Atomic oxygen densities and source rate in Io's neutral cloud derived from the Hisaki observation

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We report on the detail spatial distribution of Io’ s oxygen neutral cloud, and estimated the oxygen number density and oxygen ion source rate based on the observation of atomic oxygen emission for the first time. Atomic oxygen and sulfur in Io’ s atmosphere escape from the exosphere mainly through atmospheric sputtering. Some of the neutral atoms escape from Io’ s gravitational sphere and form neutral clouds around Jupiter. Io plasma torus is formed by ionization of these atoms by electron impact and charge exchange processes. The spatial distribution of oxygen and sulfur neutral clouds is important for understanding the plasma source in the Jovian magnetosphere. However, the detailed distribution of them has not yet been directly measured because of their faint emissions. The extreme ultraviolet spectrograph called EXCEED (Extreme Ultraviolet Spectroscope for Exospheric Dynamics) installed on JAXA’ s Hisaki satellite observed Io plasma torus since November 2013. We derived the radial profile of atomic oxygen emission at 130.4 nm by using Hisaki’ s continuous observation data (integration time; 1 min). The observation period spanned from 27 November to 31 December 2014 (35 days). This period was volcanically quiet because atomic oxygen emission around Io were weak and stable (about 12 Rayleighs (R)) compared to the volcanically active period around February 2015 (25-30 R). We found the emission peak exists inside the Io’ s orbit, and the emission extends to 7.6 Jupiter radii (RJ). The peak atomic oxygen number density is 80 cm^{-3} (at 5.7 RJ), assuming that the cloud width is 1.2 RJ in the north–south direction referred from the previous model study. Our results are in the range of the previous study based on a physical chemistry model matched to Cassini Ultraviolet Imaging Spectrometer (UVIS) emissions (atomic oxygen density at ~6 RJ is about 25 cm^{-3} during inactive periods, and rises to 120 cm^{-3} during the volcanic active period). We also suggest that larger number of oxygen atoms exit inside Io’ s orbit than those reported in a previous study. We calculated the radial profile oxygen ion source rate and found that the source rate of charge exchange is larger than that of electron impact from 4 to 7.3 RJ, and the source rate of charge exchange is smaller than that from 7.4 RJ. The total oxygen ion source rate estimated in this study is 410 kg/s where 100 kg/s is caused by electron impact ionization and 310 kg/s is caused by charge exchange. These results are consistent with the previous studies that used a physical chemistry model based on Hisaki and Cassini observations of ultraviolet emission in the Io plasma torus.

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