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Modelling of Europa's plumes

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Abstract

There are now three types of atmospheric observations suggesting the existence of plumes at Europa's surface: H I and O I ultraviolet (UV) emission excited by the dissociation of water vapor in the plumes [1], absorption by plume material imaged when Europa transited Jupiter in the UV [2], and electromagnetic perturbations induced by the plume density [3]. These plumes are of great interest because they present a unique opportunity to probe Europa's interior, which may be outgassing. However, the origins, composition, and frequency of plumes remain unconstrained. The present set of observations are sparse as well as poorly resolved spatially and temporally.

In [4], a model of the ascent of liquid water through a fracture or a pipe-like conduit from a subsurface reservoir to Europa's surface was developed in order to derive the eruption time-scale and the total volume extruded during the eruption, as a function of the reservoir volume and depth. In this model, the cryomagma (salted liquid water) stored in subsurface reservoirs which lead to eruptions when triggered by their partial freezing.

In [5], a description of Europa's exosphere was developed by taking into account two processes of surface erosion: water sublimation and water-product sputtering induced by precipitating magnetospheric ions and electrons. The evolution of the exosphere along Europa's orbit around Jupiter was reconstructed. This model, based on a Monte Carlo approach, describes the fate of the water molecules and its products when ejected from the surface.

The objectives of this work are to combine the model of cryomagma ascent at Europa developed in [4] with the exospheric model [5] in order to provide constraints on the possible evolution and structure of a plume when generated by an eruption. Our goals are to understand if Europa's exosphere is essentially produced from plumes or rather, provide an estimate on the typical timescale as well as spatial scale foreseen for a plume. Based on our knowledge of Europa's exosphere at present, the addition of the subsurface component may lead to constraints on its possible composition.

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