Programme

Below is the programme of the *EUROMECH Colloquium 666: Beyond the Free Surface: Liquid Film Flows from Theory to Applications*. Each day is organised into thematic sessions focusing on specific physical phenomena. **To access the abstracts of the presentations, simply click on the titles in the programme or scroll down**.

Wednesday 22: Capillary Flow and Thermal Effects

08:45-09:00 —— *Welcome Address* ——

08:50-09:00 *Opening Remarks from Prof. Stephen Wilson*

Session 1: Capillary Regime & Reduced Order Modelling

09:00-09:40 **Interfacial dripping faucet: generating monodisperse liquid lenses**
Prof. Javier Rodriguez-Rodriguez (Universidad Carlos III de Madrid)

09:40-10:20 **Adjustable formulations for modelling falling liquid film flows**
Prof. Christian Ruyer-Quil (Université Savoie Mont Blanc)

10:20-11:00 **Liquid film flows with surface-active agents**
Prof. Vasilis Bontozoglou (University of Thessaly)

11:00-11:30 ———— *Coffee Break* ————

11:30-12:10 **Three-Dimensional Dynamics of Falling Films in the Presence of Surfactants** Dr. Lyes Kahouadji (Imperial College London)

12:10-12:50 **Surfactants and liquid-infused surfaces: From ideal to real interfaces**
Prof. Shervin Bagheri (FLOW Center - KTH, Royal Institute of Technology)

12:50-13:30 **Evaporation and deposition of colloidal droplets on an inclined substrate**
Dr. Anna Kalogirou (University of Nottingham)

13:30-14:30 ———— *Lunch Break* ————

Session 2: Thermal Instabilities & Pattern Formation

14:30–15:10 **Evaporating Droplets on Soft Substrates: Interactions and Instabilities**
Prof. George Karapetsas (Aristotle University of Thessaloniki)

15:10–15:50 **Linear stability analysis of nonisothermal glass fiber drawing**
Prof. Benoit Scheid (Université Libre de Bruxelles)

15:50-16:20 ———— *Coffee Break* ————

16:20-17:00 **Thermal instabilities in thin liquid films: from evaporation to radiation**
Prof. Luca Biancofiore (University of L'Aquila)

Session 3: Industrial Talk 1

17:00-17:40 **Challenges in coalescence modelling for dense food emulsions**
Dr. Jo Janssen (Unilever R&D)

17:40-18:20 **Wing runback ice dynamics**
Dr. Ian Roberts (AeroTex UK)

18:20 – *Welcome Reception & Poster Session* –

Thursday 23: External Fields and Multiphysics Coupling

Session 4: Effects of Electromagnetic field

09:00-09:40 **Detailed measurements in film and other interfacial flows with heat transfer, phase change and reaction – challenges and opportunities**
Dr. Nathan Blanc (Imperial College London)

09:40-10:20 **A leaky-dielectric fluid pump**
Dr. Toby L. Kirk (University of Southampton)

10:20-11:00 **Mixing with magnetic field – the case of magnetic micro-convection**
Prof. Guntars Kitenbergs (University of Latvia)

11:00–11:30 ———— *Coffee Break* ————

11:30-12:10 **TBD** Prof. Demetrios Papageorgiou (Imperial College London)

12:10-12:40 **Instabilities in soap films**
Prof. Isabelle Cantat (Institut de Physique de Rennes)

12:40-13:30 **Optical phase mask fabrication by light-actuated closed-loop control of thermocapillary flow in liquid photopolymer films** Prof. Moran Bercovici (Technion - Israel Institute of Technology)

13:30-14:30 ———— *Lunch Break* ————

Session 5: Effects of Viscoelasticity, Acoustic waves and Evaporation

14:30-15:10 **Coating dynamics of acoustowetting oil films**
Prof. Linda J. Cummings (New Jersey Institute of Technology)

15:10-15:50 **Air-driven dynamics of viscoplastic liquid layers: mucus clearance by coughing** Prof. Duncan Robin Hewitt (University of Cambridge)

15:50-16:20 ———— *Coffee Break* ————

16:20-17:00 **Evaporation-driven solutocapillary flows in thin liquid films**
Dr. Mariana Rodriguez-Hakim (Universidad Nacional de Educación a Distancia)

