Study of solar spectra by spectroscopy

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Abstract: In this work we study the solar spectra by a monochromator. The strongest Fraunhofer lines of the Sun can easily be seen with even the most primitive spectroscope. As we move from visible to ultraviolet wavelengths the radiation originates higher in the solar atmosphere, radiation at 400 nm originates near the base of the solar photosphere, at 200 nm near the top of the photosphere, from 100 to 160 nm from the chromosphere, and less than 100 nm from the transition region and corona. Absorption lines are superimposed on the smooth continuum are absorption lines produced by different elements in the Sun's atmosphere.Spectra collecting from sun by a ½ meter, 0.3 nm resolution monochromator fitted with a photomultiplier tube shows the presence of A, B, C, D1, D2, E, F, G, H, K lines as prominent peaks during a sunny daytime.

Keywords: Solar spectra, monochromator, wavelengths, absoption line.

1. Introduction

Newton showed, sunlight is a mixture of all colors and light of all colors combined to appear white to our eyes [1]. The solar spectrum consists of a continuum with thousands of dark absorption lines superposed. The lines are called the Fraunhofer lines, and the solar spectrum is sometimes called the Fraunhofer spectrum. These lines are produced primarily in the photosphere.Absorption lines in the solar spectrum were first noticed by anEnglish astronomer Wollaton (1802) discovered dark lines in the solar spectrum. Fraunhofer (1817) rediscovered them, and noted some were not present in stars - but other stars had more. Brewster (1836) noted that the lines altered with the elevation of the sun. Now we know that each absorption line is caused by a transition of an electron between energy levels in an atom. Each element has a distinct pattern of absorption lines. Once the pattern of the lines of a particular element have been observed in the laboratory, it is possible to determine whether those elements exist elsewhere in the universe simply by pattern matching the absorption lines.

The strongest Fraunhofer lines of the Sun can easily be seen with even the most primitive spectroscope. As we move from visible to ultraviolet wavelengths the radiation originates higher in the solar atmosphere: radiation at 400 nm originates near the base of the solar photosphere, at 200 nm near the top of the photosphere, from 100 to 160 nm from the chromosphere, and less than 100 nm from the transition region and corona. When the Sun is observed from the ground, roughly half of the radiation has already been absorbed or scattered away by the atmosphere. Ozone is completely effective in removing all radiation short of 300 nm, and longward of about 1 µm large segments of the spectrum are removed by atmospheric water vapor. Hydrogen atoms in the layers of gas above the photosphere absorb photons at the wavelength of the Balmer alpha line very efficiently and these photons cannot escape very easily from the photoshphere [2].

2)The Continuum Spectrum

The basic form of the sun spectrum rising to a peak at about 450 nm. The shape is similar to a blackbody spectrum (see right), which is described by the Planck function. The form of the Planck function depends only on the temperature of the body. If the Sun were an exact blackbody, its temperature could be derived from Wien's law, $Lambda_{max}T$ = constant, or from Stefan's law, $L_{bol} = AT^4$ (where A is the area of the body, $4R^2$ in this case). As the Sun is not an exact blackbody, the temperatures obtained from these equations are only approximate: they will not be equal to each other, nor to the "physical" temperature. The most convenient observational method to derive the temperature from the continuum spectrum is to measure the ratio of fluxes (difference of magnitudes, i.e. colour index) in different wavelength bands. As hotter stars are bluer in colour (the spectrum peaks at shorter wavelengths, as seen in Wien's law), the flux ratio blue/red or blue/green (visual) will increase with increasing temperature. Because of the minus sign in the magnitude equation, the magnitude difference blue - red or blue - green (visual) will decrease with increasing temperature. To get an exact map from flux ratio or colour index to temperature, we need to use information from theoretical models. The temperature derived in this way is called the colour temperature.

3) The Absorption Lines

Absorption lines are superimposed on the smooth continuum are absorption lines produced by different elements in the Sun's atmosphere (**Fig. D5**). The strongest lines in the Sun's spectrum are the so-called H and K lines due to ionized calcium: the nine brightest lines A,B,C,D,E,F,G,H,K in order from the red end of the spectrum). The relative strengths of lines from ionised and neutral calcium (or other elements) can be used to calculate the ionisation temperature of the Sun.

