Investigating Enceladus' plumes dynamics through laboratory experiments

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Since its observations with Voyager 2, Saturn's moon Enceladus was seen to be active, resurfacing and resulting geologically younger in certain areas [1]. The Cassini mission showed other evidences of this activity, such as cryovolcanism, powered by tidal dissipation [2]: a salty water ocean laying underneath the icy crust and ejecting material through geysers, the so-called plumes [3]. The flow reaches supersonic velocities, highlighting that plumes are due to (an adiabatic) expansion of the gas through the nozzle-shaped cracks, observed in the south polar region of the moon [4]. Icy grains are formed due to nucleation of water at the surface of the ocean and in the crevasses [5]. We developed an experimental setup to study how the liquid water from the Enceladean ocean is ejected through the plumes and verify that under the icy moon's conditions the flow reaches supersonic velocities. The laboratory model includes a liquid water reservoir, corresponding to the ocean, and a nozzle, corresponding to the crevasses. We measured pressure and temperature along the nozzle to determine the influence of the reservoir and vent conditions (pressure, temperature) on the velocity, pressure and temperature profiles in the nozzle. We repeated the experiment for different nozzle geometries to determine their effects on the plume's characteristics. Using the results of several experiments, we discuss how the plumes' observations reported by Cassini can be linked with the characteristics of the icy crevasses and the depth of the sub-surface ocean.

References

[1] Steven W. Squyres et al. "The evolution of Enceladus". In: Icarus 53.2 (Feb. 1983), pp. 319–331.

[2] Gaël Choblet et al. "Powering prolonged hydrothermal activity inside Enceladus". In: Nature Astronomy 1.12 (Nov. 2017), pp. 841–847.

[3] C. C. Porco et al. "Cassini Observes the Active South Pole of Enceladus". In: Science 311.5766 (Mar. 2006), pp. 1393–1401.

[4] J ürgen Schmidt et al. "Slow dust in Enceladus' plume from condensation and wall collisions in tiger stripe fractures". In: Nature 451.7179 (Feb. 2008), pp. 685–688.

[5] N Khawaja et al. "Low-mass nitrogen-, oxygen-bearing, and aromatic compounds in Enceladean ice grains". In: Monthly Notices of the Royal Astronomical Society 489.4 (Oct. 2019), pp. 5231–5243.