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Abstract

No Sodium in the Enceladus Plume: Implications for a Sub-Surface Ocean

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One surprising discovery of the Cassini mission to Saturn has been the presence of geyser-like plumes at the south pole of the icy moon Enceladus ejecting >300 kg/s of water into Saturn's magnetosphere. In situ and remote observations (Waite et al. 2006; Hansen et al. 2006) have shown that the primary plume constituent is H_2O, and thermal measurements indicate intense heating in cracks believed to be plume vents on the surface (Spencer et al. 2006). These observations have led to speculation that the plumes are fed from a liquid water reservoir beneath Enceladus' surface.

We present results from an extremely sensitive, high-resolution spectroscopic search using the Keck and Anglo-Australian Telescopes which place a stringent upper limit on sodium emission in the Enceladus plumes. Large amounts of sodium would be expected if Enceladus' plume material were derived directly from a subsurface liquid reservoir in contact with rocky material. Chemical models predict that sodium would dissolve into such an ocean at mixing ratios relative to water of 10^{-4} to 10^{-1} (Zolotov et al., 2007). Our numerical plume models show that such high sodium concentrations would form a detectable torus encircling Saturn. Our detection upper limits for sodium in both plume and neutral torus fall orders of magnitude below these models, leading us to conclude that the Enceladus plumes do not originate in an ocean or sea. These observations support the alternative theories that the plumes are generated by shear heating of the icy crust resulting in sublimation or melting, or the decomposition of clathrates.

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