Motivation

The mechanical properties of biological cells are promising biomarkers to differentiate for example cell phenotypes, cell states or the healthiness of cells [1, 2]. Real-time deformability cytometry (RT-DC) allows probing the elasticity of ~1000 cells / s by imaging the cells flowing through a microfluidic channel [1]. In this project, we set up a new numerical model to incorporate not only elasticity but also viscoelasticity.

Results

The stationary deformations of the cells correspond with previous numerical experiments and experimental data. The viscosity significantly influences the evolution of the deformation towards the stationary state.

Computational Methods

We use a 3D two-way coupled FSI model to simulate the fluid flow (Laminar Flow interface) and the cell (Solid Mechanics interface with nearly incompressible, neo-Hookean hyperelastic material and Kelvin-Voigt viscoelasticity). The Moving Mesh interface with a swept mesh in the channel avoids numerical artifacts from re-meshing.

Conclusion

Our new numerical framework in COMSOL® reproduces previous experimental and numerical results and extends the model with viscoelasticity. Hopefully, this will allow us to probe not only elasticity but also viscoelasticity in RT-DC and pave the way for new biophysical insights.

References:
2. Urbanska et al., "Single-cell mechanical phenotype is an intrinsic marker of reprogramming and differentiation along the mouse neural lineage", Development, 2017