Orientational order and alignment of elongated particles induced by shear

Tamás Börzsönyi[1], Balázs Szabó[1], Gábor Törös[1], Sandra Wegner[2], János Török[3], Ellák Somfai[4], Tomasz Bien[2] and Ralf Stannarius[2]

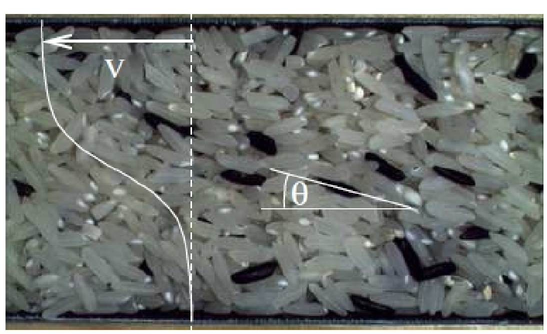
[1]*Research Institute for Solid State Physics and Optics, P.O. Box 49, H-1525 Budapest, Hungary**

[2]*Otto-von-Guericke-University, D-39106 Magdeburg, Germany*

[3]*Faculty of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany*

[4]*Department of Physics and Centre for Complexity Science, University of Warwick, Coventry CV4 7AL, UK*

Flow of large ensembles of elongated objects — often observed in nature or industry — usually induces pronounced alignment of the building blocks. This phenomenon is found at all length scales, in log jams on rivers, in seeds, nanorods, viruses, and even at molecular scales in nematic liquid crystals. On one hand, such alignment processes are poorly characterized for macroscopic objects, even though granular flows have been extensively studied in the last two decades. On the other hand, shear alignment and collective reorientation dynamics is well documented and exploited at molecular scale (for nematic liquid crystals) and can be described quantitatively by continuum theory. Here we show that shear alignment of ensembles of macroscopic particles is very similar to molecular systems, despite the completely different types of particle interactions. We demonstrate that for dry elongated grains the preferred orientation forms a small angle θ with the streamlines (*see the image below*), independent of shear rate across three decades. This angle decreases with increasing aspect ratio of the particles. The shear-induced alignment results in a considerable reduction of the effective friction of the granular material.



*Electronic address: btamas@szfki.hu