PHOTOMETRIC ATLAS OF THE SOLAR SPECTRUM FROM 1850 TO 10,000 CM^{-1}

I. INTRODUCTION

The infra-red solar spectrum has already been recorded and published by various authors (1.2.3.4.5). However. each of those atlases covers only a portion of the infra-red domain and. in most cases. the user must refer to various publications which present sections recorded with different instrumentation and under a wide range of conditions.

Instrumental techniques have progressed in the last twenty years. and the best Fourier transform spectrometers can now produce infra-red solar spectra with a resolution of 0.005 to 0.020 cm^{-1}, achieving a signal-to-noise ratio of a few thousand in about two hours for a bandwidth of 1500 cm^{-1} .

A few years ago we started a research program to record and publish homogeneous sets of spectra of the above quality covering the domain between 420 an.d 10.000 cm^{-1}. Ultimately three spectra will be published:

a) one recorded at Kitt Peak National Observatory (altitude 2095 meters) and considered as typical of what can be obtained from a major observatory, with a content of precipitable water of the order of 5 to 15 mm.

b) one obtained with much less water absorption. recorded at the Jungfraujoch International Scientific Station (altitude 3580 meters). On some cold winter days the quantity of precipitable water there can be less than 0.5 mm.

c) a spectrum obtained near the solar limb, also recorded with minimum atmospheric absorption.

Those results will be made available primarily in numerical form on magnetic tape. They may also be published later in the form of an atlas combining the three sets of observations. Since this program will require several years to complete, portions are being released as soon as they are ready. The first of these, the segment of spectrum a) between 1850 and 10.000 cm^{-1}, is now available in a preliminary form on magnetic tape. And the present volume is intended as a convenient guide to the contents of that tape.

II. OBSERVATIONS

These data were recorded using the McMath Solar Telescope of Kitt Peak National Observatory (6) and its associated Fourier Transform Spectrometer (7). To reduce the effect of solar granulation, spatial averaging was introduced by placing the image one meter out of focus for most of the observations. The effect of velocity fields (e.g.. the 5 min oscillation) was further reduced by the ~2 hour integration time.

The spectral region of interest for each scan was isolated either by an optical filter or by a low resolution double-pass zero-dispersion prism monochromator placed in the optical path before the interferometer. For all but two of the scans, the interferometer was operated in vacuum, so that no correction for the index of refraction was required. The lowest wavenumber region was observed with an arsenic-doped silicon photoconductor detector. Indium antimonide photodiode detectors were used in the central region. Calcium fluoride was the beamsplitter substrate for both of these regions. At the high wavenumber end, silicon photodiodes were used with a quartz beamsplitter.

Each observing run covered a wider spectral range than that which has been retained in the final record; for each run, only the region of highest signal-to-noise ratio has been kept. Fig. 1 gives (in dotted lines) the *S/N* ratio obtained for each run, and shows (in a solid line) how this ratio varies in the retained sections. The ordinate is the ratio between the local continuum intensity and the RMS of the noise (measured in zero signal regions, usually outside the filter bandpass).

