.30	- 1.0	- 1.1	- 1.1
7	13 SUN	+ 0.653	+ 0.649	+ 0.30	- 3.2	- 3.2	- 2.9
	ATM			+ 0.30	- 1.0	- 0.8	- 1.0
8	15 SUN	+ 0.302	+ 0.291	0.00	- 1.0	- 1.9	- 2.0
	ATM			0.00	0.0	- 0.8	- 0.9