Preliminary results of the solar corona spectroscopic observation of 9th March 2016 Total Solar Eclipse

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Abstract. Spectroscopy observation of solar corona has been carried out from 9th March 2016 Total Solar Eclipse expedition in Maba, East Halmahera. Due to limitation by the weather condition during the observation, the obtained data were not favorable. Because of the low signal to noise ratio, the wavelength calibration was not straightforward. To obtain the optimum results, steps for data reduction were performed as the following: selecting the finest data, extracting the 1D spectrum from 2D spectrum, and calibrating spectrum wavelength (including careful interpolation). In this preliminary result, we discuss the instrumentation, the data under investigation, the extraction process of spectrum, and the polynomial interpolation that has been used for extracting information from our data.

1. Introduction

The total solar eclipse that was observable from Indonesia on March, 9th 2016 has given opportunity to study the corona of the Sun since the solar corona can be observed from ground-based observation at best only during the totality of the solar eclipse.

For the event of 2016 Total Solar Eclipse, we conducted a research on spectroscopy of the corona. Corona spectrum consist of emission lines from excited ions from various sources from plasma that depend on the temperature, and most of these lines are observed as forbidden lines [1]. The spectroscopy of the corona from the eclipse give ample of opportunity to observe specific coronal lines that appear at the moment.

Despite the limitation by weather during the observation, in this preliminary report, we present the data from observation after the totality with good information, the spectrum extraction, and wavelength calibration process for the purpose to have a quick overview on wavelength-calibrated spectrum (Section 2), and finally the overview of the spectrum, also the discussion in Section 3.

2. Data and analysis

We selected Maba, East Halmahera (0° 41’ 34” N, 128° 17’ 39” E) as the site for the observation, it has the longest duration of totality on the land in Indonesia. Our equipments comprise of telescope with F/10, 9”.8, CCD camera 2125 × 1472 pixel square, 6.8μm, and spectrograph with moderate resolution (R $\sim$ 18000) and Littrow design [2]. This telescope design is suitable

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to observe and study several emission lines from the corona that probably weak according to the recent solar cycle.

However, due to weather condition that limits the data, only small and limited data were obtained from the moment of totality. To extract information from the data, it is important to have calibrated information from similar data but with a better quality during the run of the observation (comparison data).

The data with better quality obtained only prior and after the totality. The comparison data in this work was extracted after the totality, calibrated in the wavelength and features identified. For this part, we expect that we will have strong features, so called *Doublet Na 1 D* as the calibration for the wavelength of the spectrum. The *Doublet Na 1 D* also known as *Sodium doublet* is consist of two lines, the Na D_1 on 5895.92 $\mathring{A}$ and Na D_2 line on 5889.95 $\mathring{A}$. This process is a preliminary result to have spectrum calibrated to the wavelength.

Figure 1 and figure 2 show the particular calibration lamp spectrum for the expected spectrum region and the cross-section of the emission line shown. It can be shown that the data severly tilted to the vertical line and the profile is not flat enough, regardless that strong emission lines appeared. Due to these limitation, the information should be carefully extracted if we want to have proper information from the spectrum. In this work we only have quick overview on calibrated wavelength, so we only focus on the absisca information from the spectrum using IRAF as the software for analysis.

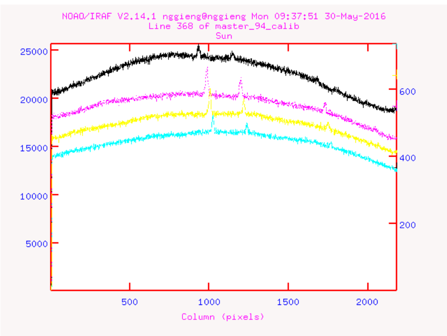

Figure 1. The calibration spectrum data for particular observed wavelength. The bright line on vertical line is the emission spectrum for calibration of the wavelength.

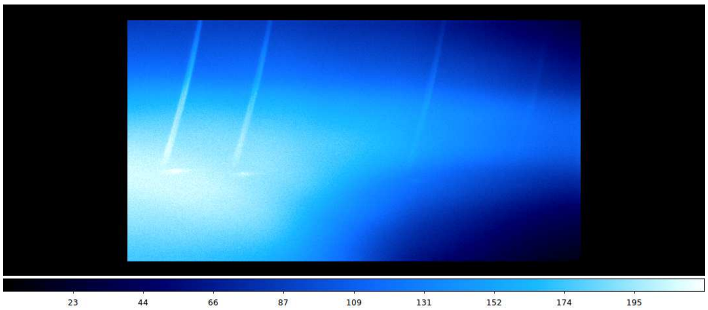

Figure 2. Shows the cross-sectional profile along the line for several lines for the calibration data for selected spectrum region as shown from left figure. Different colours represent the different lines for the image data with unit in pixels.

After standard calibration process (dark substraction and flat fielding), we followed standard spectroscopy extraction and identify the important emission line, as shown in figure 3. The emission lines were identified with related wavelength from standard *He-Ne-Ar* atlas.

