

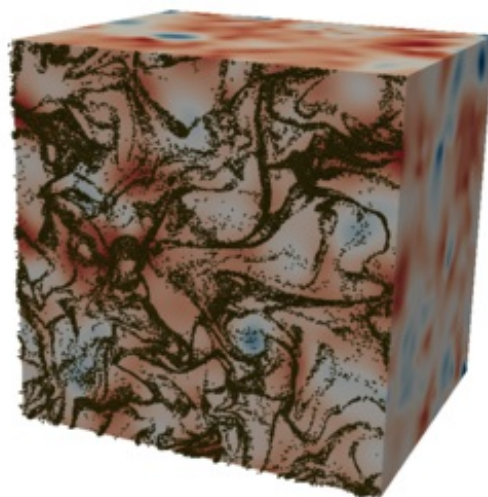


Multiphase Flow

Multiphase flows play a central role in mechanical process engineering, ranging from cavitating pumps and turbines to transporting particulate materials and the fabrication of paper and pellets. The amount of granular material, coal, grain, ore, etc. that is transported every year is enormous and very often that material is required to flow. Clearly, the ability to predict the fluid flow behaviour of these processes is central to the efficiency and effectiveness of those processes. A focal point of the Chair is aimed towards the understanding and modelling of multiphase flows, so we can accurately predict such processes. To enable this, we create and validate multiphase flow models for various types of multiphase flows across the scales.

Gas-Particle Flows

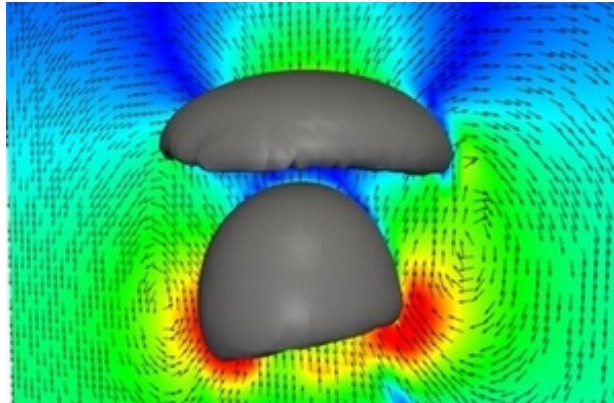
Gas-particle flows are present in many industrial processes and occur in various natural phenomena. Examples include solid waste incineration, rocket propellant combustion, fluidized bed reactors, cyclone separators, catalytic cracking, sprays, dust explosions, rain, snow, avalanches and sediment transport, to name just a few. The Chair has been studying the behaviour of gas-particle flows at the fundamental level as well as on industrial applications. At the fundamental level, studies of the interactions of particles with turbulence and the modification of turbulence by the presence of particles are carried out. Also, the effect of particle shape (i.e. non-spherical particles) has been studied extensively. State-of-the-art numerical models have been developed and validated to accurately describe turbulent gas-solid flows. These models are used to study the complex physics encountered in gas-solid flows, as well as predict the behaviour of industrially relevant flows, such as the flows in cyclones, inhalers, fluidized beds, sprays and combustors, to name a few.