Stars are divided into spectral classes on the basis of their absorption lines. The Sun is a class G star. Class G is characterised by weak hydrogen lines, comparable in strength to some metal lines, and strong H and K ionised calcium lines, which reach maximum strength in this class. Moving down the class from G0 towards K0, neutral metal lines increase in strength while ionised metals diminish, and molecular bands from the strongly bonded molecules CH and CN become strong. The CH band is Fraunhofer's G.

4) The experiment

The experiment was carried out with the spectrometer describe elswhere [3,4] with the fibre-slit coupler for focusing the solar radiation. Good intensity spectra at minimum 10-micron slit-width were obtained for maximum resolution of the peaks, which depicts that spectra were intense.

5) Results and Discussion

Different absorption lines detected with the help of the spectrometer are shownin **Figs. D1-D5.**H_α, hydrogen Balmer (C) at 656.2 nm **(Fig. D1)** is found at higher side of wavelength scanning range (650-660 nm) of the monochromator whileterrestrials oxygen band (B) found in the range 686.7 nm– 688.4 nm **(Fig. D2)**. Hydrogen Balmer line H_β (F) at 486.1 nm (**Fig. D3**) has 0.98 nm FWHM. Magnesium lines (b-1, 2) occur at 518.4 nm & 517.3 nm with a neutral line of Fe at 527.0 nm **(Fig. D3)**. Low intense doublet of neutral sodium lines Na I (D1, D2) at 589.6 nm and 589.0 nm are found and shown in **(Fig. D4)**. Bands of terrestrial oxygen (A) found in the wavelength range 759.4 nm (FWHM=2.06 nm) – 762.1 nm] and B [686.7 nm (FWHM=1.41nm)– 688.4 nm] taken together in this plot. FWHM of bandhead of O_2 (B) is greater than that of H_β (F).

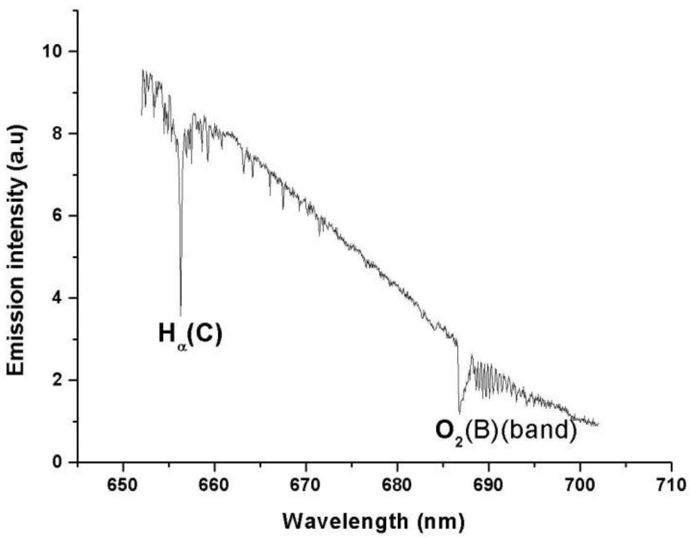

Fig. D1 Hydrogen Balmer absorption line (C) at 656.2 nm and terrestial oxygen band (686.7 nm– 688.4 nm) with 1.24 nm FWHM

