107th MSS-Seminar
Wednesday, February 15th, 15:30
Nägelsbachstr. 49b

From density functional theory for adsorption layers to statistical models of large ensembles of sliding drops

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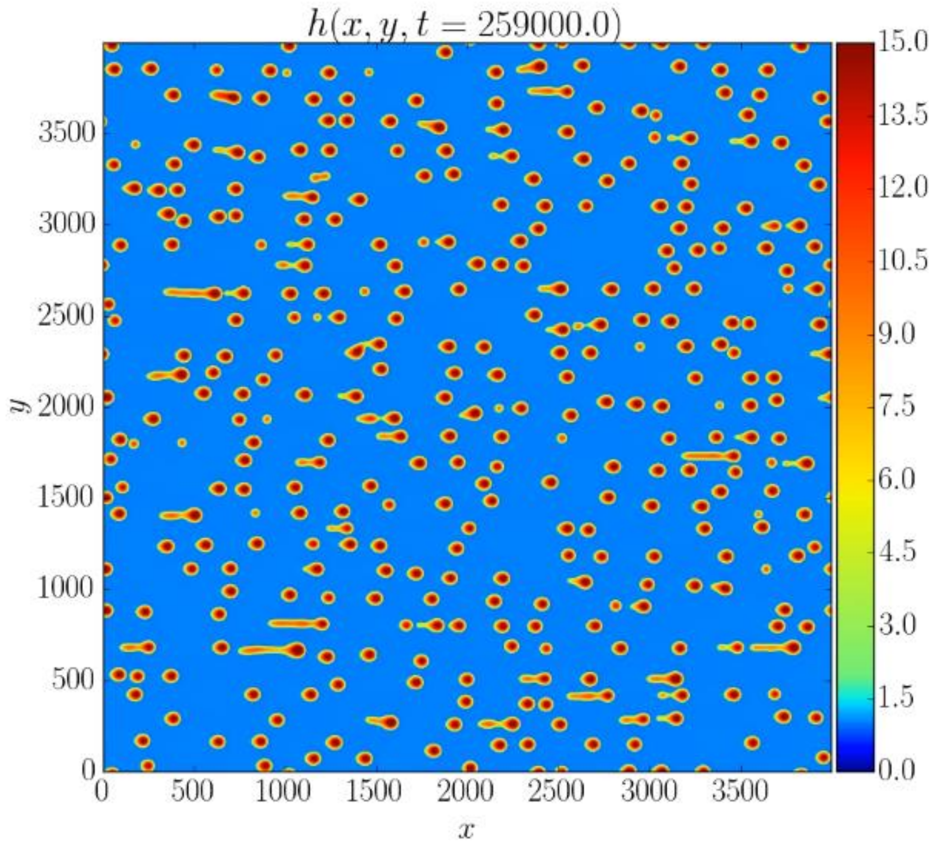

