Data-Driven Approaches to Viscous Fluid Dynamics

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The modelling of a fluid-dynamical situation commonly consists of two separate steps: First, a collection of partial differential equations is derived from so-called first principles, which ensure constraints like conservation of mass and conservation of energy. Then, material properties of the fluid enter as constitutive laws, for example by relating the strain rate to the internal stresses. This leads to a well-posed problem and allows us to predict the fluid's behaviour. However, when choosing constitutive laws, a modelling error is introduced due to limited knowledge about the material.

In this project, we skip the process of fitting a constitutive law to experimental data and instead include the measurements directly in the problem formulation. The goal becomes: *Minimise the distance to the measurement dataset, whilst satisfying first principles.* The case of stationary fluid flows has been dealt with in [1], where they consider pairs of strain and stress measurements as data. Our goal is to extend these results to the time-dependent case, which would result in a new solution concept for fluid dynamics that is purely data-driven.

References

[1] Lienstromberg, C., Schiffer, S., Schubert, R., 2022. A data-driven approach to viscous fluid mechanics – the stationary case.