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Doctoral Thesis

Magnetohydrodynamic (MHD) numerical simulations and documentation within the EU project MEESST

MEESST

The goal of the EU project MEESST (Magnetohydrodynamic Enhanced Entry System for Space Transportation, https://meesst.eu/) is to exploit MHD effects using a first demonstrator of active magnetic shielding device, by means of both experiments and numerical simulations. This demonstrator is based on a superconductive coil system and is under development within MEESST. When a spacecraft enters the Earth's atmosphere on a hyperbolic trajectory, the air flowing around the spacecraft is ionized due to friction and creates a plasma sheath on the surface. Moreover, the spacecraft travels at hypersonic speeds such that a plasma shock is formed. This subjects the spacecraft to high heat loads that need to be mitigated. Since the particles in a plasma are negatively and positively charged, the flux can be controlled by an adequately strong magnetic field. The goal is to use superconductive coils in order to increase the shock standoff distance and to respectively decrease the heat flux loads. Powerful numerical tools are required to simulate such a complex phenomenon, which includes aero-dynamics, electromagnetism and thermochemical non-equilibrium. The numerical codes will support the design of the magnetic shielding device providing predictions of the behavior of the plasma around the spacecraft. Different codes from different institutions are used within the MEESST consortium.
The capabilities of the IRS in-house codes URANUS and SAMSA will be assessed via verification activities against the air test cases that are currently in preparation using the plasma facilities at the Van Karman Institute and at IRS. At first, air plasma tests without magnet have to be simulated using URANUS. Then, SAMSA has to be extended in order to simulate the air plasma chemistry and the implemented model will be verified against the experimental activities as well as the other simulations performed within the consortium. The latter can be performed in steps: the activity could be started with an air chemistry equilibrium model, then the non-equilibrium model can be implemented for the verification, the candidate has to perform the numerical rebuilding of relevant air plasma test cases. Documentation in English should also be produced. The activities will be supported by a team mate who previously performed Argon test cases using SAMSA.

Task description of the research work:

- Introduction to URANUS and SAMSA and documentation in English;
- Literature review of simplified MHD test cases and of air plasma thermo-chemical models;
- Simulation of "without magnet" conditions using URANUS
- Implementation of the air chemistry in SAMSA
- Simulation of "with magnet" conditions using SAMSA
- Participation in project meetings, reports and publications
- Post-processing of simulations (e.g. to assess Heat flux calculations, comparison plots)
- Final dissertation report

Notes:

- Start as soon as possible
- Good knowledge of English is required, experience with coding is recommended

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Orion re-etry capsule – NASA rendering

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