17:00-17:40 **TBD** Dr. Rajesh Bhagat (University of Cambridge)

Session 6: Industrial Talk 2

17:40-18:20 **TBD** Dr. Nathaniel Baker (Renaissance Fusion)

18:20-19:00 **TBD** Mr. Patryk Wakuła (Sonte)

20:00- ———— *Conference Dinner* ————

Friday 24: Topological Modifications and Control Strategies

Session 7: Substrate Topological modification and film confinement

09:00-09:40 **Surrogate Modelling and optimisation of droplet motion on chemically patterned surfaces via automatic differentiation**
Prof. Nikos Savva (University of Cyprus)

09:40-10:20 **Dynamics of thin liquid films: Mapping out the interplay between forces.**
Prof. Jan Vermant (ETH Zürich)

10:20-11:00 **Evaporating rivulets and thin-film flow of nematics**
Prof. Stephen Wilson (University of Bath)

11:00-11:30 ———— *Coffee Break* ————

11:30-12:10 **Controlling the dewetting morphologies of thin liquid films on patterned and switchable substrates: insights from mesoscopic numerical simulations**
Dr. Andrea Scagliarini (Istituto per le Applicazioni del Calcolo - CNR)

12:10-12:50 **TBD**Prof. Camille Duprat (Ladhyx -École Polytechnique)

12:50-13:30 **Stability and Dynamics of Fluctuating Nanofilms**
Prof. James Sprittles (University of Warwick)

13:30-14:30 ———— *Lunch Break* ————

Session 8: Innovation, Control & Application

14:30-15:10 **TBD** Dr. Alice Thompson (University of Manchester)

15:10-15:50 **Controlling the Navier-Stokes equations** Dr. Alexander Wray (University of Strathclyde)

15:50-16:20 ———— *Coffee Break* ————

Session 9: Industrial Talk 3

16:20-17:00 **TBD** Dr. Lionel Vincent (Air Liquide)

17:00-17:40 *Closing Panel: Industry and Research Synergies*

Abstracts

Session 1: Capillary Regime & Reduced Order Modelling

Interfacial dripping faucet: generating monodisperse liquid lenses.

Prof. Javier Rodríguez Rodríguez
(Universidad Carlos III de Madrid)

The dripping faucet is familiar to many liquid matter scientists, both because of its practical use as a tool to generate monodisperse droplets, and its rich behaviour as a dynamical system. In this work, we present a surface analogue to a dripping faucet, where a viscous liquid slides down an immiscible liquid meniscus. Periodic pinch-off of the dripping filament is observed, generating a succession of monodisperse floating droplets – also called liquid lenses. We show that this interfacial dripping faucet can be described analogously to its single-phase counterpart, replacing surface tension by the spreading coefficient, and even undergoes a transition to a jetting regime.

Adjustable formulations for modelling falling liquid film flows.

Sanghasri Mukhopadhyay, Ranganathan Usha and Prof. Christian Ruyer-Quil
(Université Savoie Mont Blanc)

We consider a gravity driven falling liquid film on an inclined plane. We extend the parabolic-ellipse velocity profile proposed initially in Mukhopadhyay et al. JFM 952, R3 (2022) by adding a second parameter. We show that this parameter enables to adjust the velocity of the marginal linear kinematic waves in the limit of the an infinite wave number. We show that this formulation improves the accuracy of the prediction of the linear stability analysis with respect to the Orr-Sommerfeld equations. We also discuss the improvement of the prediction of the solitary wave characteristics (speed, amplitude and velocity profile) offered by this two-parameter formulation.

