Spectral type for Star SAO 124848 is F0V

Changling Li, Aidan Sweeny, Maitri Dalal

Department of Physics and Astronomy,

Colby College, Waterville, Maine 04901, USA

(Dated: October 19, 2019)

Abstract

We investigate the apparent magnitude, color indices, spectral type and temperature of target star SAO 124848 based on the images taken by Colby College's Young Telescope through differential photometry to check the accuracy of the SAO catalog. We compare our target star with a calibration star SA 111-773 in the same field whose V-band magnitude is 8.965 and B-V color index is 0.209 to generate the properties of the target star. Our results show that our target star has a V-band magnitude of 9.17 which is close to the published measurement which is 9.19. The color index B-V is 0.30 which is slightly different from the published value which is 0.26. We newly calculated the color index V-I and V-R which are 0.35 and 0.15. The spectral type is determined to be F0V with comparison with the Vilnius spectra of Bessell (1990) which is different from the published value A0V. The disagreement may due to the non-photometric weather condition and the accuracy of the telescope. Considering these possible, our results roughly agree with the published values.

Introduction

The properties of stars indicate important information about them and contribute to further studies. For example, we use their spectral type to categorize them and the spectral type of a star gives us important information such as the temperature of the star and its life circle. Many properties such as apparent magnitude, color indices and spectral type can be calculated by comparing the target star with a standard star from the same field observed from the telescope whose properties are well known. In this investigation, we choose SAO 124848 as our target star. The target star has Right Ascension 19h37m00.76s and Declination +00:08:16.35. According to Simbad[1], the V magnitude is 9.19 (Houk et al. 1999) and B-V color index is 0.26 (Houk et al. 1999). The spectral type of it is A0V (Houk et al. 1999). We exam the accuracy of the provided information by finding its apparent magnitude, color indices, and spectral type using Colby College's Young Telescope with the new photometric measurements. The standard star we chosen is in the same observing field which is SA 111-773[2]. The Right Ascension of the standard star is 19h37m15.83s and the Declination is +00:10:58.25. It has V magnitude of 8.965 (Landolt et al. 2009), B-V color index of 0.209 (Landolt et al. 2009), V-I color index of 0.265 (Landolt et al. 2009), and V-R color index of 0.121 (Landolt et al. 2009). The spectral type is B7/9 III (Houk et al. 1999). By analyzing the target star and finding its apparent magnitude, color indices, spectral type, we compare our results with the published ones and provide more information about this star such as the V-I and V-R color indices.

[1] http://simbad.u-strasbg.fr/simbad/sim-basic?Ident=sao+124848&submit=SIMBAD+search
[2] http://simbad.u-strasbg.fr/simbad/sim-basic?Ident=SA111-773&submit=SIMBAD+search

Observation and Data Reduction

Observation

We operated our observation at 8:35pm September 12th, 2019. The weather condition is non-photometric. The altitude of our source is +45°. Data were obtained at Colby College's Young Telescope, a Planewave 0.7m Corrected DallKirkham design with f/6.5. Images were taken using a Finger Lakes Instruments back-illuminated 2k x 2k CCD equipped with Cousins BVRI filters as specified by Bessell (1990). We used 5s exposure for both I and V filter, 15s for B filter and 3s for R filter. The field taken is in size 23 arcminutes x 23 arcminutes. Three images were taken for each filter and used for reduction and data processing.

Data Reduction

To process the image for analysis, a mathematical way of producing the final processed image is shown in the following:

$$Final\ image = [(Raw\ image) - (Avg\ dark)] \times \frac{mean\ value\ of\ (Flat - Avg\ dark)}{(Flat - Avg\ dark)} \qquad (1)$$

We used Jupyter Notebooks to reduce the image by subtracting the average dark which is the thermal noise from free electrons moving around in the semiconductor of the CCD and the electronic noise related to reading out the detector. Then, we divided our star images by a normalized flat. After the image reduction, we combined all the images taken in given filter into a single image for analysis. One of the reduced images is shown in figure 1.

