165th MSS-Seminar
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Room 00.156,
Cauerstraße 3, Erlangen.

What hard physics can we learn from soft hydrogel suspensions?

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Granular flows are often spatially heterogeneous featuring characteristic shear bands when strain accumulates. Understanding how such shear band localization emerges from microscopics is still a major challenge. One class of so-called non-local theories identified that the width of the shearing zone should depend on the local stress. I will discuss work in which we explicitly test this picture by introducing a uniquely stress-sensitive suspension: hydrogel suspensions. Such suspensions can be probed in a classic boundary-driven flow geometry in which shear bands can be well-tuned and characterized: the Split-Bottom Shear Cell (SBSC).

The stress-sensitive suspension is composed of mildly polydisperse soft, slippery hydrogel spheres submersed in water. We measure their flow profiles and rheology while controlling the confinement stress via hydrostatic effects and compression. We determine the average angular velocity profiles in the quasi-static flow regime using MRI-PIV and probe a range of flow speeds using discrete element method (DEM) simulations. We explicitly match a pressure-sensitive non-local granular fluidity (NGF) to the observed flow behavior. We find that shear bands for this type of suspension become extremely broad under the low confining stresses from the almost density-matched fluid particle mixture, while collapsing to a narrow shear zone under finite, externally imposed compression levels. The DEM and NGF results match the observations quantitatively, confirming the conjectured pressure sensitivity for suspensions and its role in NGF. To further emphasize the unique pressure sensitivity of the suspensions in general and the usefulness of the hydrogel suspension system in particular, we demonstrate a transition from yield stress to power law flow behavior from the rheology of the suspension.