Advanced School in Liquids and Complex Fluids: Solutions in the Spring

9–12 June 2025
Institute of Physics, London, UK

Programme

Monday 9th June

12:00	Registration
12:30	Lunch
13:30	**Welcome** Guido Bolognesi, University College London
13:45	Particles as Surfactants: Foams, Emulsions and Novel Materials Bernard P. Binks, University of Hull
14:45	**Lecture 1:** TBC Panagiota Angeli, University College London
15:30	Refreshment break
16:00	**Lecture 2**: TBC Panagiota Angeli, University College London
16:45	Networking, Drinks Reception and Poster Presentations
18:00	End of day

Tuesday 10th June

9:00	**Workshop**: TBC Panagiota Angeli, University College London

9:45	**Lecture 1**: Microstructure Evolution in Polymer and Soft Matter Nigel Clarke, University of Sheffield
10:30	Refreshment break
11:00	**Lecture 2**: Microstructure Evolution in Polymer and Soft Matter Nigel Clarke, University of Sheffield
11:45	Poster Session
12:45	Lunch
13:45	**Workshop**: Microstructure Evolution in Polymer and Soft Matter Nigel Clarke, University of Sheffield
14:30	**Lecture 1**: The physics of protein networks: exploring the structure, assembly and mechanics of protein networks across length scales Lorna Dougan, University of Leeds
15:15	**Lecture 2**: The physics of protein networks: exploring the structure, assembly and mechanics of protein networks across length scales Lorna Dougan, University of Leeds
16:00	Refreshment break
16:30	**Workshop**: The physics of protein networks: exploring the structure, assembly and mechanics of protein networks across length scales Lorna Dougan, University of Leeds
17:15	End of day

Wednesday 11th June

9:00	**Lecture 1:** Self-assembly and nucleic acid nanotechnology Lorenzo Di Michele, University of Cambridge
9:45	**Lecture 2:** Self-assembly and nucleic acid nanotechnology Lorenzo Di Michele, University of Cambridge
10:30	Refreshment break
11:00	**Workshop**: Self-assembly and nucleic acid nanotechnology Lorenzo Di Michele, University of Cambridge
11:45	Poster Session
12:45	Lunch
13:45	**How To Get Published** Sam Keane, IOP Publishing

14:45	**Complex Fluids Research in Industry** Alexander de Bruin, Johnson Matthey
15:45	Poster Prizes Alexander de Bruin, Johnson Matthey
15:50	End of day

Thursday 12th June

9:45	**Lecture 1**: Rheology and its impact on the world around us David Harbottle, University of Leeds
10:30	Refreshment break
11:00	**Lecture 2**: Rheology and its impact on the world around us David Harbottle, University of Leeds
11:45	**Workshop**: Rheology and its impact on the world around us David Harbottle, University of Leeds
12:30	Closing Guido Bolognesi, University College London
12:45	End of School

Particles as Surfactants: Foams, Emulsions and Novel Materials

Bernard P. Binks

The behaviour of small solid **particles** at liquid interfaces will be introduced. Intrigued by little activity globally since the pioneering paper by Pickering in 1907, we decided to systematically investigate the influence of particle hydrophobicity on their arrangement at planar oil-water interfaces and their stabilisation of emulsions for pure particles, both inorganic and organic. This led on to studying the preparation and properties of particle-stabilised foams and subsequently how particles adsorb at oil-oil, water-water and air-oil interfaces. New materials containing assembled particles at fluid interfaces resulted including dry water, powdered oil, oil foams and liquid marbles. Recently, we have been studying catalysis (chemical and bio-) in Pickering emulsions as a novel platform for synthesis.

It is of great interest to ask what happens when **surfactant and particles** are present simultaneously, this being the case in many commercial formulations in the food, cosmetic, pharmaceutical and agrochemical industries. We have investigated emulsions and foams in the case of like charge on surfactant and particles and in the case of opposite charge. Stimuli-responsive dispersed systems result when either or both of the surfactant and particles is stimulus-responsive.

Self-assembly and nucleic acid nanotechnology

Lorenzo Di Michele

Self-assembly is the process by which molecules and particles organise into (more or less) ordered structures and materials, driven by their mutual interactions. It is ubiquitous in biology, underpinning the structure of lipid membranes, viral capsids, and the cytoskeleton, and can be leveraged in materials science to create finite-size or macroscopic phases with unique characteristics.

Nucleic acids, DNA and RNA, have emerged as powerful building blocks for self-assembly, owing to the selectivity and predictability of base-pairing interactions, easy chemical functionalisation, remarkable stability (for the case of DNA) and biocompatibility. Leveraging these characteristics, DNA and RNA nanotechnology have evolved into powerful toolkits for engineering nanostructures and materials – from nanoscale motors to metamaterials and photonic crystals.

