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Chaos

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Cite as: Chaos **20**, 041105 (2010); https://doi.org/10.1063/1.3493418
Submitted: 17 July 2010 . Published Online: 30 December 2010

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(Received 17 July 2010; published online 30 December 2010)
[doi:10.1063/1.3493418]

Granular materials are difficult to study in three dimensions because of their opacity: Only their surface is directly visible. In close collaboration with Losert's group, we have built an "index matched scanning" device,[1,2] which allows us to study the full three-dimensional (3D) structure and flow of grains suspended in a liquid.

The device works by immersing transparent particles in a fluorescently dyed transparent fluid with the same refractive index. The resulting clear medium is imaged slice by slice by illuminating the medium with a laser sheet and recording the illuminated cross sections with a camera [Fig. 1(a)].

We use this device to probe the motion of a very dense suspension, driven very slowly at $\Omega=5\times 10^{-2}$ rps, by a rotating disk at the bottom of a box [Fig. 1(b)]. The 3D particle positions of virtually all the particles in the dense suspension can be tracked. Particle trajectories, examples of which are shown in Fig. 1(c), can be traced over time. In Fig. 2 we show, from different angles, snapshots of the instantaneous 3D flow field. Close to the bottom the particles comove with the rotating disk as shown in Fig. 2(a). In Fig. 2(b) half of all the particles are left out to reveal the 3D structure of the shearband inside the suspension.

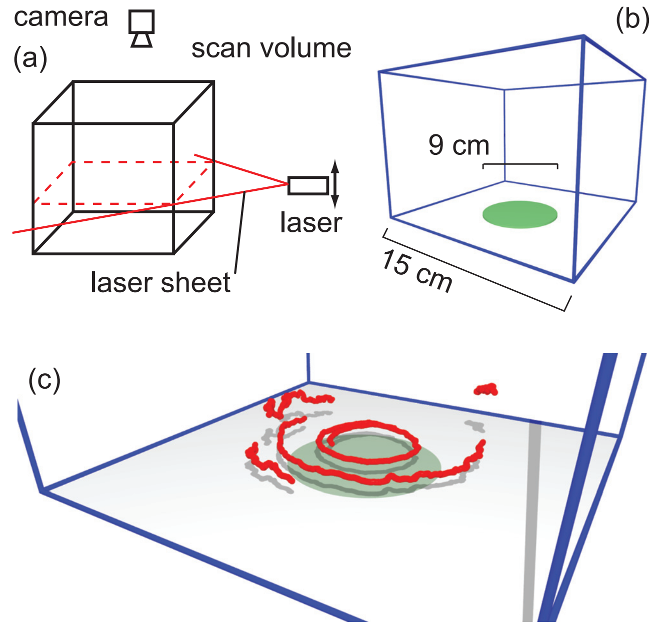

FIG. 1. (Color) (a) Sketch of the setup. The laser moves to illuminate slice by slice the whole scan volume. Slices are imaged with a digital camera. (b) The suspension, consisting of particles of 5 mm, is driven by a rotating disk. (c) Particle trajectories in the suspension.

This work was financially supported by the Dutch physics foundation FOM.

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[2]J. A. Dijksman, E. Wandersman, S. Slotterback, C. R. Berardi, W. D. Updegraff, M. van Hecke, and W. Losert, arXiv:0907.0114.

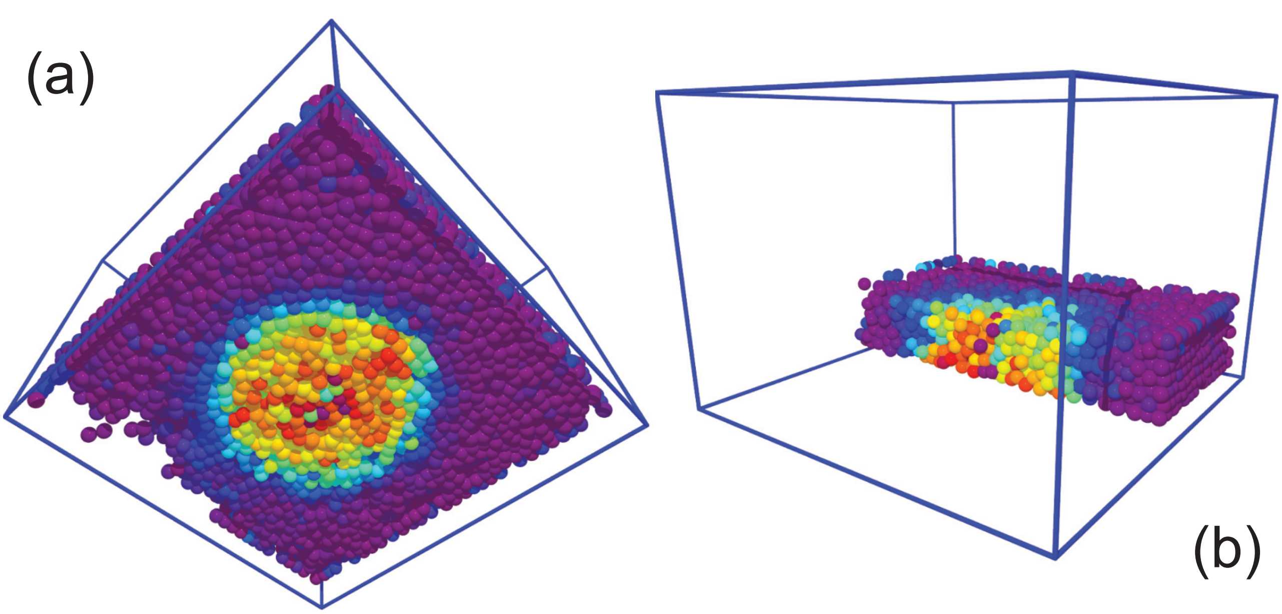

FIG. 2. (Color) Instantaneous velocity fields in the suspension: (a) view at the bottom particles close to the disk; (b) with half the particles removed. Color indicates the angular velocity; red=Ω, purple=0 (enhanced online) [URL: http://dx.doi.org/10.1063/1.3493418.1].

