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A hybrid between sharp and diffuse interface methods

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Introduction
An important issue in the numerical computation of droplet deformation is the modeling of the interface. Generally, two methods are used:

- Sharp interface method, see e.g. Bazhlekov’s poster
- Diffuse interface method, see e.g. Keestra’s poster

The method presented here is a hybrid between these two methods. The advantage is that the position of the interface is accurately known, while time-consuming remeshing of the finite element mesh is not necessary.

Numerical Method
To determine the droplet deformation, an explicit time integration scheme is used, as is shown in figure 1. The velocity field is computed on a fixed finite element grid, whereas the droplet interface is given by the position of markers which are tracked in time.

Material parameters
The different rheology of the two fluids is taken into account by using the actual material parameters at the location of the integration points. An example is given in figure 2, which shows a Poiseuille flow for two Newtonian fluids of different viscosity with the interface at one third of the tube radius.

Interfacial tension
In contrast, the influence of the interfacial tension is spread out over the entire element and its neighbors. The total force on the element is divided by the element’s volume and implemented in the FEM code as an ordinary volume force.

Results
Figure 4 shows the relaxation of a droplet. The difference between the experimentally and numerically obtained droplet width is mainly due to the different type of flow before $t = 0$.

Conclusions
- The numerical method accurately describes droplet deformation, and is able to predict breakup.
- The method can in principle be combined with any FEM model, to determine, for example, the influence of viscoelasticity on droplet deformation.