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Using a mass spectrometer in Europa's orbit to learn about its surface

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A spaceprobe orbiting Jupiter's moon Europa, of the sort considered by both ESA and NASA, would provide an opportunity to determine the composition and morphology of its tenuous atmosphere. Europa's atmosphere, though tenuous, has been detected by Earth-based telescopes. Its O_2 atmosphere was detected from Earth orbit and its much thinner alkali atmosphere was detected by ground-based telescopes. Many other species are expected, but their detection would require in-situ observation of the atmosphere with a mass spectrometer, either with or without the ability to detect neutrals. This in turn could answer questions about the surface composition and, possibly, aspects of the composition of Europa's ocean that would otherwise require a much more expensive landing mission. Its atmosphere is thought to be primarily produced by sputtering and radiation-induced decomposition of surface material by energetic ions and electrons from Jupiter's magnetosphere. The primary surface ejecta is H_2O, of which 100s of molecules are ejected per incident ion by the impacting energetic oxygen and sulfur ions. Because these yields are large, other species present in the ice can be carried into the atmosphere along with the H_2O. In addition, more volatile species, such as H_2 and O_2 are directly produced and ejected by the incident radiation. In addition, as at Enceladus, Europa may be outgassing; but, unlike Enceladus, Europa has a considerable gravitational field so that the vented gas would mostly return to the surface. Detecting the composition and spatial distribution of the ejected or vented molecules could provide insight into the composition of Europa's surface and, possibly, of its putative subsurface ocean. An outstanding question, which could be resolved by measurements from an orbiting mass spectrometer, is the identity of the hydrated sulfates seen all over Europa. This sulfates have been shown to have their highest concentrations on the trailing hemisphere and along linear tectonic features. Their infrared spectrum has been suggested to be consistent with both ocean-

derived sulfate salts and sulfuric acid produced by radiation-altered, plasma-injected sulfur. Since the suggested salts are very different, determining the spatial distribution and composition of the ejecta can be used to determine the importance of space and ocean sources of sulfur. In this paper we will describe simulations of the abundance of gas-phase molecules and molecular ions over Europa's surface. We will describe the radiation-induced source and an Enceladus-like source. The results from such simulations can then be used to determined the required sensitivity for a mass spectrometer on an orbiting probe. We will also compare our model of Europa's O_2 atmosphere to the results of the upcoming New Horizons Jupiter encounter.