Liquid film flows with surface-active agents

Prof. Vasilis Bontozoglou
(University of Thessaly)

Three-Dimensional Dynamics of Falling Films in the Presence of Surfactants

Dr. Lyes Kahouadji
(Imperial College London)

Surfactants and liquid-infused surfaces: From ideal to real interfaces

Théo Lenavetier, Julien Cerutti, Zhuxuan Cui, Prof. Shervin Bagheri ✉
(FLOW Center, KTH, Royal Institute of Technology)

Textured surfaces impregnated with a viscous lubricant exhibit important functionalities—e.g. antifouling, drag reduction, and heat-transfer enhancement—when submerged and exposed to flow. We investigate the interplay between interface mobility, surfactant distribution, texture geometry, and lubricant drainage. Optical coherence tomography (OCT) is used to measure interface curvature and mobility, while simulations provide detailed insight into surfactant transport, including three-dimensional recirculation patterns. Combined with theory, we analyze the design of classical liquid-infused surfaces, showing that mobile interfaces necessarily undergo drainage, whereas stable interfaces exhibit limited mobility. Finally, we propose LIS designs based on strategies for removing contaminated interfaces and restoring interfacial mobility.

Evaporation and deposition of colloidal droplets on an inclined substrate

Dr. Anna Kalogirou
(University of Nottingham)

Evaporation of colloidal droplets on horizontal substrates is well studied, but far less is known about how substrate inclination alters internal flows and particle deposition. Recent laboratory experiments have shown that inclination can be used to control deposition patterns and have revealed the emergence of terraces near the contact lines. In this talk, I present a lubrication-based theoretical framework for evaporating colloidal droplets on inclined substrates, extending one-sided evaporation theory to incorporate structural oscillatory disjoining pressure. The latter is an essential component for reproducing terrace formation in the thin-film region. Numerical simulations based on this model reveal how gravity and capillary-driven flow interact to generate asymmetric internal flow structures and directional deposition patterns. These predictions are then compared with experimental observations across a range of inclination angles, validating the model and highlighting its ability to capture the number, size, and spatial distribution of particle terraces.

Session 2: Thermal Instabilities & Pattern Formation

Evaporating Droplets on Soft Substrates: Interactions and Instabilities

Prof. George Karapetsas
(Aristotle University of Thessaloniki)

We present a theoretical study of thin volatile droplets evaporating on soft viscoelastic substrates, addressing both droplet–droplet interactions and particle-laden evaporation. Using lubrication theory coupled with vapour diffusion in the gas phase and substrate elasticity, we account for evaporative cooling, Marangoni stresses, and contact-line dynamics. For droplet pairs, interactions arise through both the deformable substrate and the vapour field, leading to attraction, repulsion, or symmetry breaking depending on substrate stiffness and thermocapillarity. For particle-laden droplets, substrate compliance and particle transport promote secondary wetting ridges and can trigger symmetry-breaking oscillatory instabilities. The results reveal how elastocapillary, thermocapillary, and osmotic effects jointly shape evaporation dynamics on soft solids.

Linear stability analysis of nonisothermal glass fiber drawing

Prof. Benoit Scheid
(Université Libre de Bruxelles)

The draw resonance effect appears in fiber drawing processes when the draw ratio, defined as the ratio between the take-up and the inlet velocities, exceeds a critical value. In many cases, inertia, gravity, and surface tension cannot be neglected, and a model combining all these effects is necessary in order to correctly describe the physics of the phenomenon. Additionally, it is also known that cooling can have a highly stabilizing effect on the draw resonance instability. However, a detailed analysis encompassing the effect of inertia, gravity, surface tension, and temperature is still lacking. Due to a destabilizing effect induced by geometry in the heat equation, we first show that the maximum critical draw ratio for fiber drawing can be two orders of magnitude lower than the one for the film casting problem when the heat transfer coefficient is assumed constant. By introducing a scaling making the fiber aspect ratio an independent parameter, we next show that the high value of the critical draw ratio encountered in industrial applications could be rationalized only if we consider that the heat transfer coefficient is not constant but depends on both the velocity and the cross-section area of the fiber. Within this framework, we show how the practical stability window is affected by the five control parameters: the draw ratio, the fiber aspect ratio, the inlet temperature, the convective heat transfer coefficient, and the stiffness of the non-homogeneous ambient temperature. We finally discuss the influence of radiative heat transfer on the stability.

