Micro-rheology of active matter

The project concerns microrheology of active matter - to study properties of biological microscopic constituents and its complex environment via optical microscopy and microfluidic methods. The PhD is linked to a new interdisciplinary research (funded £1.8M by EPSRC/BBSRC/MRC) involving Prof. Robin Ball from Physics, Dr. Daniel Hebenstreit from SLS and Dr. Louise Dyson from Mathematics.

The grant proposal integrates an important life sciences research topic, transcription, and a classical physics phenomenon, liquid-liquid phase transitions (LLPTs). The latter were very recently discovered in the nuclei of mammalian cells and appear to have decisive roles in organizing transcription [1]. Due to the novelty of this finding and its complex interdisciplinary nature, a mechanistic understanding is currently lacking.

Suspensions of active biological constituents such as molecular motors of various kinds, or even swimming cells constitute a type of matter coined as active fluids. By conversion of its internal energy into mechanical work, these fluids reveal interesting macroscopic properties specific to these systems, such as large self-organised motion, pattern formation or liquid-liquid phase separation. These phenomena result from the coupling of microscopic particle dynamics with active stresses or noise from the external environment [2-3], which is a classic problem in complex fluids and rheology. This constitutes a challenge since the system properties are largely unknown and difficult to access by standard methods.

The PhD proposal involves the latest state of art confocal microscopy investigation of the microscopic soft matter constituents' properties in active biological environment though microfluidics methods and statistical mechanics analysis.

The student undertaking the project will have a chance to learn and apply interdisciplinary experimental and analytical skills such as – micro and molecular biology techniques, microfluidics, optical microscopy, and image processing and statistical analysis. Working in the biophysics lab environment and within the collaboration will also teach the student with broad range of communication and self-organisation skills.

[1] Y. Shin, Y. C. Chang ,D. S. W. Lee ,J. Berry, D.W. Sanders, P. Ronceray, N. S. Wingreen, M. Haataja, C.P. Brangwynne, *Liquid Nuclear Condensates Mechanically Sense and Restructure the Genome,* ***Cell,*** **175,** 1481 (2018)

[2] A.P. Solon, Y. Fily, A. Baskaran, M. E. Cates, Y. Kafri, M. Kardar and J. Tailleur, *Pressure is not a state function for generic active fluids*, ***Nature Physics***, **11**, 673 (2015)

[3] D. Saintillan, *Rheology of Active Fluids,* ***Annu. Rev. Fluid Mech.*** **50**, 563 (2018)