CPP 73: Focus: Disordered Systems/Glasses under Shear (joint session CPP, DY)

Time: Thursday 15:30–17:00   Location: C 243

Invited Talk   CPP 73.1   Thu 15:30   C 243
Microscopic flows of complex suspensions — •Anke Lindner
— PMMH-ESPCI, Paris

The flow of complex suspensions is ubiquitous in nature and industrial
applications. Their non-Newtonian character is due to flow-induced
orientation, rearrangement, or deformation of microscopic objects sus-
pended in simple fluids. These objects can be isotropic or anisotropic,
rigid or deformable, active or passive. Linking the microstructure on
the particle level to the macroscopic response under flow is one of the
fundamental scientific challenges of soft matter physics. Recent micro-
fabrication techniques lead to a precise control of even complex particle
properties and new microfluidic rheometers show high resolution. Us-
ing these new approaches, we present two examples of flows of complex
suspensions in chosen microfluidic geometries which allow this link to
be established. First, we use a solution of flexible polymers, where
normal stresses are known to arise when the polymers are stretched
under flow and characterize the onset of elastic flow instability in a
serpentine channel as a function of its curvature. The calibrated ser-
pentine channel can then be used as a sensitive rheometer to detect
even small normal stresses in unknown suspensions. Second, we employ
a Y-channel, a powerful rheometer for measuring shear viscosities, to
study the viscosity of active suspensions of e-coli bacteria. In this way
we link the activity of the bacteria to the measured non-Newtonian
effective viscosity.

CPP 73.2   Thu 16:00   C 243
Thinning and Thickening in Active Microrheology — •Ting
Wang and Matthias Sperl — Institut für Materialphysik im Wel-
traum, DLR, Köln, Germany

When pulling a probe particle in a driven granular system with con-
stant velocity, one can characterize the probe by a velocity-dependent
friction coefficient. With increasing control velocity, the friction of the
probe keeps constant in the small-velocity regime (linear response), de-
creases in the moderate-velocity regime (thinning), and then increases
in the large-velocity regime (thickening).

There are three distinct processes behind those phenomena: diffu-
sion, damping and direct collision; the magnitude of the pulling ve-
locity determines which process dominates, resulting in thinning or
thickening behavior. We confirm this physics picture by stochastic
simulation.

CPP 73.3   Thu 16:15   C 243
**Transition to flow of binary glasses under applied stress or
strain rate** — •Marco Laurati[1], Tatjana Sentjabrskaja[1], Jan
Hendricks[1], Alan R Jacobs[2], George Petekidis[2], and Stefan
U Egelhaaf[1] — [1]Condensed Matter Physics Laboratory, Heinrich-
Heine University Düsseldorf — [2]IESL-FORTH, University of Crete

We investigate and compare the transition to flow of glasses composed
by two species of colloidal hard spheres presenting large size asym-
metry, upon application of a constant stress or constant shear rate.
The transition to flow of the binary glasses is affected by the com-
position of the mixture, and reflects changes in the prevailing caging
mechanism, i.e. transitions between different glass states [1]. Fur-

thermore, the timescales characterising the onset of flow significantly
differ depending on the nature of the applied field, i.e. stress or strain.
The relaxation of the accumulated stress after removal of the applied
field demonstrates the presence of residual stresses that can be tuned
through the mixture's composition. The recovery of strain after creep
reveals a non monotonic dependence of the recovery time as a func-
tion of the previously applied stress, with a maximum recovery time
observed in correspondence to the yield stress of the glass. [1] T. Sen-
tjabrskaja et al. (2014), Soft Matter, 10, 6546-6555.

CPP 73.4   Thu 16:30   C 243
**Yielding in concentrated colloidal dispersions: relation be-
tween stress overshoot and microscopic structure and dy-
namics** — Marco Laurati, Kevin Mutch, and •Stefan Egelhaaf
— Condensed Matter Physics Laboratory, Heinrich Heine University,
40225 Düsseldorf, Germany

The microscopic structure and dynamics of concentrated colloidal dis-
persions at different times after application of shear is determined using
confocal microscopy. When the stress overshoot occurs in the rheolog-
ical response, we observe super-diffusion and a maximally deformed
cage, i.e. maximum structural anisotropy [1,2]. The anisotropy is not
only characterized by a quadrupolar (angular momentum $l = 2$) distor-
tion expected by continuum elasticity theory, but also a higher order
hexadecupolar ($l = 4$) mode which marks the transition form reversible
elastic to irreversible plastic deformation [3]. This mode suggests that
yielding of local cages proceeds through the rearrangement of particles
in the first neighbour shells, which switch from the compressional to
the extensional axis. Also in the steady-state of shear, cage-breaking
events are found to persist. In addition to the anisotropic cage defor-
mation, yielding is also accompanied by a strong rise in the isotropic
($l = 0$) distortion, which corresponds to a pressure increase.
[1] N. Koumakis et al. (2012) Phys. Rev. Lett. 108, 098303.
[2] K.J. Mutch et al. (2013) Eur. Phys. J. - Special Topics 222, 2803.
[3] C.P. Amann et al. (2013) arxiv:1302.2030.

CPP 73.5   Thu 16:45   C 243
Continuum Mechanics Simulations in Glass Forming Liquids
— •Heliana Cardenas and Thomas Voigtmann — Deutsches Zen-
trum für Luft- und Raumfahrt, Köln, Germany

Amorphous glassy materials show complex flow features when they are
formed by solidification of dense liquids. An important feature of such
systems is the non-linear nature of the flow rule relating stresses and
strains when they are perturbed by external forces. The transition
itself is characterized by slow dynamics where the intrinsic relaxation
time plays a determining role on describing this behavior.

Schematically, the interaction of non-linear rheology and slow relax-
ation can be captured by so-called "fluidity" models, where the (spa-
tially local) structural relaxation rate is a function of flow rate. The
spatial dynamics of fluidity is controlled by a diffusion coefficient re-
lated to a cooperativity length scale.

We use finite volume method (FVM) to combine the resulting consti-
tutive equation with the Navier-Stokes equations to effectively describe
the flow behavior of glass-forming systems in various geometries and
for different time-dependent protocols.