PHYSICS AND ASTRONOMY COLLOQUIUM 04/18/2024

SURPRISES IN THE STATISTICAL PHYSICS OF ACTIVE MATTER

PROF. MIKE CATES
UNIVERSITY OF CAMBRIDGE

Classical statistical mechanics was invented to describe the macroscopic properties of large numbers of particles. It has a hidden weakness: almost all of its results depend on the microscopic forces being ultimately derived from a Hamiltonian, which governs both the microscopic mechanics and the equilibrium probability distribution (the Boltzmann distribution). This is why quantities like pressure are not only time averages of forces (on a wall), but also thermodynamic state functions (which exist independently of any wall). Active matter systems are different. Their particles take energy out of the environment, and use it for dissipative self-propulsion. Examples include swimming micro-organisms, and synthetic colloids propelled by optical or chemical energy. In such cases the usual connection between interaction forces and thermodynamic behaviour is broken. This leads to some surprising properties, such as the following. (i) The pressure of an active fluid on a wall is not a state function -- it depends on the type of wall. (ii) Random motion in a bath of active particles can be converted into a steady current by introducing inert obstacles. (iii) Fluid-fluid phase separation can arise among active particles in the complete absence of the attractive interactions that cause this in equilibrium. (iv) Various interfacial phenomena, governed in equilibrium by a single surface tension, now depend on several distinct tensions, some of which can be negative.

GRAD 2:40 PM
STUDENT MEET N' GREET (3049 PHYSICS)

COFFEE: 3:00 PM
BARKAS LOUNGE (3049 PHYSICS)

COLLOQUIUM: 3:40 PM
WINSTON CHUNG HALL (ROOM 138)

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- 2015-date: Lucasian Professor of Mathematics
- 2007-2022: Royal Society Research Professor
- 1995-2015: Professor of Natural Philosophy, School of Physics and Astronomy, University of Edinburgh
- 1992-1995: University Lecturer, Cavendish Laboratory, Cambridge
- 1989-1992: University Assistant Lecturer, Cavendish Laboratory, Cambridge
- 1988-1989: Royal Society University Research Fellow, Cavendish Laboratory, Cambridge
- 1985-1995: Junior Research Fellow (1985-1989), Teaching Fellow (1990-1995), Trinity College Cambridge

Research

Mike is a member of the Department of Applied Mathematics and Theoretical Physics. He heads the Soft Matter research group. His current research interests include: flow of colloids, polymers, emulsions, gels and other soft materials; shear-thickening and rheology in dense suspensions; dynamics of soft glasses; flow of liquid crystals; general theories of active matter; cellular locomotion; phase ordering in active and passive systems; statistical mechanics of active particles; and numerous other topics. He recently completed an ERC Advanced Grant called ADNeSP: Active and Driven Systems, Nonequilibrium Statistical Physics.

Prizes and Awards

- 2021: International Member, US National Academy of Sciences
- 2019: International Member, US National Academy of Engineering
- 2016: Bingham Medal, US Society of Rheology
- 2013: Weissenberg Award, European Society of Rheology
- 2009: Dirac Medal and Prize, Institute of Physics
- 2009: Gold Medal, British Society of Rheology
- 2007: Fellow of the Royal Society (London)
- 2005: Fellow of the Royal Society of Edinburgh
- 1996: Fellow of the Institute of Physics
- 1994: Prix Franco-Britannique (Paris Academy of Sciences)
- 1991: Maxwell Prize and Medal, Institute of Physics

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