Gas-Liquid Flows

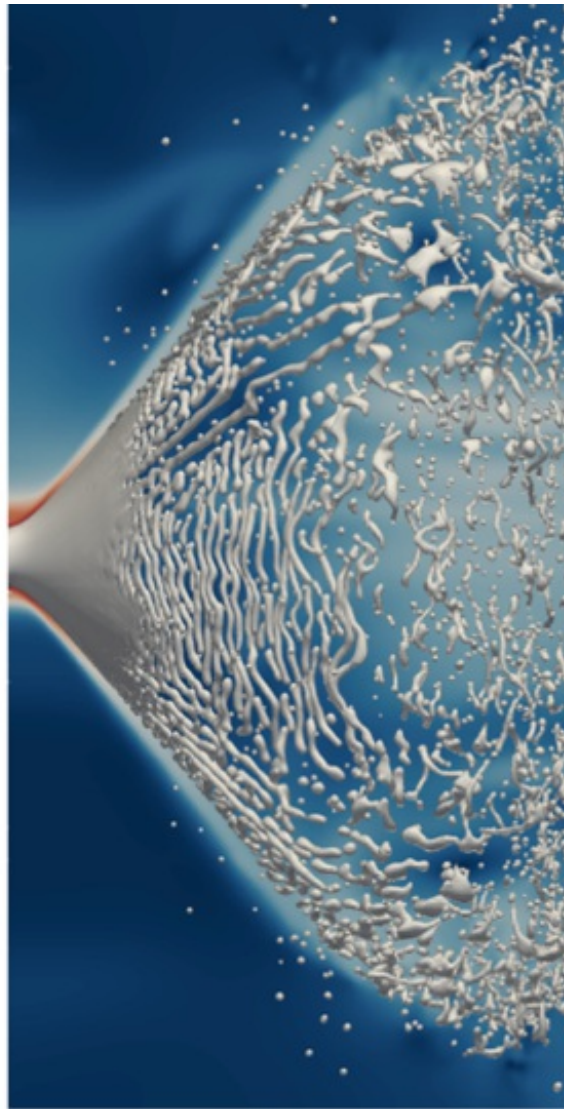
Interfacial flows, in which two or more immiscible fluids are separated by an interface where surface tension is a dominant hydrodynamic mechanism, called capillary systems, are ubiquitous in nature as well as in technical and technological applications, ranging from falling rain to inkjet printing. The research at the Chair focuses on the development of innovative computational methods for the prediction of the complex physical interactions of such flows and the application of these computational methods in the basic research of interfacial flows, thereby creating added

value for the related engineering applications. In addition, new interface flow algorithms for all Mach numbers have been developed at the Chair, to open up new research areas such as acoustic cavitation or fuel injection at supersonic speeds in ramjet engines.



Atomising liquid spray (hybrid) modelling

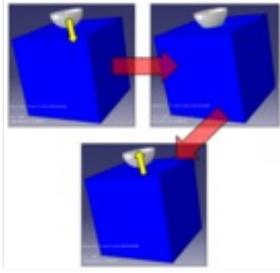
Gas-liquid flows of practical interest, such as liquid sprays, often involve temporal and spatial scales that span over several orders of magnitude. They exhibit complex flow dynamics due to the intricate geometry of the spray injector, interactions between the gas-liquid interface and turbulence, or surface-tension driven instabilities. To allow their accurate and cost-efficient modelling, we have developed a hybrid framework that fully resolves the complex interface dynamics in the primary atomisation region, and tracks the droplets present in the secondary atomisation region using the Euler-Lagrange framework. Liquid elements are transferred from one framework to the other throughout the simulation, based on physical and numerical threshold criteria.



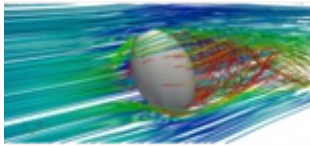
Across the scales

Studying multiphase flows across the scales means that research is carried out at different temporal and spatial scale, ranging from the study of individual particles or droplets, all the way up to full industrial apparatuses. At the scale of an individual particle or droplet, the fundamental physics are elucidated by carefully designed experiments and numerical models. Such insights help understand complex dynamics of colliding particles, the effect of surface tension, the behaviour of a triple-point, or the interaction of small-scale turbulence on a few particles, to name a few examples.

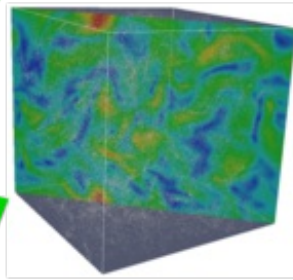
These insights gained at the small scale are used to improve our understanding of the „meso-scale“, the scale of clusters of droplets or particles, and the „macro-scale“, the scale of industrial processes. This improved understanding has led to a range of new and improved computational approaches and models, such as novel large eddy simulation models (LES) for gas-solid flows, novel Eulerian-Eulerian models for multiphase flows, and novel two-phase flow models to describe the complex behaviour of liquid films and droplets.



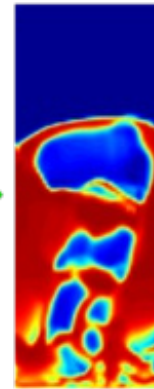
particle interactions
→ models for particle collisions



particle-fluid interactions
→ models for drag/lift/torque/coupling



particle-turbulence interaction
→ models for phase couplings



large-scale gas-solids simulation