

# Project thesis

## Implicit Solution Techniques for Atmospheric Reentry Simulations

**Course of study:** Computational Engineering Science / Computer Science  
**Kind of thesis:** Programming and Simulation  
**Programming language:** C++  
**Start:** anytime, duration 3-6 months

### Problem

Atmospheric entry is the movement of human-made objects as they enter the atmosphere of a celestial body from outer space. It is crucial for the success of the mission to accurately predict the flowfield around the space craft which is flying at a very high speed (e.g. 10km/s).

This project's goal is the implementation of new implicit numerical solution methods as part of our new software project. Implicit methods allow unsteady computations with very large time steps in contrast to explicit methods, which need much smaller time steps. However, the use of implicit methods also requires important modifications of the simulation code.

### Preliminary work

Grid management and I/O routines are readily implemented. Furthermore, interfaces for visualization of simulation data via external tools (e.g. Paraview) are finished. Explicit solution methods are available.



Abbildung 1: Atmospheric reentry of space capsule.

### Task

The implementation of implicit solution algorithms includes

- implicit time discretization (single- and multi-step methods, Runge-Kutta methods,...)
- derivative computation (finite differences, analytical, automatic differentiation,...)
- non-linear solvers (Newton solver, dual time-stepping,...)
- linear solvers (iterative or direct) and preconditioners
- performance tests as well as analysis of the results

Depending on the group, the work can be divided into several parts. There can be a focus on specific parts and other extensions can be studies as well (e.g. adaptive time-stepping, error estimation,...).

### Supervision

Contact: **Julian Köllermeier, M.Sc.**  
Adress: Lehrstuhl für Mathematik (CCES)  
Schinkelstr. 2, 52062 Aachen  
Room: 328b (Rogowski building, 3rd floor)  
Tel.: +49(0)241 80 98664  
Email: koellermeier@mathcces.rwth-aachen.de