Publications of the Korean Astronomical Society
30: 757 ∼ 759, 2015 September

pISSN: 1225-1534
eISSN: 2287-6936
http://dx.doi.org/10.5303/PKAS.2015.30.2.757

A HANDY SPECTROGRAPH AND ITS APPLICATION IN ASTRONOMICAL EDUCATION

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(Received November 30, 2014; Reviced May 31, 2015; Aaccepted June 30, 2015)

ABSTRACT

I use a common educational spectrographic device (SV2100R) in order to obtain astronomical spectra after inventing a new adaptor for telescopes. Experimental classes and learning projects in schools and public outreach are well established regarding imaging and photometry observations. However, experiments using astronomical spectrographs are rather hard to find because the procedures of spectral extraction and wavelength calibration is less convenient. SV2100R is a 1D CCD array and thus has the advantage of not requiring spectral extraction. In addition, basic wavelength calibration is preformed by the the provided software. It was adapted to a 12-inch reflecting telescope in the Korea Science Academy of KAIST in Busan and a spectrum of the bright object, Arcturus, was successfully obtained. This means one can provide educational programs on the topic of astronomical spectra. A few suggested projects are presented.

Key words: Spectroscopy; adaptor; education

1. INTRODUCTION

Light gives important information and spectra play a key role in investigating stellar temperatures, chemical compositions and relative motions. Electromagnetic radiation is one of main objectives of education in astronomy as well as for Newton dynamics. Introductory astronomy often teaches about spectral properties, Doppler shift, Wien's law, Stefan-Boltzman's law, and Kirchhoff's law (Bardar & Brecher 2008; Slater et al. 2001).

Major learning objectives are 1) having an intrinsic interest in science, 2) developing critical reasoning skills and 3) understanding nature. Self-motivated learning is thought to be an effective learning process and project based education is becoming important, as well as lecture-based methods. Handling telescopes in astronomical observatories is a good tool for active learning in astronomy. Most educational programs using telescopes for imaging or photometric observations at universities, schools for science and public outreach in astronomical centers. Understanding and experiments for electromagnetic spectra have an important role in education for introductory astronomy. The development of spectroscopic experiments using telescope will be helpful for developing knowledge of light and electromagnetic spectra for both introductory astronomy and self-motivated science projects.

In schools, universities and public outreach programs, the prism or grating film is normally applied to observe the spectrum of light sources. It is straightforward, however it is not recordable. If the grating film is combined with a DSLR camera, the spectrum could be easily recorded and spectra extracted. In this case, spectral extraction and wavelength calibration are required for data reduction. Recently, an astronomical spectroscopic device has been made for education in terms of learning the structure of the device and the detection of astronomical spectra Lee et al. (2013).

As a result of the importance of spectral education in astronomy, I developed astronomical spectroscopic observations in education using a commercial spectrograph attached to the telescope using a new adaptor. The spectroscope has been widely used for educational purposes, and is normally used in chemistry projects or labs. The new adaptor fixes the spectroscope to the telescope and makes detection through the telescope easy. It has obtained spectra of reflected sunlight from bright planets and bright stellar spectra.

2. SPECTROSCOPIC DEVICE WITH NEW ADAPTOR

The educational spectroscopic device, SV2100R, manufactured by K-Mac, has been used. It contains a grating of 600 lines/mm and uses a 1-D CCD array of 2,048 pixels. Wavelength coverage is 250 ∼ 800 nm and has a spectral resolution better than than 1nm. There is no need to extract spectra from the spectral image because it is already a 1D array. The provided software makes it easier for to carry out reduction in terms of spectral extraction and wavelength calibration. Due to the 1D array, there is no need to extract the spectrum from the

Figure 1. New adaptor to install spectrometer into telescope.

Figure 2. Installed spectrometer in a 5-inch refractor telescope.

image. Furthermore it provides its own spectral reference and calibrated wavelength in situ. This makes the data reduction easier and is a key point in its application for education.

A new adapter for the device has been developed in order to fix the spectroscopic device into a telescope having a 2.5-inch diameter tube (Fig. 1). It has been manufactured by AstroDreamTech (2011) and Fig. 2 shows the installation. The device now can be applied to astronomical uses in addition to general education purposes.

3. DETECTION OF SPECTRA

Astronomical spectra have been obtained of the moon and a bright star using a 5-inch refractor and 12-inch reflector respectively. The observatory is located at our school in Busan, the 2nd biggest city in Korea. The Moon is bright enough to detect the spectrum using a

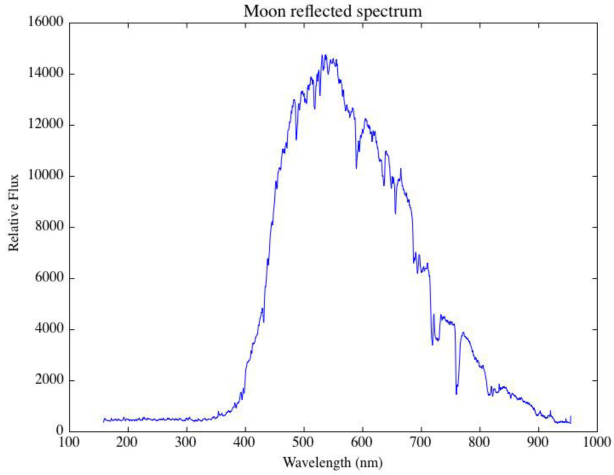

Figure 3. The spectrum of the Moon. Exposure time of 500 msec.