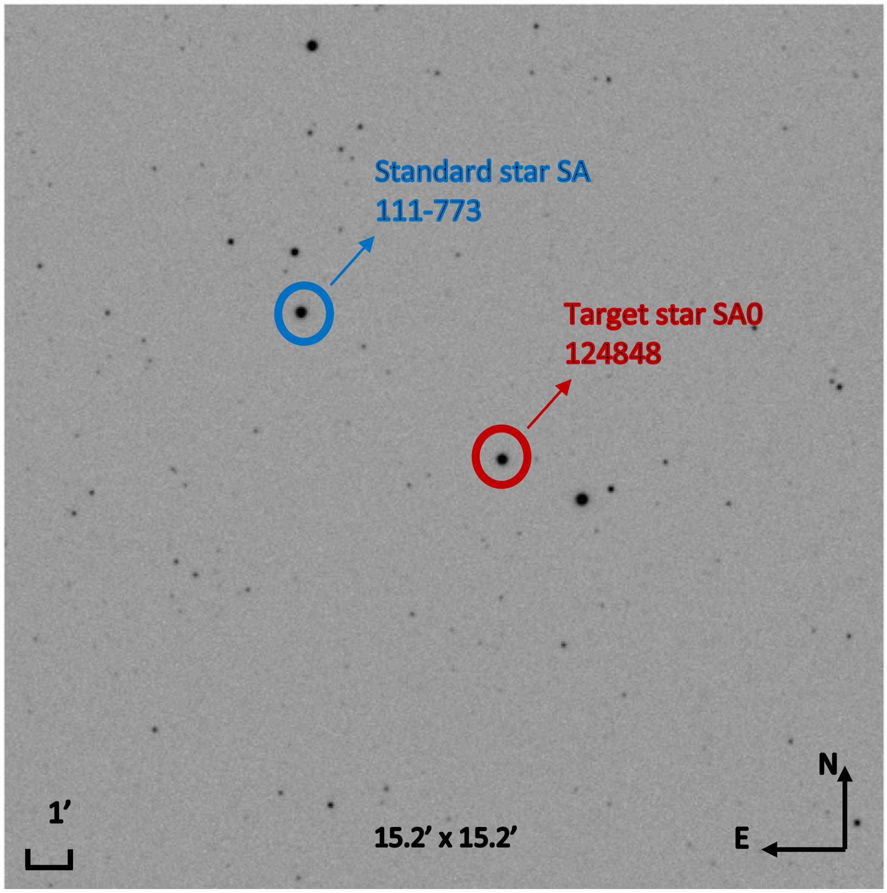

Figure 1. The reduced image of filter V with exposure time 5s. The size of the field is 15.2 arcminutes by 15.2 arcminutes. The standard star SA 111-773 is circled in blue and the target star SAO 124848 is circled in red. The RA of the target star is 19h37m00.76s and the Declination is +00:08:16.35. The scale is indicated on the left bottom corner and the direction is indicated on the right bottom corner.

To obtain the apparent magnitude of our target star and thus the color indices and spectral type, we use differential photometry by comparing the brightness of our target star to the standard star. Brightness for both stars were measured in all four filters. According to the equation for apparent magnitude

$$\mathrm{m} = -2.5\log F + C \tag{2}$$

to find the zeropoint C, we need to obtain the linear brightness measure F which is the number of photons our CCD camera registers. In order to count up all the photons, we use a circular aperture whose radius is large enough to include all the starlight but small enough that it does not include too much background sky light to define the edge of the star. The aperture radii for all four filters is 10.05 arcsec. The total counts in the aperture contain both starlight and background sky. Therefore, we need to subtract the background sky level for which we defined an annulus around our star that is free from starlight in order to measure pure sky. A graph for the aperture and annulus is shown in figure 2:

