# Hydrodynamic theory of wet particle systems

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## Project description

The objective of the proposed research project is to develop a hydrodynamic description of the flow of wet granular materials, which is based on detailed knowledge of the links between micro-scale and macro-scale material parameters.

## Publications:

(1) Schwarze, R., Gladkyy, A., Uhlig, F., Luding, S.: Rheology of weakly wetted granular materials: a comparison of experimental and numerical data. Granular Matter **15**(4), 455 – 465 (2013). doi 10.1007/s10035-013-0430-z.

(2) Schwarze, R., Gladkyy, Luding, S.: Critical state flow rules for cfd simulations of wet granular flows. Fundamentals and Applications PARTICLES 2013 153 – 164 (2013).

(3) Gladkyy, A., Schwarze, R.: Rheology of weakly wetted granular materials: a comparison of experimental and numerical data. Granular Matter (accepted). doi 10.1007/s10035-014-0527-z.

## Presentations:

(i) March 2013, Numerische Rheologie feuchter, granularer Materialien, ProcNet, Weimar, Germany

(ii) September 2013, Critical state flow rules for CFD simulations of wet granular flows, Particles 2013, Stuttgart, Germany

(iii) July 2014, Applications of DEM at TU Bergakademie Freiberg, 1st Yade Workshop, Grenoble, France

## Contributed Open-Source projects:

A) Rheometeranalyze, License GPL-3. The program is written to analyze the DEM-simulations of rheometer. Used for micro-macro transition of simulated data. The software is written from scratch. Techniques: C++, Boost, VTK, ALGLIB, Eigen3, CMake.

B) Yade, License GPL-2. Yade is an extensible open-source framework for discrete numerical models, focused on Discrete Element Method. Implemented capillary bridge models on the base of viscoelastic contact model. Techniques: C++, Boost, VTK, Python, Eigen3, CMake.

C) Gapart, License GPL-3. Gapart is the program to modify particle-pack-files for DEM-simulations. The program is used to move, scale, mark, cut particles etc. The software is written from scratch.

## Ongoing Efforts:

a) DEM-simulations and analyze of dry and weakly wetted granular material. The used geometry of the shear-cell is a split-bottom construction. Also different geometries of shear cells were investigated.

b) Implementation and comparison of different capillary bridge models. Although force-displacement curves are showing some differences, macro parameters of sheared material do not depend on capillary bridge model visibly. The liquid content change the cohesiveness of the sheared material (see (3) for more details).

c) Implementation and analyze of liquid migration model.

d) CFD-simulations of the shear-cell.