EnEx - **Di**rectional **M**elting in **Ice** (DiMIce)

Student research project / Bachelor thesis offer:
sIM-CoMeT - A fast and embeddable tool to compute the dynamics of the IceMole melting probe

EnEx - Directional Melting in Ice (DiMIce) is a project at Aachen Institute for Advanced Study in Computational Engineering Science (AICES). It is embedded into the Enceladus Explorer (EnEx) initiative which is controlled by DLR space administration and its main objective is to model melting probe dynamics [1].

Modeling the motion of melting probes is a challenging multi-physics problem. With sIM-CoMeT, we intend to support the EnEx initiative with a tool to simulate the IceMole (IM) melting probe [2] dynamics for a given heating configuration with low computational costs by making use of a semi-analytical approach. For simple geometries and heating system configurations it is possible to simplify the governing equations to derive a semi-analytical solution. This concept reduces the complexity level and can be used as a first approach to support embedded trajectory control. This is done by approximating the geometry with a collection of 2d plates (one plate for each wall), in which each is called a dynamics driver. In a preprocessing step, sIM-CoMeT maps the effective heat onto the dynamics drivers and decides which dynamics driver mostly influences the melting dynamics. Then it uses only the selected one and approximates the real melting motion with a quasi-steady state melting approach, which is based on the so-called lubrication assumption [3] together with a finite difference approximation of the heat equation to iteratively compute the motion.

sIM-CoMeT is currently under development and a prototype code is implemented in Matlab. In order to reduce computational time and to have a Matlab-independent version, we want to implement sIM-CoMeT in C/C++. Additionally, an embeddable algorithm to select the responsible dynamics driver for a given heating configuration has to be developed and implemented. This requires a strategy to distribute the effective heat flow rate of the heating cartridges and wall heaters onto the dynamics drivers. Once the interfaces have been implemented, real data of the IM melting probe can be used for validation and/or calibration.

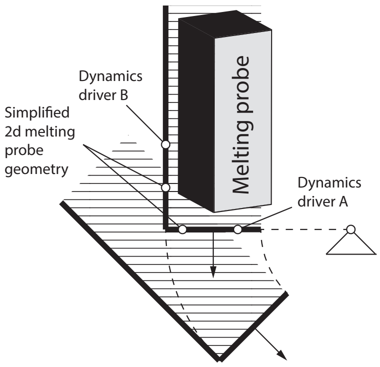

Figure: Schematic of the 2d curvilinear melting method applied to a 3d melting probe.

Objectives

- Implementation of a standalone C/C++ version of sIM-CoMeT
- Development and implementation of the thermal mapping
- Development of a decision tree reflecting the design of the IM (selection of the dynamics driver)
- Interface implementation
- Real data validation and/or calibration
- Software documentation

Requirements

- Knowledge of C/C++ (necessary) and Matlab (beneficial)
- Experience in software engineering and numerical code development
- Basic knowledge of heat transfer and fluid dynamics (beneficial)

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[1] http://enex.rwth-aachen.de

[2] Kowalski, J., et al. *Navigation technology for exploration of glacier ice with maneuverable melting probes.* Cold Regions Science and Technology 123 (2016): 53-70.

[2] Schüller, K., Julia Kowalski, and P. Råback. *Curvilinear melting - A preliminary experimental and numerical study.* International Journal of Heat and Mass Transfer 92 (2016): 884-892.