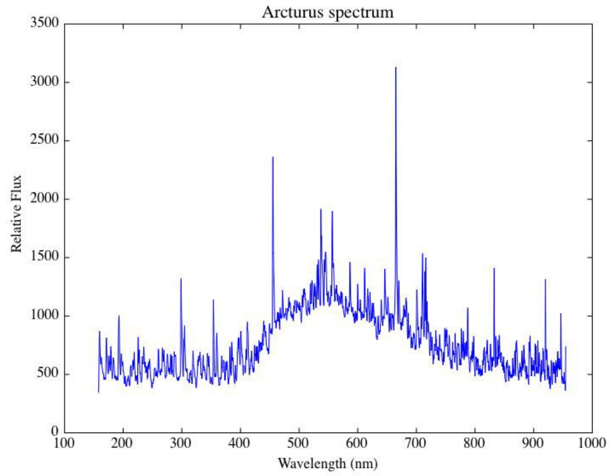

Figure 4. The spectrum of Arcturus. Exposure time of 1500 msec.

5-inch telescope (Fig. 3), however a 12-inch reflector is required to obtain a spectrum of the bright star, Arcturus (Fig.4). Telluric emissions are present in the stellar spectrum and it has been reduced using a spectrum of the empty sky (Fig. 5, 6).

The spectra show continuum emission over a wide range of visible wavelength as well as absorption lines. Continuum spectra could represent a black body radiation curves data reduction in terms of intensity is carried out properly. Absorption lines can be analyzed for chemical and physical properties.

4. APPLICATION IN EDUCATION

One can detect the reflected sunlight of planets in our solar system and the contina of bright stars using small telescopes. It successfully obtains absorption lines superimposed on continuous spectrum in the most of the visible wavelength range. In terms of education, students are able to obtain astronomical spectra easily

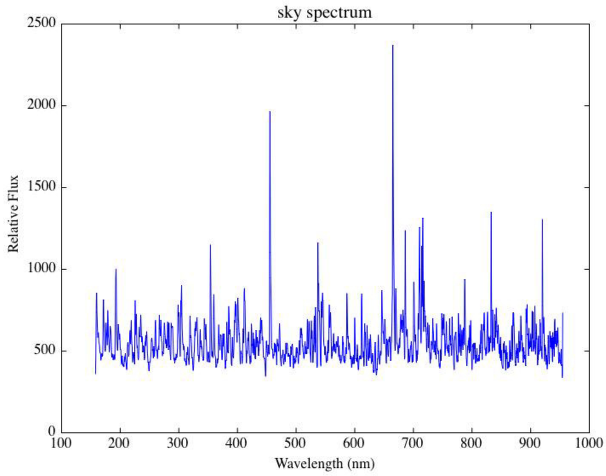

Figure 5. Sky Spectrum. Exposure time of 1500 msec.

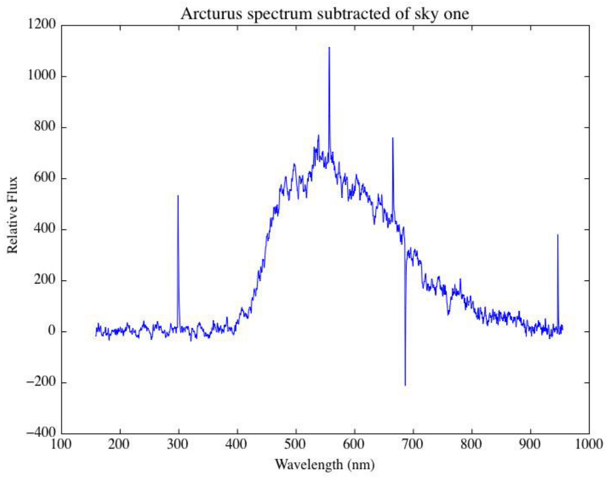

Figure 6. Sky subtracted spectrum

and to analyze these spectra. In universities, schools, and public/private astronomical observatories, instructors can develop learning programs in the area of spectroscopy.

Project-based learning or term-projects are a useful form of learning. Our students have raised their own research questions for which they can use astronomical spectroscopy. Two projects are introduced in this conference proceedings. One is the comparison of spectra between jovian and terrestrial planets (Lee & Song 2015) and the other is an extraction of Mars's red color from its spectrum (Lee et al. 2015).

There are two difficult issues with this spectroscopic device. 1) I assume the spectra obtained are from the brightest source in the field of view. This ambiguity should be considered when taking the spectra. It uses all light coming from the telescope diameter and the target position is not sure. It might not be easy to obtain spectra of specific objects in the field of view. 2) It shows a continuous spectrum and can be possibly used to analyze blackbody radiation. However, we are not sure about the quantum efficiency of the CCD array and it should be calibrated further if one wants to use the device confidently for this purpose.

ACKNOWLEDGMENTS

This work was funded by the Ministry of Science, ICT and Future Planning.

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