# CREATION OF AN ENHANCED TRUE-COLOR IMAGE OF EMISSION NEBULA NGC 7635

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## Abstract

In this investigation, we observe nebula NGC 7635 and create the RGB color image based on the images taken by Colby College's Young Telescope. We assign image taken in H-alpha filter as red, R filter as green and V filter as blue and find the weights of each filter using the color balance star SAO 20581 which is in the same observation field and has spectral type G. We found that the nebula NGC 7635 to be red overall which indicates its type which is an emission nebula and it is mostly composed by hydrogen. However, the color balance star does not appear to be white in this image which is due to the adjustment of minimum level of each filter for the best visual result of the nebula and the different sensitivity towards the starlight of each filter.

## Introduction

A nebula is a cosmic cloud of gas and dust floating in space[1]. The color of the nebula indicates the atom composition of the gas cloud as well as the type of the nebula. For example, a nebula with red color is most likely to be an emission nebula. An emission nebula is a gas clod that has been ionized by the radiation from nearby stars. The colors in emission nebula come from different elements within the gas. As electron falls back down from the ionized state to the ground state, they give off a photon of frequency corresponding to a difference in energy between the two states. Because of the abundance of hydrogen in emission nebulae, the color tends to be red.

However, due to the restriction of the wavelength range by inserting filters in front of the CCD cameras of the telescope, the enhanced true-color image cannot be directly obtained. Thus, we need to combine images taken from three different filters that are assigned with different RGB colors post-processing into an RGB image.

In this investigation, we choose to create the enhanced true-color image of an emission nebula NGC 7635 which is also known as the Bubble Nebula. As it is an emission nebula, it is expected to be in red overall.

## Observations and data reduction

### Observation

[1] http://www.seasky.org/celestial-objects/nebulae.html

We operated our observation at 8:05pm September 18th, 2019. The weather condition is almost photometric. Necessary information of the target nebula NGC 7635 is listed in Table 1.

**Table 1**. The values of the properties of the nebula from SkyX. The Right Ascension in epoch 2000.0 is 23h20m44.997s and the Declination in epoch 2000.0 is 61°12'41.989''. The V magnitude is 6.5. The apparent size is approximately 20 arcminutes x 15 arcminutes.

| Property | Value[2] |
|---|---|
| Right Ascension (epoch 2000.0) | 23h20m44.997s |
| Declination (epoch 2000.0) | 61°12'41.989'' |
| V magnitude | 6.5 |
| Apparent size | 20 arcminutes x 15 arcminutes |

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 300s exposure for H-alpha filter, 60s exposure for R filter, and 120s exposure for V filter. For each filter, one image is taken for processing. The field taken is in size 25 arcminutes × 25 arcminutes.

## Data Reduction

We create the RGB image of the nebula by assigning the filter with the longest wavelength to be "red", the filter with the next longest wavelength to be "green", and the filter with the shortest wavelength to be "blue". In this investigation, the H-alpha filter is set to be "red", the R filter is

[2] Values obtained from software SkyX

set to be “green”, and the V filter is set to be “blue”. To have the final image of each filter for creation of the RGB image, a mathematical way of producing the final processed image is used and the equation (1) is shown in the following:

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

We reduce the image, firstly, by subtracting the average dark with the same exposure time as the filter. Dark 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. Afterwards, we divide our star images by a normalized flat. Flat frames indicate how the pixels in the detector respond to a uniform light source and can be used to correct for areas of the detector that are less sensitive than other areas, including the vignetted corners and regions where dust grains are present. Then, we register the nebula images to have the images aligned. One image is chosen as the reference image and a reference star near the center of the image is used as the indication for alignment. In each image, the centroid of the reference star is found and the shifts in x and y of the reference star in other images comparing to the reference image are calculated. Applying the found shifts, we align other images with the reference image to get the final image for each filter.

Then we use a chosen color balance star to find out the proper weight for each filter. The color balance star we chose is SAO 20581 which is in the same observing field as the nebula and it has a G spectral type. The reason why we choose a star with G spectral type is that the Sun has a G spectral type and human eye sees this as white light. We let the G-typed color balance star have equal amounts of red, green, and blue light and then count up the flux of the star in each of three filters to figure out the multiplicative factor in order for the fluxes to be equal. We take the filter with the largest flux and assign this a normalization of 1 and find the weights of other two images by dividing the highest flux value by the flux value of each. The weight of R filter image is set to be 1, the H-alpha filter is calculated to be 10.49 and V filter to be 2.05. Then we apply the weights to the nebula image to create the final color image.

To produce the final color image, we use the method of Lupton et al.(2004). and adjust the minimum level for each filter.

## Result and Discussion

The final color image of nebula NGC 7635 is shown in figure 1.

