Spectral analyses of resonance scattering of Sr and Ba for determination of thermospheric neutral wind

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1. Introduction: We developed a measurement technique for the wind velocity profile in the thermospheric rarefied atmosphere by Lithium(Li) releases from sounding rockets in cooperation with JAXA and NASA. We observed barium (Ba) and barium ion (Ba^+) released by sounding rocket in Norway in November, 2014, and observed the thermospheric neutral wind and the ion drift at an altitude range of 150~400 km. In the future, Japan is going to carry out the similar measurement using strontium (Sr), and the experiment using the Sr ejection system was performed as a preliminary experiment on ground in Gunma prefecture in September, 2014. Here we report both of the results of the spectrum analyses from the observed images of Sr and Ba in order to verify the released components of Ba and Sr.

2. Spectrum analysis: The spectrum observation method of this experiment in Norway was observation of spectrum images by a camera (Nikon D700) with an attached diffraction grating (500 line/mm) without a slit to the front of lens. The spectrum observation for the Sr preliminary experiment on ground was performed using a video camera (SONY DCR-PC101) attached to the same diffraction grating with a slit as well as a fiber input type spectrophotometer. We analysed the brightness distribution of the 1st order spectrum section using a developed image processing software by using IDL (Interactive Data Language) language and made a brightness level in each pixel on the image. Then, photographed bright-line spectrum of the Ar gas by a small Ar discharge tube was used for calibration of the spectrum camera and the spectrum video camera. The Ar lines are used as a basis of wavelengths for calibration. We acquired multiple Ar line wavelengths to calibrate calibrated the brightness spectrum distribution of Sr emission on ground as well as Ba and Ba^+ resonance scattering light in thermosphere. In addition, the spatial integrated spectrum strength obtained by the fiber input type spectrophotometer was also used for Sr measurement.

3. Spectrum analysis and discussion: From the spectrum analysis of the images taken at the rocket experiment in Norway, emission spectrum of wavelengths at 455 nm, 557 nm and 610 nm - 661 nm was confirmed. The wavelengths were fixed as the wavelengths of the documented Ba^+ and the Ba emissions at 455 nm and 553 nm. From the spectrum analysis, we can confirm an emission wavelength at 460 nm obtained at the Sr ground experiment as 460.7 nm emission which is documented as the Sr spectrum line. We could clearly detect Sr 460.7 nm by integrating multiple spectrum sections on an image. From the data analysis for the spectrophotometer measurement, we confirmed a spectrum of iron (Fe) and aluminum (Al) at 635 nm, 644 nm and 656-659 nm as well as oxygen (O_2) at of 668 nm –671 nm, suggesting the effect by the thermite reaction in case of the Sr release.

4. Conclusion: We confirmed the emissions at the of wavelengths 455 nm and 557 nm from the sequential spectrum images which the sounding rocket experiment in Norway provided and those were fixed as Ba^+ and Ba, thus Ba release and ionization were confirmed. In addition, it is concluded that when we confirm a brightness peak at 460.7 nm by the two types of spectrum data obtaind by the ground measurement, Sr release and emission was confirmed.

Keywords: strontium, resonance scattering, thermosphere

