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Laboratory experiments recreating icy moons' geysers

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Abstract

The Cassini mission revealed the presence of plumes on Enceladus and showed the chemical complexity present in these environments. The plumes are supposed to represent the composition of the Ocean, but how plumes and the ocean are linked has been addressed by theories [1,2] but not yet experimentally. By recreating plumes in laboratory, we aim to apply reverse engineering by understanding how the content of the plumes, which has been extensively observed by Cassini, reflects the conditions in the ocean.

1. Introduction

The Cassini mission, launched in 1997, brought a new vision on the habitability of our solar system. While the icy moons orbiting Jupiter or Saturn were supposed to be cold and inert objects well outside the habitable zone (where water can be found liquid), Cassini showed that Saturn's moon Enceladus is very active, with a warm interior heated by tidal forces [3], allowing the presence of an ocean under the icy crust [4]. This ocean escapes through geysers (plumes) from the icy surface to reach the exosphere. Cassini did many fly byes through the plumes, measuring their composition and characteristics and showed that the ocean under the icy crust is salty, and contains complex organic molecules [5]. One possible explanation is that the subsurface ocean is covered with an organic film (as this is the case for earth's oceans) that is carried in the plumes by bubbles evaporating from the ocean. Another characteristic of the plumes is their very large velocities, reaching 700-900 m/s [6], highlighting that plumes are due to expansion of the gas through a nozzle like crevasse. While the data provided by Cassini gave rise to many possible theories and scenarios, the latest data have been taken last year and we will have to wait at least 7 years with Europa Clipper and 10 years with JUICE to be able to further investigate icy moons. The measurements from Cassini left us with many unanswered questions: Is there life on Enceladus? And if yes, could you see it in the plumes and how would you detect it?

2. Experimental procedure

We are developing an experimental setup to verify experimentally that under the icy moon's conditions (pressure, temperature) a plume reaches hypersonic/supersonic velocities, and will determine how the ocean (liquid water) translates into plume (compare composition). We designed and build a reservoir where liquid water can be frozen, mimicking the moon's icy crust. A mould, introduced in the reservoir and removed once the water is frozen, simulates the crevasse. The mould is designed such as to establish the hypersonic/supersonic velocities in the plumes. The bottom of the reservoir contains liquid water corresponding to the sub-surface ocean. The first step of the experimental setup is shown in the picture in Figure 1. The results from the first experiments showed the recreation of a slow plume, because the pressure obtained in the chamber was too high. The next experiments will be performed at the wind tunnel laboratories where Particle Image Velocimetry (PIV) techniques can be used to track whether particles present in the liquid water can be also found in the plumes. These first improvements will allow to test and validate our concept and to start first measurements to understand the relation between the plumes and the ocean.

3. Figure

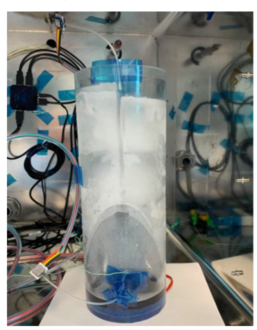

Figure 1: First experimental step mimicking the icy moon's icy crust, ocean and plumes.

4. Summary and Conclusions

The setup developed showed that it is possible to recreate slow plumes in laboratory. More experimental steps are necessary to reproduce the conditions found on Enceladus which will be detailed in the presentation.

5. References

[1] Yeoh et al. 2015 Icarus 253, 205;

[2] Schmidt et al. 2008, Nature 451, 685

[3] Porco et al. 2014 ,ApJ 148

[4] Thomas et al. 2016, Icarus 264 37

[5] Postberg et al. 2018, Nature 558, 564

[6] Yeoh et al. 2016, Icarus 281, 357