Adaptive coupling of Marangoni convection at droplet ensembles

Karin Schwarzenberger[1,2], Marcel Mokbel[3], Norbert Weber[1], Sebastian Aland[3], Kerstin Eckert[1,2]

[1] *Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany*
[2] *Institute of Process Engineering and Environmental Technology, TU Dresden, 01062 Dresden, Germany*
[3] *Faculty of Informatics/Mathematics, HTW Dresden, 01069 Dresden, Germany*

Marangoni convection is a small-scale flow caused by gradients of interfacial tension. It can show spatio-temporal structures in the form of relaxation oscillations (ROs) due to subsequent consumption and regeneration of its driving force [1]. Works published on this topic indicate that several effects may induce ROs, such as adsorption kinetics of the surface-active solute [1,2].

In this study, we present ROs observed at ensembles of droplets placed in a vertical concentration gradient of a simple alcohol. The generated oscillation frequency immediately adapts to the local concentration gradient. Depending on the distance between the droplets, convective interaction can lead to a synchronization of the ROs over the whole ensemble. Our experimental findings are supported by 2D numerical simulations which assume a linear concentration gradient [3]. As shown in Fig. 1, this simplified model is capable of reproducing the synchronization of ROs observed experimentally. By our combined experimental and numerical approach, we achieve a thorough understanding of the coupled convection-diffusion processes at the droplets depending on the system parameters [4]. Since the oscillation frequency is set by the local concentration gradient, the ROs can directly reveal information about the process state.

These findings are not only important for various configurations in nature and technology where concentration gradients of surface-active substances exist in the presence of drops or bubbles. The small length scale of Marangoni convection opens the possibility to utilize this effect for passive mixing [5] or information transmission in microfluidic devices [4].

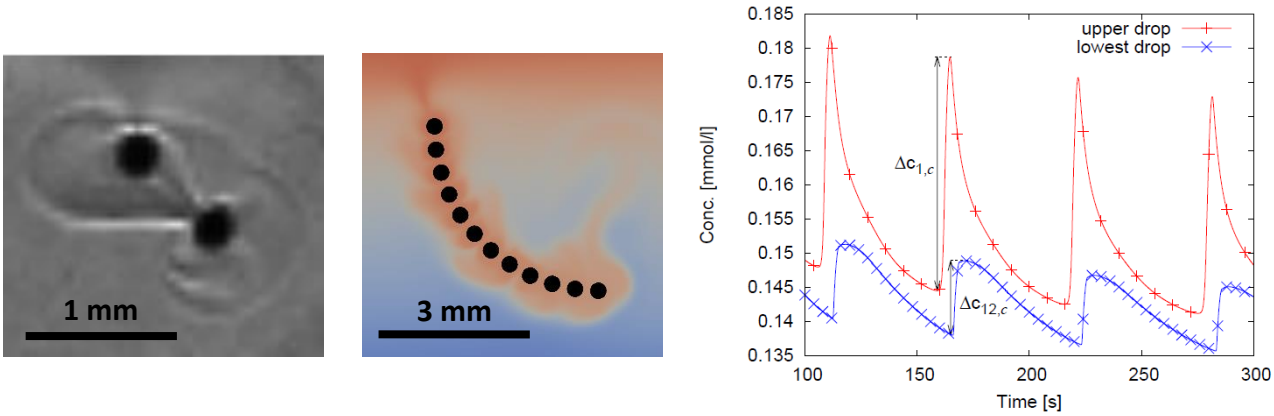

Figure 1. Convective interaction of droplet ROs [4] in experiment (left) and simulations (middle, right).

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[3] Schwarzenberger, Aland, Domnick, Odenbach, Eckert, *Coll. Surf. A* **481** (2015), 633.
[4] Mokbel, Schwarzenberger, Aland, Eckert, *Soft Matter* **14** (2018), 9250.
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