We then found the relation between pixels to wavelength by fitting with spline polynomial, as shown in figure 4. We also tried to see the stability of the relation by fitting the second order relation as shown in figure 5. It can be shown that the data are quiet well fit between the two relation, so we have good confidence that the wavelength is well related to particular pixels. Next, we applied the identification wavelength to spectrum.

3. Result and discussion

Figure 6 shows the result of calibrated spectrum under investigation, the expected features appear clearly as strong absorption lines (marked by red rectangle)

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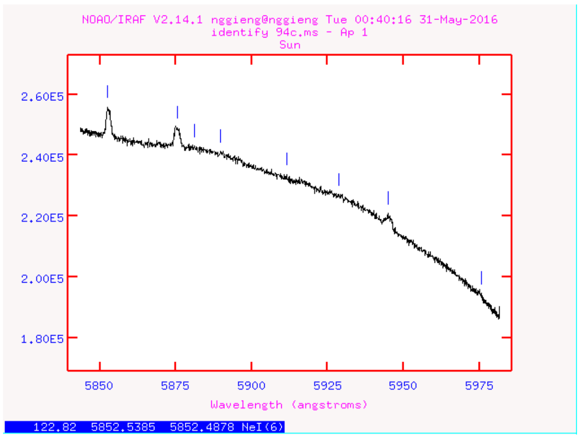

Figure 3. Identification of several emission line identified shown with vertical blue line above the spectrum.

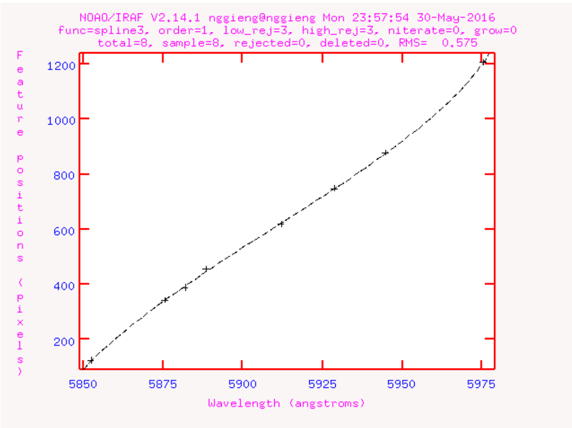

Figure 4. The fitting of the relation between wavelength (absisca) and pixels value (ordinate).

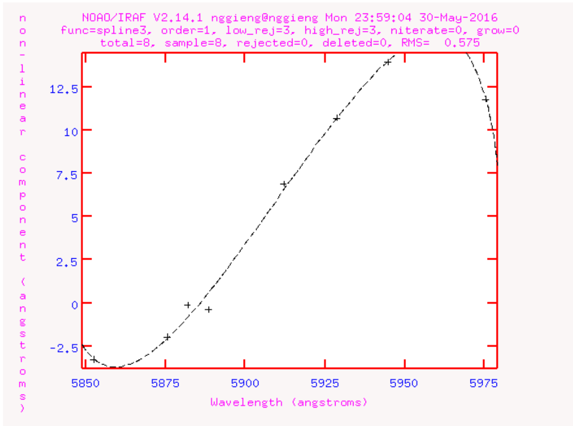

Figure 5. The non-linear part of the relation between wavelength and pixels.

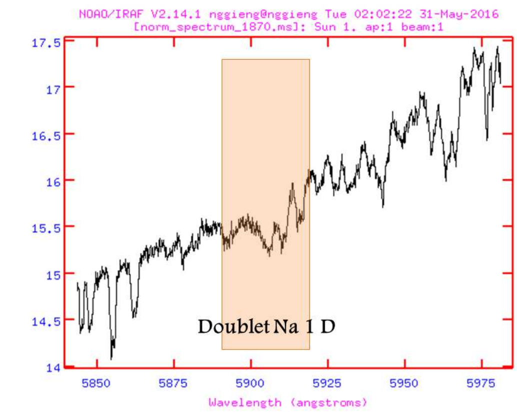

Figure 6. *Doublet Na 1 D* is marked in the red rectangle.

However to have the proper spectrum information, the result still needs more corrections. As seen in figure 1, it is necessary to apply geometrical correction to the spectrum. We can choose between calibrating flux or normalization, however we have to be certain about the proper coordinate on ordinate direction, so the geometrical correction still need to be done by long slit transformation method.

Another aspect to be considered is the spectrum from the corona is located outside the selected domain and in poor quality data, so the identification of the expected lines on different wavelenght region might be done by polynomial fitting. The expected coronal line is not on exactly on sodium doublet region. Some method can be consider, such as Legendre, Chebyshev, or Spline method to fit. However this selection of the method will rely on the quality of the extracted data.

4. Conclusion

We have shown that our instrument was capable to obtain the spectrum with good quality even in the condition that could severly limit to obtain the best data. As we have demonstrated, we still could extract the expected *Doublet Na 1 D* lines. Since the spectrum coverage is very narow, if the expected spectrum line is located on different region that is on very poor condition, the result from this extraction can be used to fit the expected line as the additional information to give the proper information.

Acknowledgments

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