UV radiation experiment of SO_2 frost based on Jupiter moon Io’ s environment

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Jupiter's moon Io is covered with a tenuous sulfur oxide atmosphere (~10^{-3} Pa) consisting mainly of SO_2 (~90%) and SO_2 surface frost. This atmosphere is produced by direct eruption from volcanic vents and sublimation of SO_2 surface frost due to an increase in the surface temperature on the day side. The SO_2 in the atmosphere is dissociated into O and S atoms by electron impact and sunlight in the ultraviolet wavelength range, and some of it escapes from the Io-gravitational field by atmospheric sputtering. On the other hand, it is not clear whether the "solid" SO_2 frost on the surface is decomposed or promoted to grow by UV radiation. Baklouti et al. (2007) conducted the laboratory experiments using SO_2 with a small amount of S_2O, assuming red sediments around a specific Pele Patera on Io. They irradiated the sample by light in the wavelength range of UV to visible, and measured the mid-infrared spectrum. However, if we want to assume the effect of UV light on the “universal” Io surface frost, UV irradiation experiments on pure SO_2 frost is more preferred. If we can obtain spectra obtained from laboratory measurements reproducing a tenuous and cold atmosphere, surface frost, and UV irradiation that can be compared with ground-based observations, we can step into the relationship between SO_2 frost morphology, spatio-temporal changes in Io's various volcanic activities, and solar irradiation. It also can contribute to a complementary understanding of planetary science and condensed matter physics and chemistry.
The following procedure is used to clarify the relationship between UV intensity/wavelength and chemical denaturation of SO_2 condensed particles by mid-infrared spectroscopy. We use a cryostat with a small chamber connected to a liquid nitrogen dewar (see the poster by Negishi et al. in the same session for details). Inside of the small chamber is maintained at pressure of 10^{-3} Pa and temperature of 110-130 K, which are similar to the environment at the dayside surface of Io. SO_2 gas is sprayed onto the CsI plate, which is attached to a dewar sample holder, and then the frost is deposited. A deuterium lamp with a peak UV wavelength of 160 nm and a xenon lamp with a continuous spectrum from the far UV to the visible region are used as light sources to irradiate the SO_2 frost. In case that the deuterium lamp is used, the UV irradiance received by the sample is estimated to be ~10^4 W/m^2. On the other hand, the solar irradiance in the Jupiter magnetosphere at 120-250 nm is about 8.9×10^{-2} W/m^2. By irradiating the sample with UV light for one minute, the sample would experience the equivalent of 140 days of solar UV radiation on Io. By adjusting the duration of the UV irradiation, the experiment will also reveal the relationship between the intensity and age of the UV irradiation and the change in SO_2 frost. For in-situ observation of the experiment, an imaging Fourier transform mid-infrared spectrometer based on the near-common-path wavefront-division phase-shift interferometry (Qi et al., 2015) is used to obtain the spatial two-dimensional transmission and absorption spectra. At the same time, the sample holder in the chamber is visually checked and visually imaged using a magnifying glass. In this presentation, we will discuss how the morphological change of SO_2 frost occurs during UV irradiation through the change of the obtained 2D mid-IR absorption spectrum.

Keywords: Io, Mid infrared, Laboratory experiment