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Ion sputtering and radiolysis of ice at the Galilean moons

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Abstract

The exosphere of an icy moon is the result of different surface release processes and subsequent modification of the released particles. The main constituent of the icy surface is water with minor portion of heavy water (H_2O_2) and other impurities. This means that probably the major released species is H_2O. Nevertheless, the particles experience photolysis and radiolysis due to solar UV and Jupiter's magnetospheric plasma respectively. The initial species of these processes in ice are OH, H and O, with the possibility of H_2. These dissociated species can react to reform water and/or new species, creating an exosphere that, at the end, is a mixture of different molecules. Specifically, the presence of initially excited O_2 in ice has been inferred from the associated luminescence bands produced via O+O--> O_2*. Moreover, the Hubble Space Telescope observations, initially, revealed the existence of a tenuous O_2 atmosphere in Europa, with a column density of about (0.24-1.4) 10^{15} cm^{-2}, whereas, later, the Ultraviolet Imaging Spectrograph on the Cassini, during its flyby of Jupiter, confirmed this discovery.

In this work, starting from a previously developed MC model for the generation of Europa's exosphere, where the only considered species was water, we make a first attempt to simulate the more realistic O_2 atmosphere of Europa. Due to radiolysis of ice and subsequent release of O_2 molecules, considering a) a specific configuration where leading hemisphere coincides with sunlit hemisphere and b) the moon's surface temperature map, we estimate along the Europa-Sun line a column density of about 1.4 10^{15} cm^{-2} at the dayside and 2 10^{14} cm^{-2}, at the nightside. We also make a more detailed estimation of the sputtered-water exosphere of this moon, taking into consideration the trailing-leading hemispheres asymetry in the magnetospheric ion bombardment. We compare the results of this analysis with those obtained by other models and with the in situ measurements and discuss them, in the context of future missions.