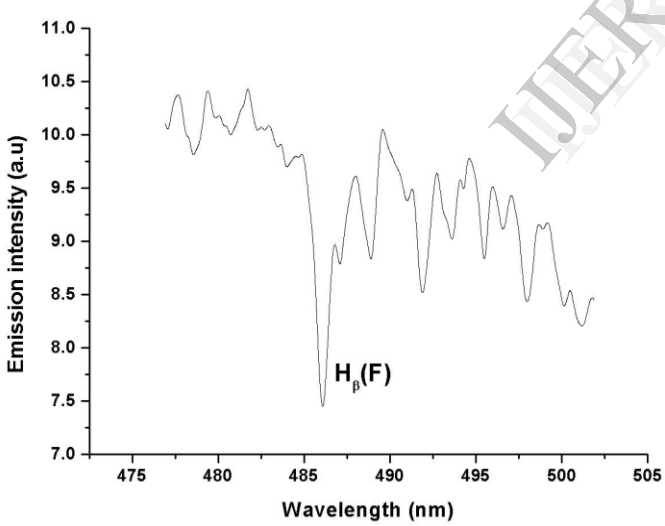

Fig. D2 Hydrogen Balmer absorption line (F) at 486.1 nm with 0.98 nm FWHM

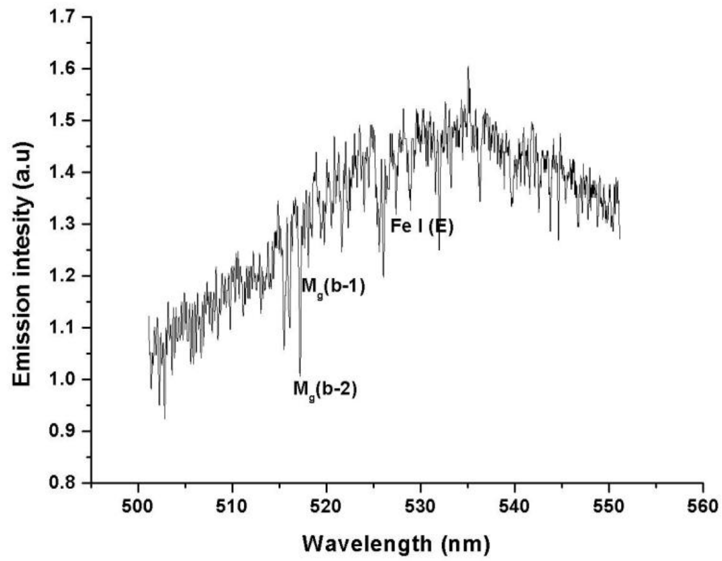

Fig. D3 Magnesium lines (b-1,2) at 518.4 nm & 517.3 nm and neutral line of Fe at 527.0 nm

