Instabilities in the spatiotemporal dynamics of a shear-thickening cornstarch suspension

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Shear-thickening is a rheological property generally observed in highly concentrated suspensions and dispersions. For increasing imposed shear stresses σ above a critical value σ_c, the viscosity of the fluid $\eta = \sigma/\dot{\gamma}$ increases dramatically, $\dot{\gamma}$ being the suspension shear rate (Fig. 1Left). Recent theories predict that discontinuous shear thickening (DST) involves an instability, the nature of which remains elusive. Here, we explore unsteady dynamics in a dense cornstarch suspension by coupling long rheological measurements under constant shear stresses to ultrasound imaging. In [1], we demonstrate that unsteadiness in DST results from localized bands that travel along the vorticity direction with a specific signature on the global shear rate response ((Fig. 1Right). These propagating events coexist with quiescent phases for stresses slightly above DST onset, resulting in intermittent, turbulentlike dynamics. Deeper into DST, events proliferate, leading to simpler, Gaussian dynamics. We interpret our results in terms of unstable vorticity bands as inferred from recent model and numerical simulations [2].

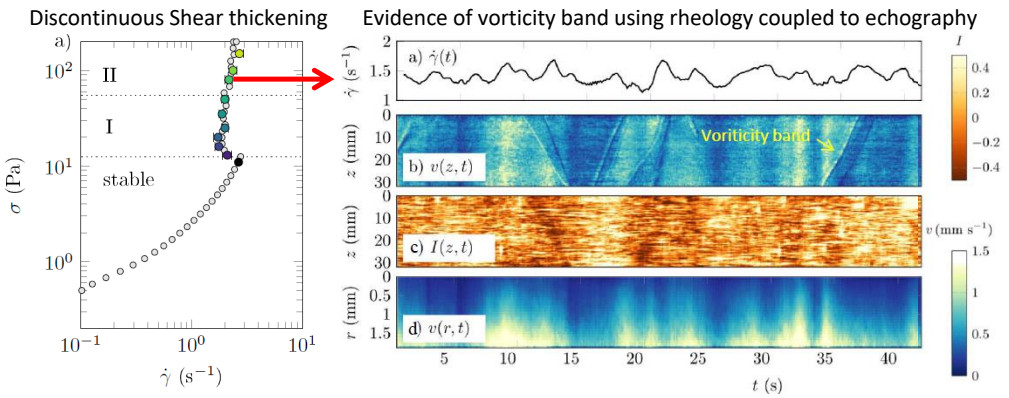

Figure 1. Vorticity bands in shear thickening suspensions (cornstarch). Right : flow curve of the corn starch suspension. Left : spatio temporal graphs of the velocity $v(r, z, t)$ and the intensity $I(r, z, t)$ (proportional to the cornstrach local concentration) in cornstarch suspension in the DST regime. Graph (b) shows the presence of vorticity band.

Références

1. R. N. Chacko & et al., Dynamic vorticity banding in discontinuously shear thickening suspensions, *PRL*, **131**, 108003 (2018).
2. B. Saint-Michel & T. Gibaud & S. Manneville, Uncovering instabilities in the spatiotemporal dynamics of a shear-thickening cornstarch suspension, *PRX*, **8**, 031006 (2018).