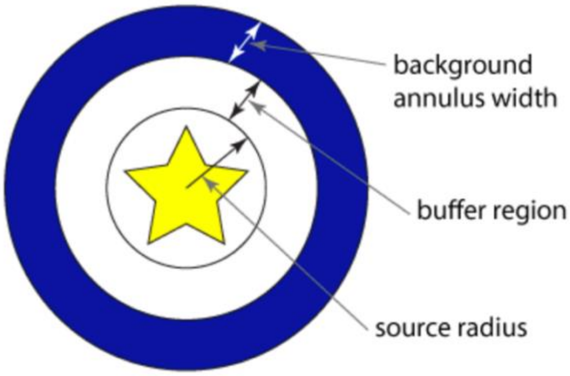

Figure 2. The graph for the aperture and annulus. The source radius is the aperture radii which is 10.05 arcsec. The buffer region is to create a buffer zone as to not have starlight in the annulus. The blue region is the annulus where the background sky level is measured.

The aperture photometry measurement indicates for the standard star, the flux counts with corresponding filters as shown in table 1.

Calibration (Standard) Star	
Color	Flux(counts)
V	903280.83
B	1470371.74
R	670390.39
I	425953.59

Table 1. The flux counts with corresponding filters for the calibration(standard) star.

In addition, as different telescopes and CCD cameras have different response to colors, we used a transformation coefficient to correct the zeropoint based on the color of our source and the response of our system. The transformation coefficients help us determine the true magnitude and color of the star. These transformation coefficients are determined for our system by Professor McGrath, by observing standard star fields over many nights. The equations for correction of zeropoint for each filter are listed below:

$$C_{vi} = (V - I) - T_{vi} \times (v - i) \qquad T_{vi} = 0.9727 \tag{3}$$

$$C_{vr} = (V - R) - T_{vr} \times (v - r) \qquad T_{vr} = 0.9832 \tag{4}$$

$$C_{bv} = (B - V) - T_{bv} \times (b - v) \qquad T_{bv} = 1.0765 \tag{5}$$

$$C_{v} = V - v - T_{v} \times (V - I) \qquad T_{v} = -0.0322 \tag{6}$$

where C is the zeropoint correction. Capital letters are the known magnitude of our star in a given filter and lowercase letters are the instrumental magnitudes from measured value without any zeropoint. T are the transformation coefficients. The result for each zeropoint C with corresponding color or color index is shown in the table 2.

Determination of Zeropoint correction	
Color or Color index	Zeropoint correction, C
V-I	1.06
V-R	0.44
B-V	0.78
V	23.87

Table 2. The zeropoint correction C with corresponding color or color index deduced from the measurement of calibration(standard) star.

After calculating the zeropoint correction, we repeated the aperture photometry measurement for our target star with the same aperture radii which is 10.05arcsec. The flux counts with corresponding filters are shown in the table 3.

Target Star	
Color	Flux(counts)
V	751212.80
B	1136164.29
R	569023.77
I	382855.06

Table 3. The flux counts with corresponding filters for the target star.

With the obtained zeropoint correction and transformation coefficient, we use the equations (3), (4), (5), and (6) to calculate the apparent magnitude and color indices of our target star. We then use each value of the color indices calculated to estimate a spectral type for the star by referring to Vilnius spectral of Bessell(1990).

Result and Discussion

For our target star SAO 124848, we calculated a V-band magnitude of 9.17, a B-V color index of 0.30, a V-R color index of 0.15 and a V-I color index of 0.35. From the color indices and comparison with the Vilnius spectral of Bessell(1990), we determined that the star has a F0V spectral type. Our V-band magnitude is close to the published value which is 9.19 with a difference of 0.02. The B-V color index is slightly different from the published value which is 0.26 with a difference of 0.04. The spectral type is also different from the published one which is A0V. The disagreements may be due to the weather condition as the observation happened on a non-photometric night which can cause a lower measurement on V-band magnitude and thus results in higher value in B-V. One way to check this is to check the magnitude of another known star in the same field or take the data on a different day or different time in the same night to compare the value. In addition, our telescope may not be as accurate and thus the value and image taken may have some errors. One way to improve this is to use a different telescope from a different site which may be hard to achieve.

Reference

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