Spectra, Surface Temperature, and Surface Composition of Main Sequence Stars

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Abstract

We study spectra, surface temperatures, and surface compositional elements of 44 stars from the Sloan Digital Sky Survey (SDSS). The sample can be categorized based on their observed surface temperatures into 4 spectral types: A, F, G, and K, along with 11 very hot and very cool stars that can not be categorized by this method. Spectral type A, F, G, K has 1, 21, 4, and 7 stars, respectively. Elements that are observed in all stars are hydrogen and iron. The Hα, Hβ, Hδ, and Hγ are observed prominently in all spectra. We also present findings on other elements in each spectral type.

Methodology

We select spectra of 44 stars from the Data Release 7 of the Sloan Digital Sky Survey (SDSS) using SDSS SkyServer (*http://cas.sdss.org*). Using the SDSS SkyServer's SQL interface, we obtain their apparent magnitudes in *u, g, r,* and *i* filter, centering at ultraviolet, green, red, and infrared, respectively. We then calculate the color indices of these stars by subtracting apparent magnitudes in green and red ($g - r$) and sort the sample by their $g - r$ color indices. This allows us to analyze spectra of stars in the spectral order of the main sequence stars from O, B, A, F, G, K to M. We use the *VisualSpec* software (*http://www.astrosurf.com/vdesnoux*) to view the FITS file of SDSS spectra to find the wavelength of blackbody peak and categorize stars into spectral types by determining their surface temperature with Wien's displacement law given by $T\,[K] = 0.0029\ m / \lambda_{max}$, where λ_{max} is the wavelength of blackbody peak. We use information in table 1 to categorize surface temperature found into spectral types of main sequence stars.

Table 1. Spectral type, temperature, and wavelength of blackbody peak in main sequence stars

Spectral Type	Temperature (K)	Blackbody Peak Wavelength (nm)
O	> 30000	shorter 97 (Ultraviolet)
B	30000 – 10000	97 – 290 (Ultraviolet)
A	10,000 – 7,500	290 – 390 (Violet)
F	7,500 – 6,000	390 – 480 (Blue)
G	6,000 – 5,000	480 – 580 (Yellow)
K	5,000 – 3500	580 – 830 (Red)
M	< 3,500	longer 830 (Infrared)

After categorizing 44 stars into spectral types, we consider spectra of star in each spectral type and analyze their surface composition by identifying absorption lines in the spectra with *VisualSpec* software. The *VisualSpec* software provides a database of spectral lines measured in laboratory and their relative intensities. In this way we can find every possible spectral line (as measured in laboratory) automatically at any given wavelengths. But to identify the elements responsible for producing the absorption lines from the pool of many possible candidates we also consider possibility of occurrence of the elements by considering the relative abundance of elements in the solar system (*http://media4.obspm.fr/exoplanets/pages_outil-atomes/elements.html*) and assume the same abundance in the star and our solar system. That is, if two candidate elements for one line exist, we associate the line with the element with greater relative abundances.

Results

- **Spectral type A: 1 Star.** Very strong hydrogen absorption lines, namely Hα, Hβ, Hδ, and Hγ with very little absorption lines of other elements (Fig. 2a).
- **Spectral type F: 21 Stars.** Most prominently hydrogen, but also observed are iron, calcium, nitrogen, magnesium, silicon, helium, oxygen, nickel, sulfur, carbon, chromium, and neon (Fig. 2b)
- **Spectral type G: 4 Stars.** This is the sun-like stars. We found that a majority of absorption lines are iron and also is calcium, oxygen, nitrogen, chromium, magnesium, neon, sulfur, hydrogen, helium, silicon, carbon, cobalt (Fig. 2c)
- **Spectral type K: 7 Stars.** K-stars have the largest number of absorption lines. We found that most lines are iron and also calcium, oxygen, nitrogen, sulfur, neon, silicon, carbon, magnesium (Fig. 2d)

Unknown spectral types. Due to the limited spectral range of SDSS from 3,800 – 9,200 Angstrom star, with peak wavelength of blackbody emission shorter than 3,800 Angstrom or longer than 9,200 Angstrom, very hot stars and very cool stars, respectively, can not be categorized into spectral types using our method. This is the reason that spectral type O, B, and M have no identified sample among our sample of 44 stars.

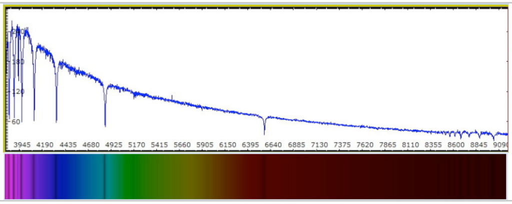

Fig. 2a. Spectrum of A star

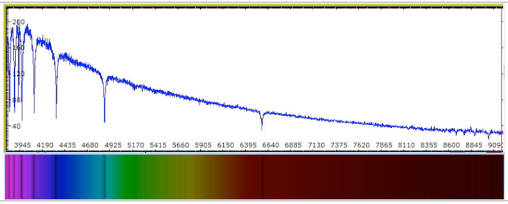

Fig. 2b. Spectrum of F star

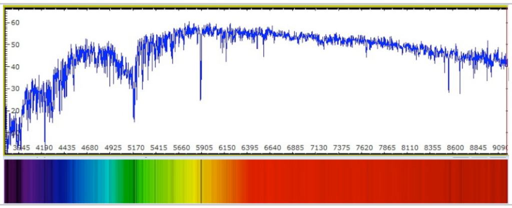

Fig. 2c. Spectrum of G star

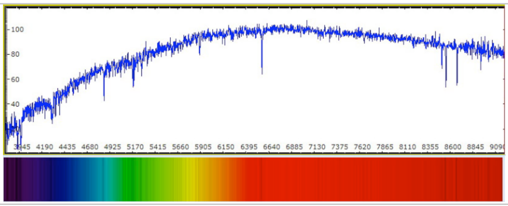

Fig. 2d. Spectrum of K star

Fig. 2. Example spectra of A, F, G, and K from SDSS

Conclusion

We select 44 stars with spectra from the SDSS database, determine their color indices to sort our sample by spectral type, categorized stars in to spectral types using the observed peak wavelength of blackbody emission, and identify elements producing absorption lines in their spectra. This yields the surface elements of each type of the stars. Hydrogen and iron are the most prominently observed elements on all types of stars in our sample. Additionally, calcium is observed in F, G, and K stars along with oxygen and other elements with lower relative abundances.