A search for atomic sodium and calcium in the atmosphere of the icy Galilean moons of Jupiter with ground-based telescope

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Study of the Galilean moon atmospheres has been advanced by space missions of the last 25 years, e.g., Voyager, Hubble Space Telescope, and Galileo, and numerous ground-based observations. Thus we now know these moons have tenuous atmosphere with SO_2 for Io and oxygen for Europa as primary species. On the other hand, minor species in the atmosphere can aid in investigation of surface composition and transportation processes between moons. For Io and Europa, numerous sets of observations exist of atomic sodium and potassium [Brown and Chaffee, 1974; Trafton, 1975; Brown and Hill, 1996; Brown, 2001]. For Io, the sodium D_1 (5,895.92 Å) and D_2 (5,889.95 Å) emission lines brightness of the sodium nebula has a positive correlation with Io's volcanic activity [Mendillo et al., 2004; Yoneda et al., 2015], which strongly suggests that the sodium originates from the Io’s interior. For Europa, spectrographic evidence on the surface acquired from the Galileo spacecraft suggests that hydrated salt minerals, such as magnesium and sodium sulfates, sodium carbonate and their mixtures, are concentrated at the linear features and in the chaotic terrains [McCord et al., 1999]. Furthermore, recent visible spectroscopic observations by the Hubble Space Telescope suggests the presence of sodium chloride on Europa [Trumbo et al. 2019]. The value of [Na]/[K] for the Europa’s atmosphere, ~25+/-3 [Brown et al., 2001], is used to express that Europa’s atmospheric alkalis are endogenic because of the relatively close to the predicted value for the Europa’s ocean [Zolotov and Shock, 2001] than the meteoroid source value of ~13 [Carlson et al., 2009]. However, we have no definitive conclusions about the endogenic or exogenic origin of Europa’s alkalis at present, and the compositional relationship between the Europa’s ocean, the surface and the atmosphere is unknown. In addition, although an emission signal from magnesium atoms has been expected, no positive signal has been reported [Horst and Brown, 2013]. Further observations expect to bring better understandings for the source of these materials and interaction processes on and around Europa.

We search minor species, on the icy Galilean moons of Jupiter using the ground-based telescope of Hokkaido University (Pirka telescope, the primary mirror is 1.6 m in diameter). The Pirka telescope and its on-board observation device has started full-scale operation in 2011 with priority to observe planetary bodies in the Solar System. The multi spectral imaging device [Watanabe et al., 2012] has been installed at the Cassegrain focus of the telescope and it allow us to obtain surface spectral data with wavelength between 350 and 1050 nm. We observed the Galileo satellite in 2018-2020 and searched for sodium and calcium in the Io and Europa atmospheres. Here we will report the investigation.

Keywords: Galilean moon, atmosphere, ground-based observation