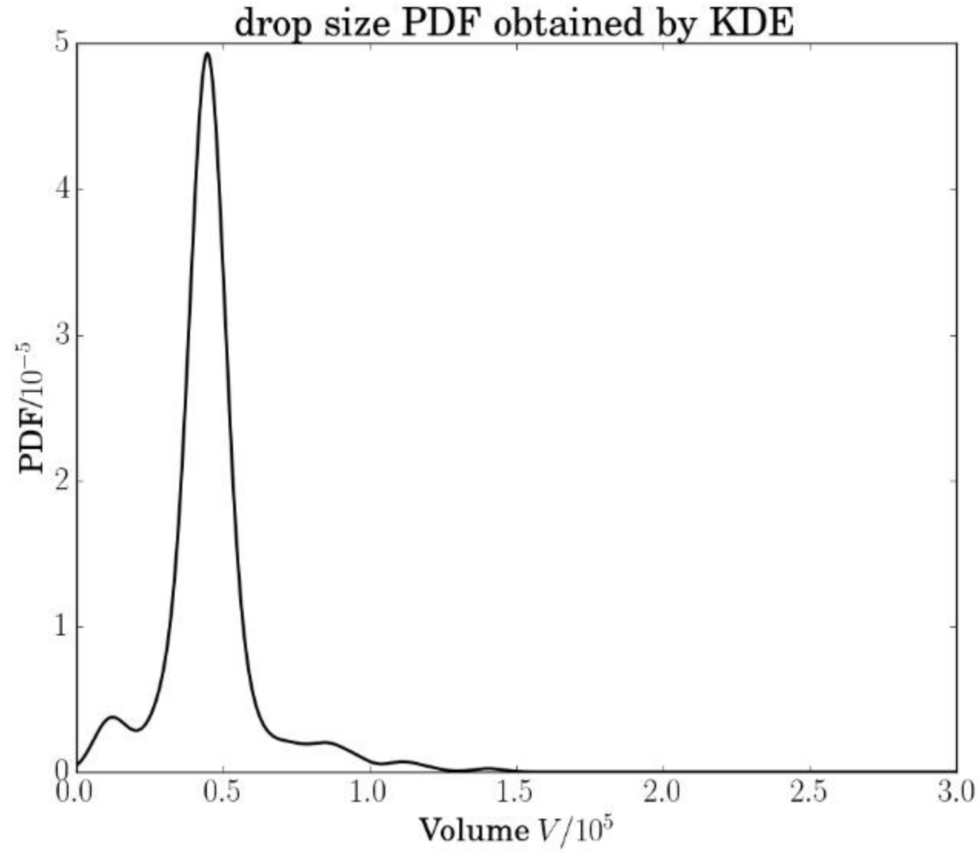

After a brief review of a number of experiments on dewetting/spreading/sliding thin films/drops of simple liquids we introduce the concept of a gradient dynamics (hydrodynamic long-wave) model for the evolution of interface-dominated films and drops on solid substrates.

Next, we employ classical density functional theory (DFT) [1] to determine wetting potentials and Derjaguin (disjoining) pressures that encode the adsorption and wetting behaviour of liquids at solid substrates including the possible layered packing of molecules at the substrate [2]. These pressures are incorporated in the dynamical model. As an example we consider the spreading of individual (terraced) drops on both, an adsorption (or precursor) layer and completely dry substrates. To achieve this, the model is modified such that for very thin layers a diffusion equation is recovered [3].

Next, we study the dynamics of individual sliding drops on an incline [4]. In particular, we employ continuation techniques to analyse sliding drops and their transformations in dependence of the driving force. We show that a number of shape transitions occur at saddle-node bifurcations. Further there is a global bifurcation that results in dynamic states where a main sliding droplet emits small satellite droplets at its rear (pearling instability) that subsequently coalesce with the next droplet. These pearling states show the period-doubling route to chaos [5].

The single-drop results are then related to direct numerical simulations on a large domain that examine the interaction of many sliding drops. The ongoing merging and pearling behavior results in a stationary distribution of drop sizes, whose shape depends on the substrate inclination and the overall liquid volume. We illustrate that aspects of the steady long-time drop size distribution may be deduced from the bifurcation diagrams for individual drops. In the final coarse graining step we use the single-drop diagram to construct a statistical model for the time evolution of the drop size distribution and show that it captures the main features of the full scale simulations.

[1] A.P. Hughes, U. Thiele, and A.J. Archer, Am. J. Phys. 82, 1119-1129 (2014).

[2] A.P. Hughes, U. Thiele and A.J. Archer, J. Chem. Phys. 142, 074702 (2015) and preprint at http://arxiv.org/abs/1611.06957.

[3] H. Yin, D.N. Sibley, U. Thiele and A.J. Archer, preprint at http://arxiv.org/abs/1611.00390.

[4] T. Podgorski, J.-M. Flesselles and L. Limat, Phys. Rev. Lett. 87, 036102 (2001).

[5] S. Engelnkemper, M. Wilczek, S. V. Gurevich and U. Thiele, Phys. Rev. Fluids 1, 073901 (2016).