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Enceladus' plume: Formation and dynamics of icy grains

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We investigate scenarios for the condensation of ice grains in water gas vents at Enceladus' south pole. The gas emanating from the polar region escapes from hot subsurface regions to vacuum through a system of cracks. By expansion the gas becomes over-saturated and condensation sets in. We present a thermodynamically consistent model for condensation and particle growth in channels of variable cross section, which couples the hydrodynamic equations for the gas with thermodynamic equations for the phase transition. For the nucleation rates we use relations following from experimental data for water vapor at various temperatures and values of the over-saturation. Averaging over plausible ranges of parameters of the channel geometry our model yields a distribution of particle sizes ranging from a fraction of a micron to a few microns. From a probabilistic model for collisions of the grains with channel walls and ballistic acceleration in the dilute gas stream we derive a speed-size distribution of the grains. Our model predicts that large grains can be considerably slower than the the satellite's escape velocity, which is in turn smaller than the gas speed. Thus, our result can explain why a large fraction of the grains falls back to the surface. The size-distribution is consistent with particle-sizes of the E-ring inferred from photometry and in-situ measurements. We use the speed-size distribution as input for dynamical models of grains ejected into Enceladus' Hill sphere from the south polar area. In this way we construct an effective model plume and investigate its stratification and brightness.