Reference: Philippi J., Bechert M., Chouffart Q., Waucquez C. & Scheid B., Linear stability analysis of nonisothermal glass fiber drawing, Physical Review Fluids 7, 043901 (2022)

Thermal instabilities in thin liquid films: from evaporation to radiation

Prof. Luca Biancofiore
(University of L'Aquila)

Thin liquid films are widely used for thermal management and energy applications, where interfacial dynamics strongly couple with heat transfer. In evaporating films, thermal effects such as latent heat removal, vapor recoil and thermocapillary stresses can profoundly modify interfacial stability, leading to complex instability mechanisms that remain only partially understood. In this talk, I first present recent results on evaporation-driven instabilities in falling and sheared thin films. Our recent work goes beyond classical one-sided formulations by introducing a two-phase model that explicitly accounts for vapor diffusion and its coupling with interfacial dynamics. In particular, we extend kinetic–diffusion evaporation models by consistently incorporating evaporative mass loss and film thinning, leading to reduced evolution equations derived via long-wave theory. This framework captures the competition between thermodynamic nonequilibrium at the interface and vapor diffusion in the gas phase, which naturally defines different evaporation regimes. The resulting reduced models reveal how evaporation alters classical instability thresholds and nonlinear wave dynamics through the interplay between Marangoni stresses, phase change and interfacial deformation, and highlight the emergence of distinct instability mechanisms depending on whether evaporation is transfer-rate-limited or diffusion-limited. In the final part, I discuss ongoing work aimed at extending these reduced descriptions beyond evaporation by incorporating radiative effects motivated by solar-driven applications. Radiation introduces new couplings through spatially varying heat fluxes and optical interactions at the liquid interface, opening new perspectives for the control and optimization of thermally driven thin-film flows.

Session 3: Industrial Talk 1

Challenges in coalescence modelling for dense food emulsions

Dr. Jo Janssen
(Unilever R&D)

Wing runback ice dynamics

Dr. Ian Roberts
(AeroTex UK)

When aircraft fly through clouds containing supercooled large droplets, large ice formation can form on the lifting surfaces and other components, presenting a significant hazard to safe flight. To prevent the formation of large ice shape, modern commercial aircraft wings have heating systems integrated into the leading edges. On the lower surface of the wing, anti-ice systems are designed to be running wet as whilst the formation on the main wing may increase drag, they do not pose a risk to the aircraft. The upper surface is where the lift is generated, and therefore the systems are designed to be fully-evaporative across most common conditions. Under the most severe or Supercooled Large Droplet conditions, full evaporation cannot be achieved resulting in the formation of runback ice accretions which may be in the form or roughness, ridges or frozen rivulets These shapes compromise the performance of the aircraft and therefore their formation needs to be better understood. The goal of this presentation is to present some challenges to the academic community related to film and droplet dynamics. The aim being to develop models that can improve our understanding of these formations and how they may be mitigated, through the use of coatings or other methods to remove the water from the surface.

Session 4: Effects of Electromagnetic field

Detailed measurements in film and other interfacial flows with heat transfer, phase change and reaction – challenges and opportunities

Dr. Nathan Blanc ✉ and Prof. Christos N. Markides ✉
(Clean Energy Processes (CEP) Laboratory, Department of Chemical Engineering, Imperial College London)

Clean Energy Processes (CEP) Laboratory, Department of Chemical Engineering, Imperial College London, London SW7 2AZ, U.K. The availability of spatiotemporally-resolved information in multiphase flows remains limited due to the challenges in performing such measurements. Interfacial flows, specifically, present unique challenges, such as restricted fluid domains, moving and complex interfaces, and large refractive index changes. Experimental techniques based on optical principles can provide information with high spatiotemporal resolution on important scalar and vector fields of interest. We will present efforts to develop and apply a variety of optical techniques to a range of interfacial flows, with a focus on simultaneous deployment for the provision of multiphysics information, and discuss the challenges faced when attempting such measurements in selected flows.

A leaky-dielectric fluid pump

Dr. Toby L. Kirk
(University of Southampton)

In this talk I will introduce a new architecture for pumping leaky-dielectric fluids arbitrary distances down microchannels. For two such fluids layered in a channel, the pumping mechanism utilizes Maxwell stresses on fluid interfaces (referred to as menisci) induced by a periodic array of electrode pairs inserted between the two fluids and separated by the menisci. The electrode pairs are asymmetrically spaced and held at different potentials, generating an electric field with variation along the menisci. To induce surface charge accumulation, an electric field (and thus current flow) is also imposed in the direction normal to the menisci. The existence of both a normal and tangential electric field gives rise to Maxwell stresses on each meniscus, driving the flow in opposite directions on adjacent menisci. But the asymmetric nature of the electrodes leads to one meniscus dominating, causing a net pumping in one direction. The pumping speed and direction can be controlled by the (four) potentials of the electrodes. In the analysis, matched asymptotic expansions are employed, together with complex conformal mapping methods to produce closed-form solutions (rare for a nontrivial multiphase flow) for the pumping speed.

