Experimental report

10/01/2018

Proposal: **9-10-1508** **Council:** 10/2016

Title: Exploring the Origin of Viscoelasticity in Colloidal Suspensions

Research area: Physics

This proposal is a resubmission of 9-10-1472

Main proposer: **Wei Ren CHEN**

Experimental team: Takuya IWASHITA
Wei Ren CHEN
Takeshi EGAMI
Christopher LAM

Local contacts: Lionel PORCAR

Samples: Silica
Ethylene glycol

Instrument	Requested days	Allocated days	From	To
D22	4	4	17/02/2017	21/02/2017

Abstract:

Using charged colloidal suspension as a model system, we were able to connect the nonlinear rheological characteristics and the non-equilibrium microstructure under steady shear flow and proposed a new mechanism of deformation. We demonstrated that the nonlinear rheological behavior is a direct consequence of the presence of a localized elastic response within a certain length scale promoted by particle interaction. We believe that the presence of this 'elastic zone' is responsible of the nonlinear rheological behaviors of charged colloidal suspensions in general. To prove this hypothesis, we plan to investigate suspensions with the same volume fraction but different interaction potential by tuning the ionic strength of the solution in order to determine the dependence of the elastic zone with interaction potentials.

Dynamically Correlated Region in Sheared Colloidal Suspensions Revealed by Neutron Scattering

We investigate the flow behavior of colloidal suspensions using small-angle neutron scattering and rheology. Understanding the deformation behavior of colloidal materials is of fundamental as well as practical importance. Despite the significant progress made in the past decade by computational and experimental studies in the search of the microscopic connection between rheological properties and structural distortion, the influence of inter-particle potential on the nonlinear flow behavior has not been fully resolved. In this study, we report the observation of a dynamically correlated region (DCR) in a charge-stabilized colloidal glass by the combination of in-situ small-angle neutron scattering and rheometry. By examining the structure under a series of different shear rates, we demonstrate the existence of a dynamically correlated region (DCR), and may extract the shear-rate-dependent size (**Figure 1**). Using this, we have demonstrated that:

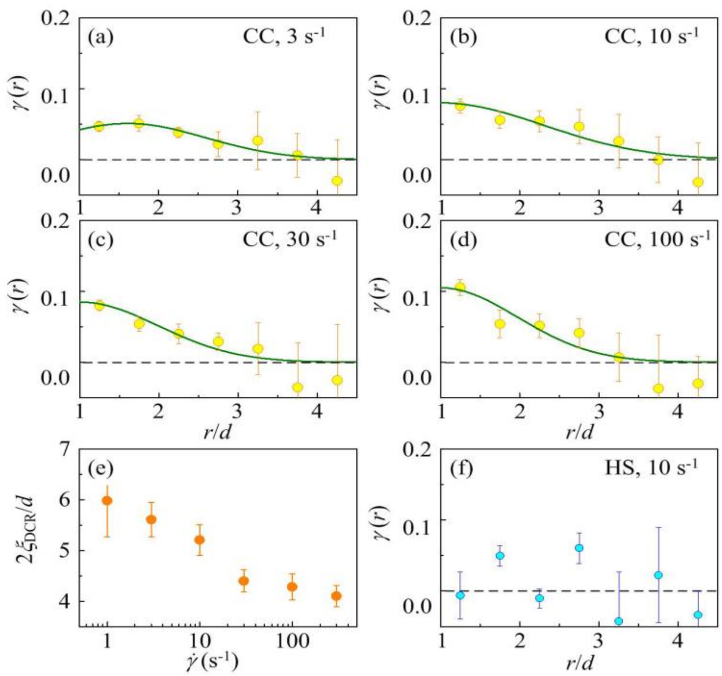

Figure 1. (a)-(d) Dynamically correlated region (DCR) of the charged colloidal (CC) suspension determined from Eqn. (1) at different shear rate; The symbols are experimental data and the green lines are fitting curves. (e) the size of DCR as a function of shear rate; (f) The result of the hard-sphere (HS) suspension with the same number density. No effective DCR is observed.

1. This short-lived and localized DCR, whose landscape is described by the particle distribution function $\gamma(r)$ extracted experimentally based on our theoretical approach, provides the configurational mechanism for resisting the imposed shear strain.

2. The evolution of the size of DCR correlates positively with the shear thinning phenomenon.

These findings not only identify the DCR as the elementary underlying mechanism for the macroscopic nonlinear flow behavior, but also highlights the important role of local mechanical correlations in determining the rheology of disorder materials. Moreover, they shed new light on understanding the flow and deformation behavior of soft matter with strong interactions. Lastly, by quantifying the effect of deformation cooperativity, our result provides a crucial benchmark for future first-principle theories of rheology.