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3D Monte-Carlo Model of Europa's Water Plumes

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With the pending launches of JUICE and Europa Clipper within the next three years, interest in Europa plumes and the implications they might hold has regained momentum.

In 2014, Roth et al. presented first evidence for Europa plume activity based on Hubble Space Telescope (HST) Space Telescope Imaging Spectograph (STIS) Lyman-alpha and OI 1304 Å line emission observations. The observed line emissions imply two underlying plumic sources, located ~20° apart, exhibiting radial expansions of ~200 km and latitudinal expansions of ~20°, and containing ~2,000 kg of H2O (~1.5 □ 10^{16} H_2O/cm^2). Since then, several more Europa plume observation attempts were undertaken, though only a hand full proved successful.

Most importantly, the true nature of the observed plume signature still remains to be determined. Plumes can either originate from the topmost surface layer, from within the ice layer, or from the sub-surface ocean. Depending on the location of origin, the plumes contain information about vastly different zones: If they are surficial, they will contain information about the highly irradiated and highly processed surface, if they originate from the sub-surface ocean, they might hold information on Europa's potentially life-bearing region.

In this presentation, we present 3D Monte-Carlo model results of three different plume scenarios, two of which originate in Europa's surface ice layer (near-surface liquid inclusion and diapir) whereas the third originates in the sub-surface ocean (oceanic plume). In this model we trace not only the H_2O molecules, but also its dissociation products, i.e., OH, H and O. To compare the plume structures obtained from the Monte-Carlo model to the HST-STIS observations, we include all known relevant Lyman-alpha and OI 1304 Å emission excitation mechanisms in our model. Such a comparison does not only shed more light on the plumes that have already been observed, but will also help targeting plume measurements in the near future, as well as interpreting in situ measurements once such become available.