Mixing with magnetic field – the case of magnetic micro-convection

Prof. Guntars Kitenbergs
(University of Latvia)

External magnetic field can induce an instability driven flows across a miscible magnetic fluid and water interface, forming peculiar finger like patterns. This phenomenon - magnetic micro-convection – not only allows to tune microfluidic mixing with an external field but also provides an interesting multiphysics problem with an interplay between diffusion, magnetism and gravity. I will show how careful experimental work and extended simulations allow to unravel the peculiarities of this complex phenomenon.

TBD

Prof. Demetrios Papageorgiou
(Imperial College London)

Instabilities in soap films

Prof. Isabelle, Cantat ✉, Corentin Tregouet
(Institut de Physique de Rennes)

Even though liquid foams and bubble suspensions are ubiquitous in everyday life and industrial processes, their ageing and eventual destruction remain a puzzling problem. In the presence of surfactants, thin liquid films are known to drain through marginal regeneration, which involves periodic patterns of film thickness along the rim of the film. The origin of these patterns in horizontal films (i.e. neglecting gravity) still resists theoretical modelling. In this work, we theoretically address the case of a flat horizontal film with a thickness perturbation, either positive (a bump) or negative (a groove), which is initially invariant under translation along one direction. This pattern relaxes towards a flat film by capillarity. By performing a linear stability analysis on this evolving pattern, we demonstrate that the invariance is spontaneously broken, causing the elongated thickness perturbation pattern to destabilise into a necklace of circular spots. The unstable and stable modes are derived analytically in well-defined limits, and the full evolution of the thickness profile is characterised. The original destabilisation process we identify may be relevant to explain the appearance of the marginal regeneration patterns near a meniscus and thus shed new light on thin films drainage.

Optical phase mask fabrication by light-actuated closed-loop controlof thermocapillary flow in liquid photopolymer films

Jonathan Ericson, Boaz Gavriel, Prof. Moran Bercovici
(Technion - Israel Institute of Technology)

I will present our approach for fabrication of optical phase masks by shaping photopolymer films using light-induced thermocapillary flow. We project spatially patterned light onto absorbing metal pads beneath the film, generate controlled temperature gradients, and create surface-tension-driven flows that deform the liquid–air interface into a prescribed topography. By solving an inverse problem, we compute the illumination pattern required to produce a desired topography, enabling rapid fabrication of optical elements. I will further present our ongoing work to integrate real-time topography measurements and closed-loop control to dynamically update the projected light pattern, improving both shape accuracy and convergence speed.

Session 5: Effects of Viscoelasticity, Acoustic waves and Evaporation

Coating dynamics of acoustowetting oil films

Prof. Linda J. Cummings
(New Jersey Institute of Technology)

Air-driven dynamics of viscoplastic liquid layers: mucus clearance by coughing

Prof. Duncan Robin Hewitt
(University of Cambridge)

Evaporation-driven solutocapillary flows in thin liquid films

Dr. Mariana Rodriguez-Hakim ✉, Joseph M. Barakat, Xingyi Shi, Gerald G. Fuller, Eric S. G. Shaqfeh
(Department of Fundamental Physics, Universidad Nacional de Educación a Distancia - Department of Chemical Engineering, Stanford University)

Solutocapillary Marangoni flows arise when a nonuniform distribution of chemical species creates gradients in surface tension. These flows are important in coating applications, where evaporation in a multicomponent liquid induces concentration gradients, leading to defects in the final product. Our experiments reveal solutocapillary flows in thin films with solute fractions as low as 0.01%. Disjoining pressure gradients supply a mechanism to stabilize ultrathin films (10 nm), which can thus sustain solutocapillary flow at such low volume fractions. Our experiments and theory reveal the synergistic action of evaporation and disjoining pressure in creating and sustaining solutocapillary flows in thin films.