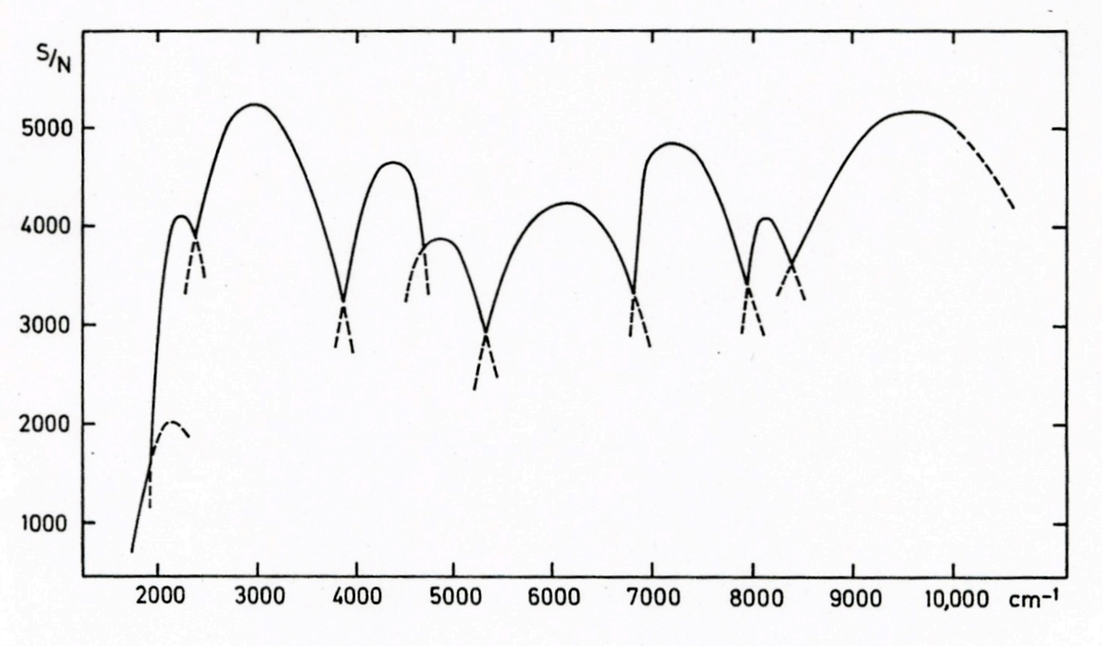

Fig. 1. The signal-to-noise ratio as a function of wavenumber.

For each section, two more pieces of information can be found on the magnetic tape (see appendix):

a) the airmass, referred to sea level.

b) the quantity of precipitable water in the path (in mm) estimated from the intensity of individual water lines of known strength (8,9).

III. DATA REDUCTION

In the first step, the Fourier transform was computed without any apodization, producing a *sinx/x* apparatus function. The spacing between successive independent points of the so obtained spectrum (spectral elements) or distance between the zero crossings of the *sinx/x*, is given on the magnetic tape for each section of the atlas (see appendix).

As a second step in the reduction procedure (not applied to the section between 8500 and 10,000 cm^{-1}) the spectrum was smoothed by convolution with a Gaussian function. The full width at half height of the Gaussian is also given on the magnetic tape. The final apparatus function is thus the convolution product of the *sinx/x* and the Gaussian function as described by these two parameters.

The vacuum wavenumber scale has been calibrated, for each section of the atlas, using N_2O and CO_2 lines. That scale is valid only for terrestrial absorption features; solar lines are displaced by Doppler shift. The correct wavenumber of a solar line can be computed by multiplying the corresponding terrestrial value by the factor called" WAVECORR ",also given on the tape. . To simplify the manipulation of the data, the spectrum has been re-sampled by interpolation at 0.004 cm^{-1} intervals. The wavelength scale on the drawings is, as usual, expressed in Angstroms in STP air.

The intensity scale has been adjusted to place the local continuum on, or very close to, the 100% line. The estimated local continuum was first drawn on a low dispersion - high resolution presentation of each section of the spectrum and then given to the computer for the correction process. Great care has been taken to avoid any discontinuity at the junction points of the different sections. The cover of this book shows a low dispersion - high resolution tracing of the entire domain.

The zero line of the drawings is shown as computed, without any correction. Close examination will show that the zero line is not always exactly at zero signal position. Such errors are very difficult to avoid in Fourier transform spectroscopy. They have, however, been kept here under 0.5 % of full scale through careful recording of the interferograms. These very small (and very smooth) displacements of the zero line have been corrected on the magnetic tape.

IV. THE MAGNETIC TAPE

As already stressed, this atlas is not intended to be used directly for research purposes; it only illustrates the contents of the magnetic tape, which contains the spectral data in numerical form (as well as other needed information). To obtain a copy of that tape, fill in and mail the form inserted immediately after the title page.

In this first version. the tape contains two files: one with the general information and the spectrum; and one containing an ANSI standard FORTRAN program showing how the contents of the tape can be extracted.

The data file is normally divided into records each containing 158 80-character card images. The first record is a "Big Information Block" (BIB) giving general information pertinent to the entire atlas. The 157th card image contains the number of spectral data records following in the file.

Each subsequent record begins with a one card image "Short Information Block" (SIB) giving information valid for that record only. The SIB contains successively the record number (I5), the wavenumber of the first data point of the record (F15.4), the wavenumber sampling interval (F10.4), the estimated signal-to-noise ratio of the continuum (Il0), the observation designation number (I5), and finally the wavenumber where the atlas switches from one observation to another (F15.4). The SIB is followed by 157 card images with 2500 intensity values, written in a (16I5) format. The scale of the data is from 0 (no signal) to 10000 (local continuum). It is possible to record 2512 data values on the 157 card images, but with a sampling interval of 0.004 cm^{-1} , 10.000 cm^{-1} require only 2500 values. The last 12 data positions on the last card image of each record have not been filled with blanks or zeroes: we have chosen instead to insert there the first 12 values of the next record, to help with some types of data manipulations which cross record boundaries. The appendix lists the first 200 card images of the file, showing the BIB followed by the first SIB and the first 656 data values.

On special order, readers who use computers which are not capable of handling records of 12640 characters may receive a tape blocked in accordance with their special needs.

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VI. REFERENCES

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L. Delbouille *J. Brault*
G. *Roland* *L. Testerman*

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