# Incremental identification of transport models in laminar wavy film flows

Falling films occur as a very thin liquid phase in a number of multiphase unit operations where heat and/or mass transport takes place, such as packed columns, falling film reactors or evaporative cooling towers. New application areas of falling films include separation, mixing and reaction in micro-falling film reactors. Falling film flows are known to exhibit complex dynamics and nonlinearity due to the developing surface waves. Experimental investigations have revealed that these surface waves play an important role in the intensification of heat and mass transfer. Despite its importance, this intensification is still not well understood and detailed transport models supporting the design of technical systems are still lacking.

The unstable and dynamical free boundary of the liquid phase renders the direct numerical solution of the detailed flow model in three space dimensions numerically complex and computationally demanding. In this work, we follow an alternative approach for supporting the design of technical systems relying on a simplified approximate model, which is capable to accurately depict the intensification of the transport processes. The real computational domain related to the liquid phase with dynamical free boundary is approximated by a simplified one with a known stationary boundary. In compensation, effective transport coefficients are introduced to capture the enhanced, wave-induced transport in the reduced computational domain. For these transport coefficients suitable transport models have to be developed.

The identification of a transport model structure and model parameters in transient, three-dimensional transport equations represents a complex, highly nonlinear inverse problem. A direct solution of such a problem is not attainable because of the lack of knowledge on the (correct) model structure and good initial values for the model parameters. In this work, we rely on the novel, rigorous method of incremental model identification, which decomposes the original identification problem into steps of easier to handle subproblems. This way, incremental model identification not only allows for the identification of the structure and the parameters of a transport model, but also supports the rigorous decision making on the best-suited transport model structure. As a result, a reliable transport model is identified, which is able to accurately represent the transport in the film flow. This method requires no a-priori knowledge on the unknown transport, which makes it especially adequate for real applications.

One further and very important subject matter when dealing with an accurate identification is the problem of design of an optimal experiment. This way, experimental conditions are determined, such that the measurement data collected from that experiment results in a model of high confidence. The most important methodical ingredient for the design of optimal experiments is the availability of an efficient and robust parameter estimation framework. Utilizing the steps of incremental model identification, in this work, we make important first steps towards the design of the optimal experimental conditions of a falling film experiment to result in a transport model of high precision both, in its structure and in its parameters.