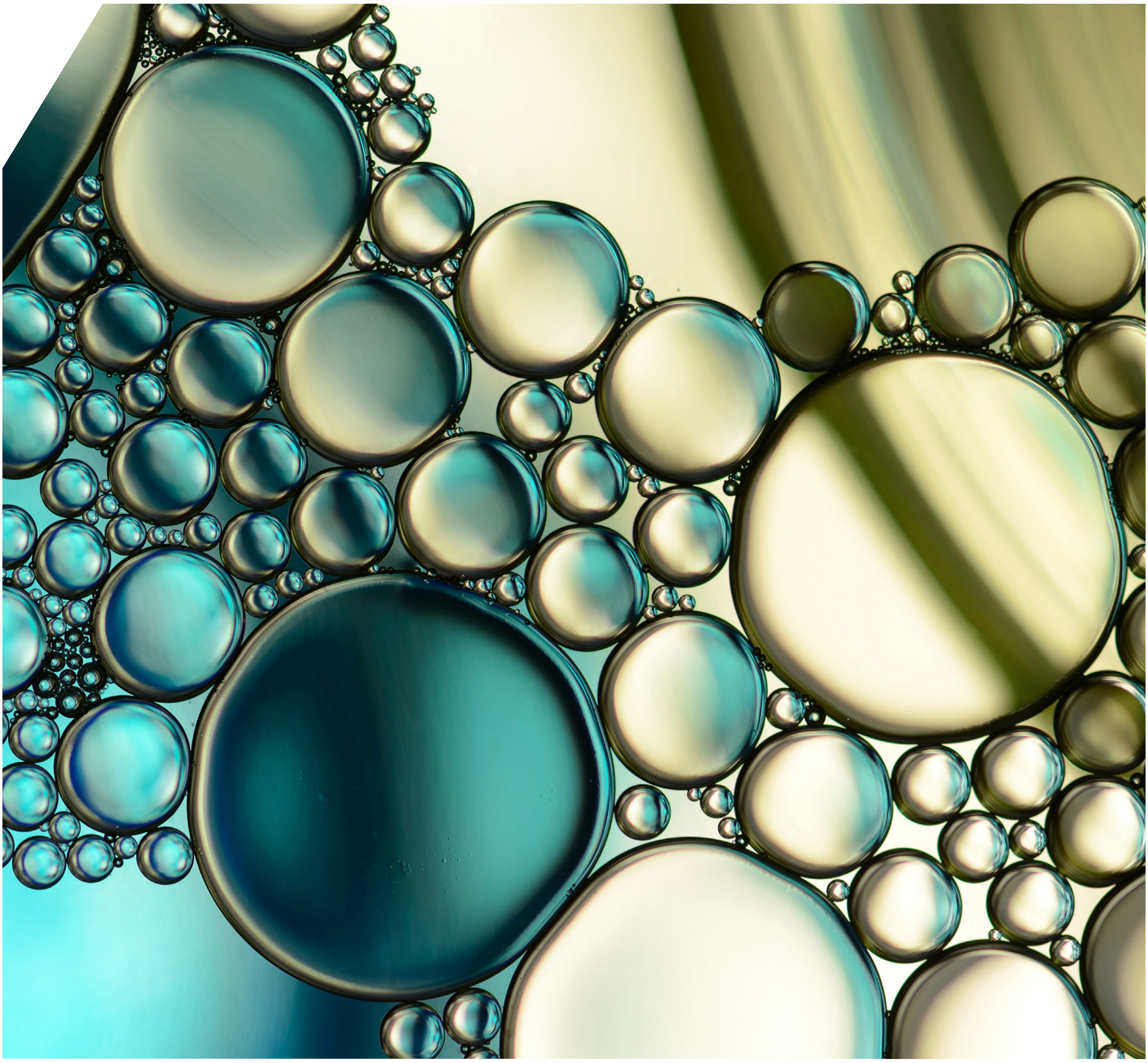


Computation of multiphase particle laden complex fluids

With ever-increasing computing power, it is possible to develop robust and accurate computational tools that can resolve the behavior of multiphase complex fluids.

Over the last five decades, particle dynamics in viscoelastic fluids have been extensively studied experimentally; however, the interplay of multiple physical variables and flow parameters turn experiments into a high-dimensional challenge. Therefore, when dealing with such complex fluid/solid multiphase systems, the availability of comprehensive computational fluid dynamic (CFD) tools can play a major role in exploring parameter space.

With ever-increasing computing power, it is possible to develop robust and accurate computational tools that can resolve the behavior of multiphase complex fluids, involving the effects of microstructural evolution, nonlinear matrix fluid rheology, particle and fluid inertia, viscoelasticity, flow-unsteadiness, and many-body interactions, in addition to complex multi-connected and evolving computational domains.

scientific challenge

The flow of complex fluids is an ubiquitous problem in advanced manufacturing operations. For example; polymer processing of highly-filled viscoelastic melts and elastomers, cementing and hydraulic fracturing operations using solids-filled muds and slurries, as well as biological applications, e.g the flow-induced migration of circulating cancer cells in biopolymeric media such as blood.