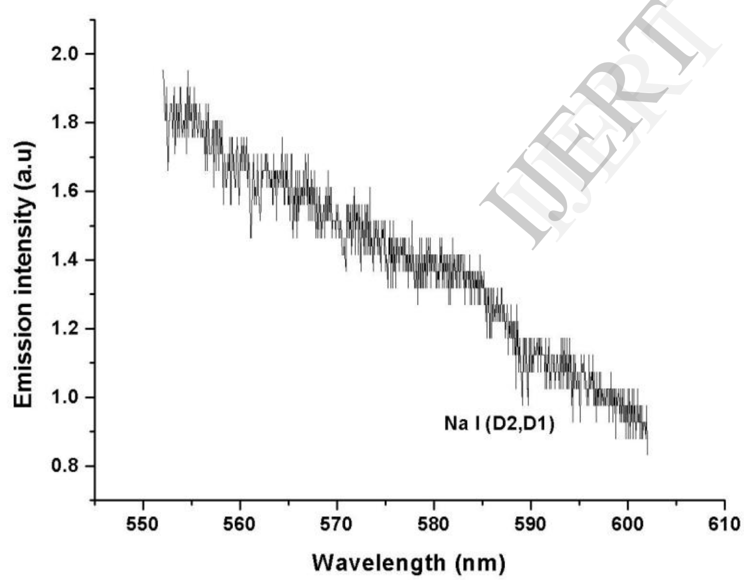

Fig. D4 Neutral sodium lines Na I (D1,D2) at 589.6 nm and 589.0 nm

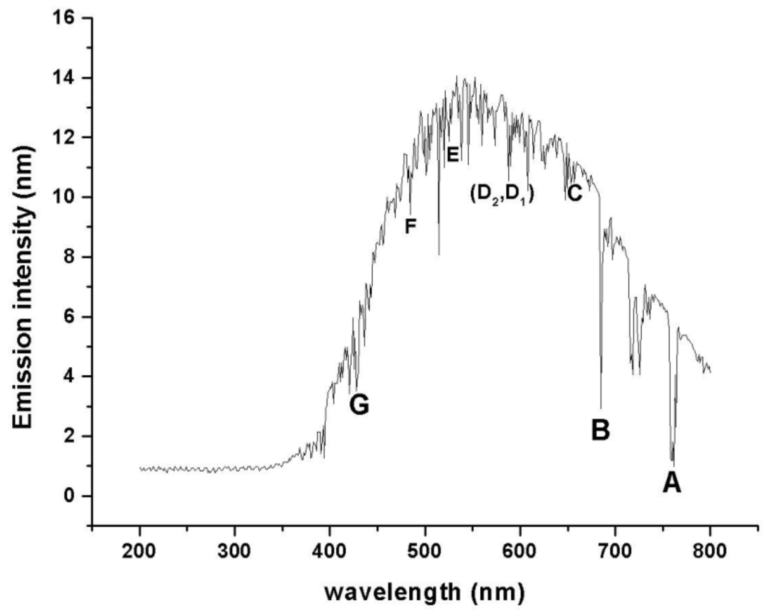

Fig. D5 Solar spectra and various absorption lines (**Table D.1**)

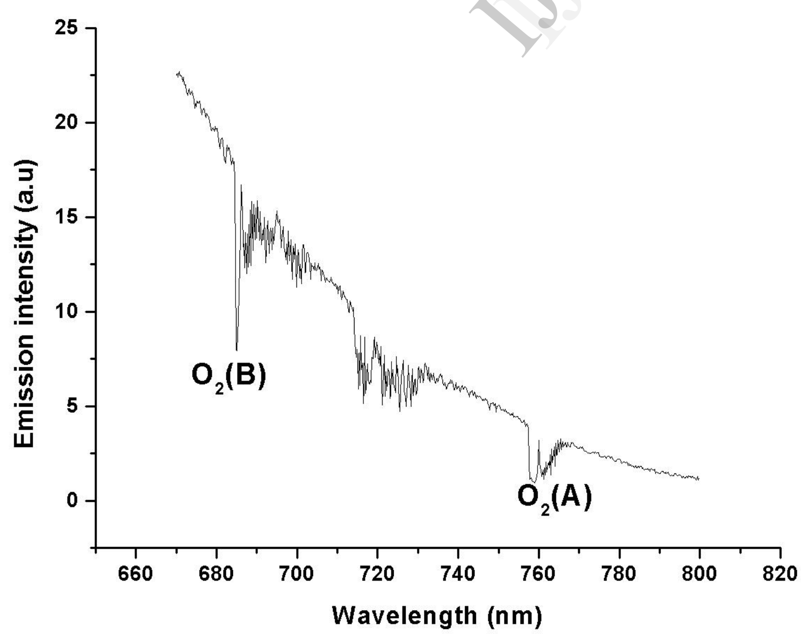

Fig. D6 Absorption lines (**Table D.1**) Bands of terrestrial oxygen A [759.4 nm (FWHM=2.06 nm) – 762.1 nm] and B [686.7 nm (FWHM=1.41nm)– 688.4 nm]

Table D.1 – Absorption lines		
A	759.4	terrestrial oxygen
B	686.7	terrestrial oxygen
C	656.3	hydrogen (Hα)
D_1	589.6	neutral sodium (Na I)
D_2	589.0	neutral sodium (Na I)
E	527.0	neutral iron (Fe I)
F	486.1	hydrogen (H_β)
G	430.4	Fe and Ca
H	396.8	ionized calcium (Ca II)
K	393.4	ionized calcium (Ca II)

Table D.1 List of lines observed in solar spectra

6) Conclusion

Spectra collecting from sun by a ½ meter, 0.3 nm resolution monochromator fitted with a photomultiplier tube shows the presence of A, B, C, D1, D2, E, F, G, H, K lines as prominent peaks during a sunny daytime.

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