This short course will provide a brief introduction to the thermodynamic fundamentals of self-assembly (lecture 1), and the basic concepts of DNA and RNA nanotechnology (lecture 2). In the workshop, we familiarise with a powerful tool for the thermodynamic modelling and design of nucleic acid nanosystems (NUPACK, nupack.org), and use it to design novel DNA nanostructures.

Microstructure Evolution in Polymer and Soft Matter

Nigel Clarke

De-mixing and crystallisation are two of the most ubiquitous examples of material self-assembly, occurring frequently in complex fluids and living systems, as well as being of great importance to the development of metallic alloys. These thermodynamically driven processes have enabled the development of multi-phase polymer blends and composites for use in sophisticated applications, including structural aerospace components, flexible solar cells, and filtration membranes. In each case, superior functionality is derived from the micro-structure, the prediction of which has failed to maintain pace with synthetic and formulation advances. The interplay of non-equilibrium statistical physics, diffusion, rheology and hydrodynamics, causes multiple processes with overlapping time and length scales. This complexity has stalled the development of an overarching theoretical framework. I will introduce phase field methods for predicting microstructure evolution giving examples of successes and challenges.

The physics of protein networks: exploring the structure, assembly and mechanics of protein networks across length scales

Lorna Dougan

Over the last decade folded globular proteins and their assemblies have emerged as a distinct new class of soft condensed matter with striking properties. A major reason for the recent interest has been their importance in living systems, where protein assemblies form the principal structural components of scaffolds and provide a porous network for intracellular transport and organisation. However, a major challenge in this field is to construct a theory which translates the mechanical properties of an individual protein and the collective response of a network of proteins. In these lectures, we will begin by considering the structural and mechanical properties of single globular proteins. We will explore the ways that proteins can be cross-linked to form a percolating network, in the form of a water-rich protein hydrogel, and introduce the techniques used to examine the structural and mechanical properties of these materials. We will examine scaling laws from colloid and polymer theories and consider which might best describe the behaviour of folded and unfolded protein networks. Finally, we will explore the emerging area of ‘engineering living matrices’, in which proteins are used as biologically functional building blocks to create novel scaffolds which can sense and respond to specific environmental cues. In the accompanying workshop we will explore important concepts of the physics of protein networks in a making-based approach using embroidery and weaving, including exploring self-avoiding random walks and biopolymer flexibility and mechanics.

How to Get Published Workshop

Sam Keane

These highly valued workshop provides insight into the world of publishing and covers the following topics:

- Choosing the right journal for your research
- Publication ethics
- Top tips for writing your article so it captures the interest of editors/reviewers
- Peer review and responding to reviewers
- Post-acceptance activities to promote your article

The workshop is around 1 hour long (45 minutes of content and 15 minutes for questions) and are usually very well-received, especially by postgraduate students as it gives them a good overview of the publishing process, which they should find useful during their careers.

Rheology and its impact on the world around us

David Harbottle

Rheology is the study of the flow and deformation of materials. It has great importance in industrial applications governing the stability, texture and flowability of materials that impact our daily lives from foods to cosmetics and pharmaceuticals. It is also critical to the function of the human body, with abnormal blood rheology linked to diseases such as thrombosis, and the interfacial rheology of the tear film crucial to prevent dry eye that would cause blurring of vision.

In this workshop, we will link the fundamental concepts of rheology to different applications. In particular, interfacial rheology or 2D rheology, which describes the flow at an interface (gas-liquid, liquid-liquid), governs the stability of foams and emulsions, with the dilatational rheology component determinant for species that reversibly adsorb at an interface, such as surfactant molecules, and the shear rheology component determinant for species that irreversibly adsorb at an interface, such as colloidal particles. With new understanding of how different chemical species partition at an interface, it is now possible to design new materials that exhibit high structural strength, are lightweight, have very high surface area, and can be 3D printed into a range of shapes/structures.

The workshop also includes the making of ooho water balls, an interfacial film of sodium alginate that encapsulates water and is a biodegradable packaging that has the potential to replace plastic water bottles.

Selected papers:

1)3D printing of Pickering emulsions, Pickering foams and capillary suspensions – A review of stabilization, rheology and applications; Advances in Colloid and Interface Science Volume 332, 2024, 103274

2) Demulsification of Pickering emulsions: Advances in understanding mechanisms to applications; Soft Matter, 2024, 20, 7344-7356

3) Problematic Stabilizing Films in Petroleum Emulsions: Shear Rheological Response of Viscoelastic Asphaltene Films and the Effect on Drop Coalescence; Langmuir, 2014, 30, 23, 6730-6738

4) Foaming Behavior of Polymer-Coated Colloids: The Need for Thick Liquid Films; Langmuir, 2017, 33, 26, 6528-6539

5) Critical role of nanocomposites at air–water interface: From aqueous foams to foam-based lightweight functional materials; Chemical Engineering Journal, 2021, 416, 129121