In a viscoelastic fluid, in addition to the complexities derived from the particle shape and volume fraction, the presence of a wide range of internal time-scales and length-scales describing the material microstructure makes the dynamics very challenging to parameterize, both experimentally and numerically. For the latter to be applied to systems with a large number of particles, a detailed coupling model, between the discrete and continuous phases, is required, and it should integrate all interactions on various length scales.

solution

To simulate the bulk flow of complex fluids, comprising a viscoelastic fluid with disperse particles, a robust three-dimensional numerical model, based on the Eulerian-Lagrangian multiphase approach, is being developed. This model integrates the presence of particles as the discrete phase embedded in a viscoelastic fluid, which is treated as a continuum phase. The continuity, momentum and constitutive rheology equations are solved for the viscoelastic continuum, and a momentum exchange model is used to couple the constituent phases.

Several constitutive laws for drag, lift, hindrance and retardation are required to account for the transport of the discrete phase. To develop drag and lift models, we use a detailed 3D numerical model to study the viscoelastic flow past a single particle. For the hindrance and retardation, we separately consider the flow past a collection of particles randomly distributed, which involves a large number of production runs, O(104). These extensive CFD investigations with detailed meshes, requires powerful computing resources as offered by our Gompute HPC platform.

The capacity of the cluster and booking scheme can be customized conveniently to meet the requirements of this computational rheological framework. The opensource computational library OpenFOAM® is being used to perform all the studies and numerical developments.

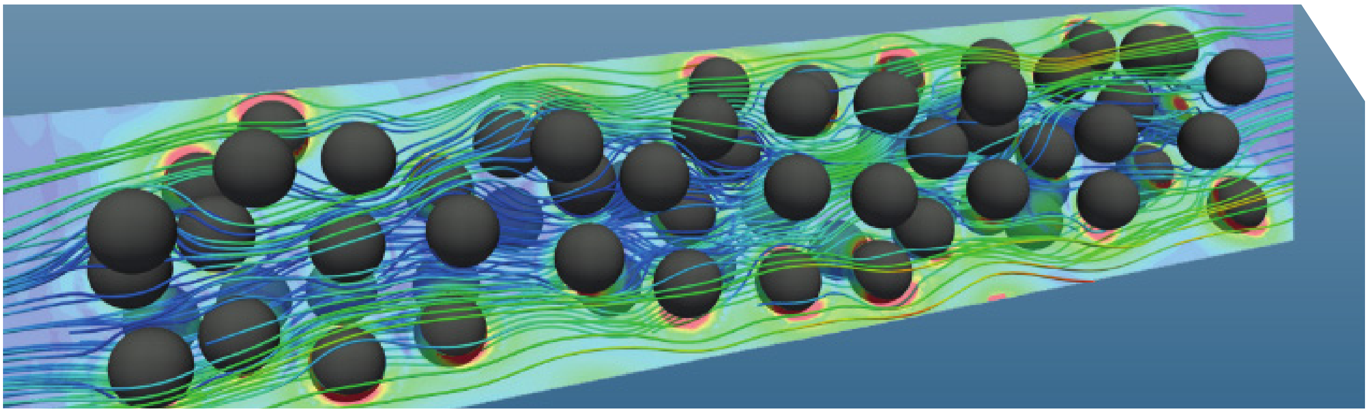
About OpenFOAM

OpenFOAM is the free, open source CFD software developed primarily by OpenCFD Ltd since 2004. It has a large user base across most areas of engineering and science, from both commercial and academic organisations.

OpenFOAM has an extensive range of features to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics.

results and benefits

The access to atNorth's Gompute HPC platform allows us to perform the large number of parametric numerical studies mandatory to devise accurate coupling models, covering a wide range of flow conditions and material system properties, within a reasonable timeframe. Moreover, with such computational power, the EulerianLagrangian solver under development can be used to study in detail the complex behavior of multiphase material systems of interest in several fields, such as: polymer processing, cementing and hydraulic fracturing operations and many biological applications. These possibilities are expected to provide us with a better understanding of the major underlying physical phenomena and, consequently, have a major impact on the design of systems composed of the multiphase complex materials of interest.



atNorth is a leading Nordic data center services company that offers sustainable, cost-effective, scalable colocation and high-performance computing services trusted by industry-leading organizations. The business acquired leading High Performance Computing (HPC) provider, Gompute, in 2023 enabling a compelling full stack offering tailored to AI and other critical high performance workloads.

With sustainability at its core, atNorth's data centers run on renewable energy resources and support circular economy principles. All atNorth sites leverage innovative design, power efficiency, and intelligent operations to provide long-term infrastructure and flexible colocation deployments. The tailor-made solutions enable businesses to calculate, simulate, train and visualize data workloads in an efficient, cost-optimized way.

atNorth is headquartered in Reykjavik, Iceland and operates seven data centers in strategic locations across the Nordics, with additional sites to open in Helsinki, Finland and in Ballerup, Denmark in Q2 2025, as well as its tenth under development in Kouvola, Finland and its eleventh site in Ølgod, Denmark

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