TBD

Dr. Rajesh Bhagat
(University of Cambridge)

Session 6: Industrial Talk 2

TBD

Dr. Nathaniel Baker
(Renaissance Fusion)

TBD

Mr. Patryk Wakuła
(Sonte)

Session 7: Substrate Topological modification and film confinement

Surrogate Modelling and optimisation of droplet motion on chemically patterned surfaces via automatic differentiation

Prof. Nikos Savva
(University of Cyprus)

Mapping out the interplay between forces - Prof. Jan Vermant

Dynamics of thin liquid films: Mapping out the interplay between forces

Prof. Jan Vermant
(ETH Zürich)

Thin-film stability governs macroscopic behaviour in foams, emulsions, and lung surfactants, yet the coupling between hydrodynamics, Marangoni stresses, and disjoining pressure remains unresolved. Using a dynamic thin-film balance with fluorescent lipid imaging and tunable electro-osmotic forcing, we independently control interfacial mobility and visualise surfactant concentration fields during drainage. We observe strong interfacial asymmetries and localized convective flows, revealing a dynamic coupling in which surfactant depletion both generates lateral stresses and weakens local disjoining pressure. Surprisingly, sufficiently high interfacial mobility induces spatial hydrodynamic instabilities that prolong film lifetime. The transition is governed by the competition between tangential transport and drainage timescales. We will alo present some results on how the stress boundary condition leads to variations of the flow field inside the film.

Evaporating rivulets and thin-film flow of nematics

Prof. Stephen Wilson
(University of Bath)

Controlling the dewetting morphologies of thin liquid films on patterned and switchable substrates: insights from mesoscopic numerical simulations

Dr. Andrea Scagliarini
(Istituto per le Applicazioni del Calcolo - CNR)

Patterned, switchable and adaptive substrates emerged as valuable tools for controlling wetting and actuation of droplet motion. I will present results from recent computational studies on the dynamics of an unstable thin liquid film deposited on a switchable substrate, modeled with a space- and time-varying contact angle. For a sufficiently large rate of wettability variation, a morphological transition appears, whereby the film breaks nto metastable rivulets. A criterion discriminating whether droplets or rivulets appear is identified in terms of a single dimensionless parameter. I will provide a theoretical derivation of the dependence of film rupture times, droplet shape, and rivulet lifetime on the pattern wavelength and speed. Finally, the effect of thermal fluctuations in the dewetting of ultra-thin films and the fate of a ring-shaped rivulets on patterned substrates will be also discussed.

TBD

Prof. Camille Duprat
(Ladhyx -École Polytechnique)

Stability and Dynamics of Fluctuating Nanofilms

Prof. James Sprittles
(University of Warwick)

Thin liquid films at the nanoscale are strongly influenced by thermal fluctuations, which can fundamentally alter their surface dynamics and routes to rupture. I will first briefly discuss how stochastic descriptions of capillary waves can be used to capture the transient roughening of initially smooth films, going beyond classical equilibrium capillary wave theory and providing guidance at nanometre scales. The main focus of the talk will then be on how thermal fluctuations can destabilise thin films well outside the classical spinodal regime, leading to rupture via rare, extreme 'rogue nanowaves' even when linear theory predicts stability. Using a combination of molecular dynamics, fluctuating hydrodynamics, and rare-event theory, I will outline a framework that captures thermally driven film evolution and rupture with both physical fidelity and computational efficiency.

Session 8: Innovation, Control & Application

TBD

Dr. Alice Thompson
(University of Manchester)

Controlling the Navier-Stokes equations

Dr. Alexander Wray
(University of Strathclyde)

Multiphase flows are ubiquitous in nature and industry, and controlling them has applications everywhere from carbon sequestration to medical diagnostics. As a consequence, control has seen an ever-increasing focus in the field of fluid dynamics. Unfortunately, due to computational cost, multi-phase studies have typically confined their focus to lubrication-type equations, which have limited applicability.

Session 9: Industrial Talk 3

TBD

Dr. Lionel Vincent
(Air Liquide)