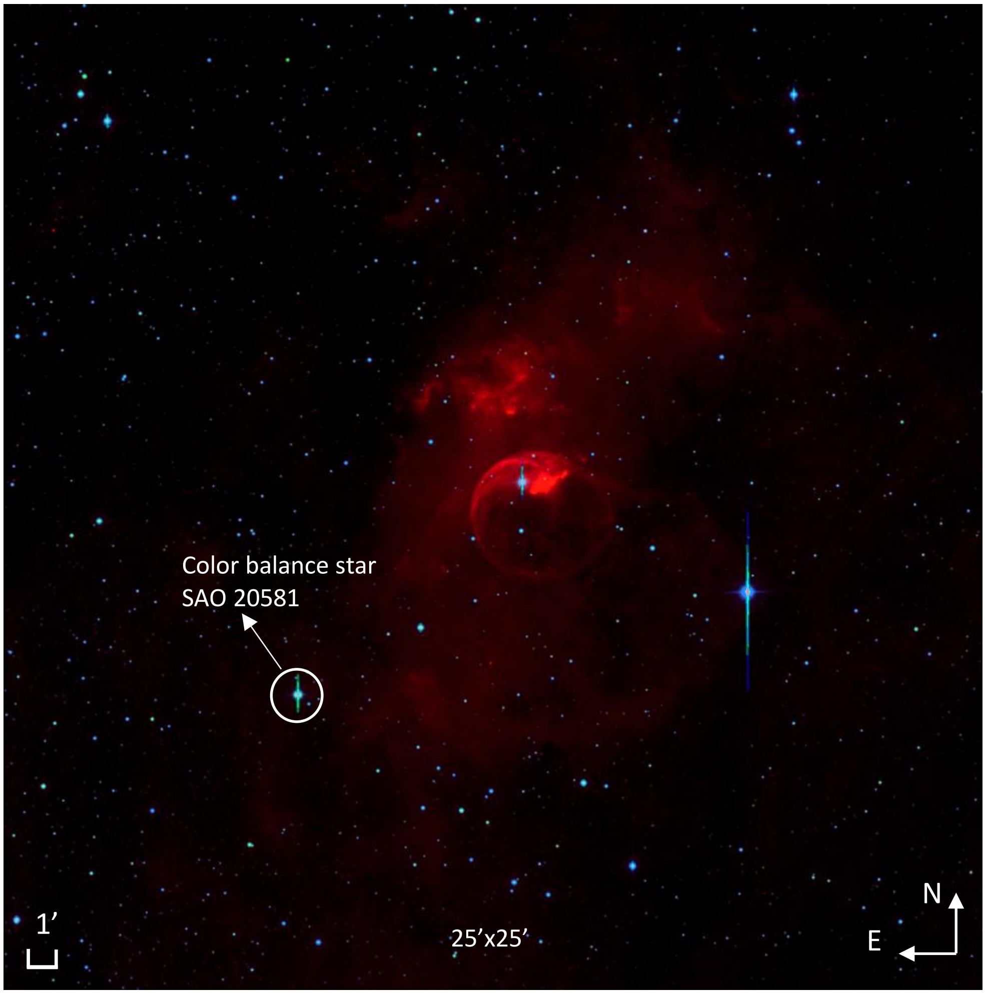


**Figure 1**. The color image of the nebula NGC 7635. The nebula appears to be read which indicates it is an emission nebula. The color balance star SAO 20581 is circled on the figure. The size of the field is 25 arcminutes x 25 arcminutes. The scale is indicated on the left bottom corner and the direction is indicated on the right bottom corner.

As shown by the image, the nebula is mostly red which means that it is an emission nebula and most of the atoms composing the gas cloud is hydrogen. The red light is from the Ha transition of the electron of hydrogen. At the center of the nebula, a greenish-blue star is shown which may be a newly formed star and that region can be a star forming region. Our color balance star is not appearing to be white here which is due to the adjustment of the minimum level of each filter for the best visual result of the nebula. This may make our generated color image differ from the actual color of the nebula. It indicates that it can be difficult to produce an image that is not only visually beautiful but scientifically useful using our method as it is hard to achieve a better result by adjusting the RGB components. In addition, it can also be because we used H-alpha filter which is a narrowband filter and it is not particularly sensitive to star light, in order to enhance features in our nebula. Some stars are also shown to be saturated which is also due to the different sensitivity of light of some filters. This may be corrected if we try different filters with different exposure time or take multiple images using the same filter.

In conclusion, our final color image roughly presents the color of the nebula and indicates some features of it considering the possible errors of the adjustment of the color and the different sensitivities of the filters.

## Reference

Lupton, R., Blanton, M. R., Fekete, G., Hogg, D. W., O'Mullane, W., Szalay, A., Wherry, N. 2004, PASP, 116, 133