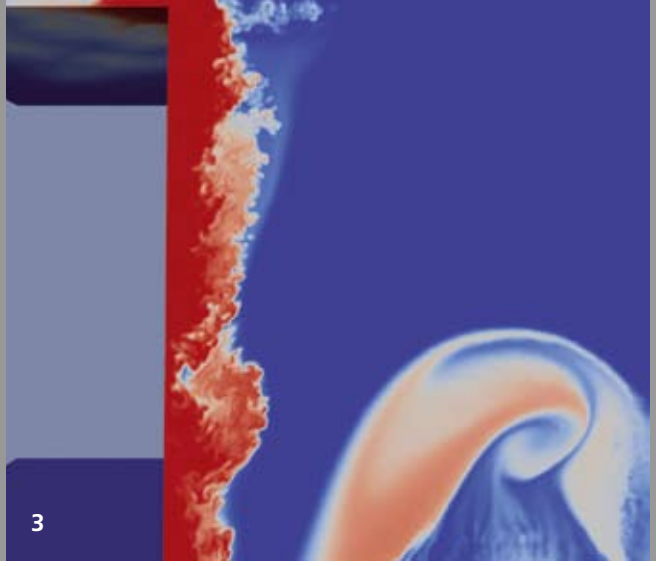

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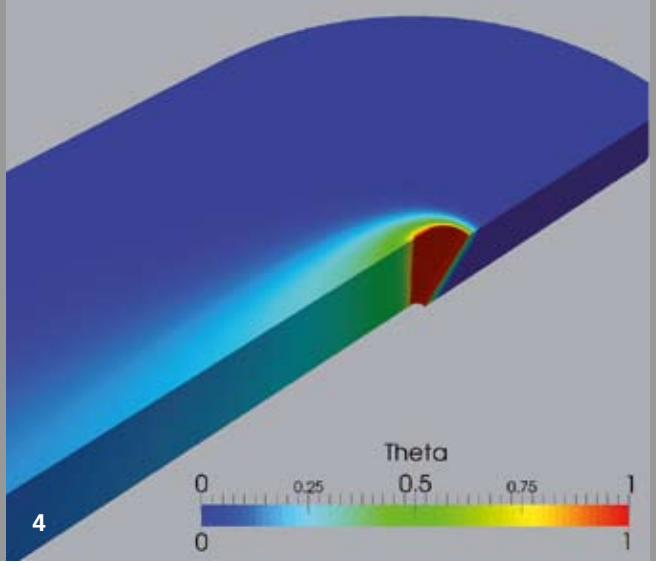

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SIMULATION – A NUMERICAL LIBRARY FOR LASER APPLICATIONS

Task

For laser materials processing, the correlation between the parameters and the quality of the processing result is often strongly non-linear and can even be discontinuous. For this reason, simulation is becoming more and more important for the analysis of dynamic processes, ones difficult to access at an experimental level. The multi-scale tasks to be solved are coupled to free boundaries. Simulations can only be utilized effectively, if the numerically task is quickly solved at sufficient spatial and temporal resolution.

Method

Beginning with the requirements of such multi-scale tasks and of high precision and spatial resolution in a boundary layer at simultaneously low calculation times, spectral elements and discontinuous Galerkin methods have been implemented. Using massive parallelization with MPI and OpenMP, the calculation times were drastically reduced. The motion of the free boundaries is described numerically with an interface capturing method, the so-called level set method. Level set methods represent robust and simultaneously precise numerical methods for describing complex surface movements, even when extreme changes in topologies appear.

Result

The numerical methods were implemented in a modular C++ library. This offers the ability to quickly and flexibly develop parallelized simulations according to the building block principle. Examples are the fast solving of a multi-component gas flow during laser oxygen cutting (Figure 3) and a calculation of surface movements and temperature during laser fusion cutting (Figure 4).

Applications

With this new calculation process, complex problems for laser materials processing can be simulated with high resolution in short computing times. Applications are, for example, the dimensioning of nozzles for gas flow during cutting, welding and drilling with laser radiation.

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3 Simulation of a turbulent multi-component flow during laser flame cutting.

4 Simulation of temperature distribution during laser fusion cutting with level set and spectral element methods.