**Radu Cimpeanu**

**Active control of liquid film flows: beyond reduced-order models**

The ability to robustly and efficiently control the dynamics of nonlinear systems lies at the heart of many current technological challenges, ranging from drug delivery systems to ensuring flight safety. Most such scenarios are too complex to tackle directly, and reduced-order modelling is used in order to create viable mathematical representations of the target systems. This simplified setting allows for the development of rigorous control-theoretical approaches, but the propagation of their effects back up the hierarchy and into real-world systems remains a significant challenge. Using the canonical setup of a liquid film falling down an inclined plane under the action of active controls, we develop a multi-level modelling framework containing both analytical models and direct numerical simulations acting as a computational platform. Three separate approaches will be described: 1. a simple yet powerful analytically-informed feedback strategy via blowing/suction (Cimpeanu, Gomes and Papageorgiou, Nonlinear Dynamics, 2021), 2. a linear-quadratic regulation optimal control methodology (Holroyd, Cimpeanu and Gomes, arXiv:2301.11379, 2023), and 3. a model-predictive control loop using electrostatic effects aimed at dripping prevention (Wray, Cimpeanu and Gomes, Physical Review Fluids, 2022). In each case the extended ranges of applicability of the hybrid mechanisms, as well as the detailed effects of the controls in terms of stability and treatment of nonlinearity, are examined in detail. This helps us gain a systematic understanding of the information transfer inside the flows, ultimately informing next-generation interfacial control strategies.