Modelling the dielectric properties of the geyser deposited snow layer on Enceladus

Pia Friend, Alexander Kyriacou, and Klaus Helbing
Mathematische und Naturwissenschaftliche Fakultät, University of Wuppertal, Germany

Saturn’s icy moon Enceladus is with its roughly 500 km diameter a differentiated geological active body that harbours a liquid ocean between its rocky core and icy mantle. This ocean is among the most promising places to host extraterrestrial life in our solar system.

At Enceladus’ south pole terrain, active geysers form a passage from the ocean to the surface; erupting ice, dust and gas particles. Most of those particles escape the moon's gravity, but some portion falls back to the surface. Considering the current output, about 10 m of snow gets sedimented at a distance of about 100 m away from the geysers within $10^5-10^6$ years. Hence, depending on the timescale the geysers are active at the same location, the snow layer would have a thickness of some km already, assuming no densification.

A first model of the density profile of the snow layer as a function of the ice/vacuum ratio will be provided at the conference. To investigate the density at the surface, mainly the distribution of the ice grain shapes and the grain sizes have to be considered and put into a state equation. For modelling the density change in respect to the depth, also the pressure from the overlying weight has to be accounted for. As temperatures at Enceladus’ surface are too low, neither sintering nor processes such as melting and re-freezing can thereby contribute to densification. These processes however are acting in terrestrial glaciers. We propose therefore, because the temperatures on Enceladus are far below the melting point of ice, to consider the ice grains on Enceladus rather as sand than as snow in respect to these materials on Earth, when modelling the density within the snow layer.

After obtaining the ratio between ice and vacuum, it is possible to define the dielectric properties of the snow layer. The dielectric profile in turn is the primary diagnostic property for radar based geophysical investigation. It determines the velocity of radio waves in a medium as well as their reflection and refraction at interfaces.

Because of the above mentioned possibility that primitive extraterrestrial life might exist in Enceladus’ hidden ocean, there will likely be future space missions with the aim to reach a water reservoir and probe it. A well-defined density profile could then help to radar navigate a melting probe through the ice.