SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations (IP)

Author: Mr. Kai Schüller
RWTH Aachen, Germany, schueller@aices.rwth-aachen.de

Dr. Julia Kowalski
RWTH Aachen, Germany, kowalski@aices.rwth-aachen.de

IMPROVED UNDERSTANDING OF MELTING PROBE CONCEPTS FOR EXTRATERRESTRIAL ICE EXPLORATION

Abstract

It is now widely accepted that the presence of subglacial liquid water on the icy moons of our solar system bears some potential for the development of extraterrestrial life. To access those regions, a technology is needed which penetrates the covering icy crust of the water reservoirs. Due to its comparably small mass and size, a thermal melting probe (TMP) is a good candidate for such a task.

Typically, the analysis of space missions involving a TMP relies on a very simplified model to determine its power budget, namely a simple energy balance for an idealized cylindrical TMP geometry. This approach, however, is not very accurate because the transport of heat in the ice is not considered correctly and thermal losses are estimated through an empirical efficiency factor. Once a TMP is operated, unknown and heterogeneous environmental conditions may influence its melting behavior, which always results in an uncertainty when simulating the melting trajectory. Such uncertainty can be dealt with by an independent position determination system, e.g. by triangulation with acoustic pingers near the surface. In order to reduce the number of necessary position updates and to enable a reasonable range for trajectory planning, we however need reliable simulation tools.

In this contribution we address this challenge and suggest two complementary models to analyze different aspects of TMP's, namely a 2d melt-film model and a 3d two-phase model that uses the enthalpy-porosity method to explicitly integrate phase change with convection in the melt. Advantages of this approach are its flexibility in terms of TMP geometry and phase interface topology. Therefore it is not limited to TMP applications but can also be used to analyze a variety of engineering problems involving phase change, e.g. latent thermal energy storages for thermal control in space.

We will present the models, as well as four case studies. These are used to develop an improved understanding of melting into extraterrestrial ice by TMP technology.