Among the classic problems in the study of minimal surfaces is the competition between solutions of different topology that span a given contour. Recent work on soap films spanning deformable wire frames has brought to the fore the dynamical processes that accompany the transition from one solution to another, specifically the topological transition from a one-sided surface (Möbius strip) to a two-sided one. We study this problem in detail, focusing on the "twist singularity" associated with the change in the linking number between the film's Plateau border and the wire, and the twist-to-writhe conversion of the border as the frame is deformed. Geometrical aspects of the evolving surfaces are examined by means of a model of ruled surfaces spanning parametrized contours in comparison with minimal surfaces obtained numerically. These results explain how twist of the border generates experimentally observed light caustics and reveal the role of the finite size of the wire frame that supports the minimal surfaces.

r.e.goldstein@damtp.cam.ac.uk

11:30–210B

Surface wave patterns: Faraday waves and cross-waves

Jeff Porter†, *Ignacio Tinao, Ana Laveron-Simavilla*
E.T.S.I. Aeronauticos, Universidad Politecnica de Madrid, Madrid, Spain

The behavior of vibrated fluids and, in particular, of the surface or interfacial waves that commonly appear in such systems, has been a subject of continued experimental and theoretical attention since Faraday's seminal experiments in 1831. Here we examine the connection between Faraday waves, which arise in vertically vibrated systems, and cross-waves, which are found in horizontally forced systems, by combining vertical and horizontal forcing. Ongoing experiments utilizing two perpendicularly oriented shakers are described, including the effect on pattern formation of varying the two forcing frequencies, amplitudes, and phases. Theoretical results, based on the analysis of reduced models, and on numerical simulations, are then described and compared to experiment. Finally, the interest of a related microgravity experiment is briefly discussed and implications for fluid management strategies are considered.

jeff.porter@upm.es

11:50–210B

Coherent structures in turbulence: A dynamical-systems perspective

*John F. Gibson**,†, *Predrag Cvitanovic***, *Jonathon Halcrow*+, *Divakar Viswanath*++, *Evan Brand**
**Department of Mathematics and Statistics, University of New Hampshire, Durham, USA*
***School of Physics, Georgia Institute of Technology, Atlanta, USA*
+*Institute for Physical Sciences, Mclean, USA*
++*Department of Mathematics, Michigan University, Ann Arbor, USA*

The recent computation of fully nonlinear unstable solutions to turbulent shear flows has created exciting new connections between turbulence and dynamical systems theory. Here we present a number of equilibrium, traveling wave, and periodic orbit solutions to plane Couette flow for Reynolds numbers above the onset of turbulence. The solutions are embedded in the invariant measure of the flow, and can be used to construct revealing state space portraits of turbulent dynamics. Specifically, we find several heteroclinic connections between unstable equilibria, and we observe the turbulent flow shadowing the periodic orbits of the flow and the low-dimensional unstable manifolds of the flow's equilibrium solutions. We argue that coherent structures in turbulence result from close passes to weakly unstable solutions of the flow dynamics. Further, the invariant measure of the turbulent flow appears to be well-approximated by a large set of its unstable periodic orbits.

john.gibson@unh.edu

MS03: Fluid-structure interactions in biological systems
10:50–12:10, Wednesday, 22 August
Paul Watton, UK, Chair
Michael Shelley, USA, Chair
Room: 211

10:50–211

Mode switching and synchronization in Chlamydomonas flagella

Kirsty Y. Wan, Kyriacos C. Leptos, Raymond E. Goldstein†
Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences, University of Cambridge, Cambridge, UK

Cilia and flagella are implicated in a variety of physiological processes, ranging from sensory transduction to provision of cellular motility. Using the model unicellular alga C. reinhardtii, whose flagella typify the evolutionarily conserved eukaryotic flagellar structure, we probe the permissible modes of beating that a flagellum can exhibit, and in turn how a pair of them can interact, with the aim of furthering an understanding of the generic phenomenon of how neighbouring, weakly coupled flagella can be brought into synchrony by virtue of their immersion in a shared fluid environment. The circumstances affecting how such synchrony can arise, and in particular, where synchrony can fail, or take unusual forms, may be of great biomedical consequence in the context of mammalian ciliopathies.

Goldstein@damtp.cam.ac.uk

11:10–211

Spanwise stretching and collapse motions stabilize leading-edge vortex in slow-flying bats

Shizhao Wang†, *Guowei He, Xing Zhang*
LNM, Institute of Mechanics, Chinese Academy of Sciences, Beijing, China

A stable leading-edge vortex (LEV) could generate high lift which could not be predicted by the conventional aerodynamics theories. The mechanisms to keep the LEV stable is still not clear. In this study, we numerically simulate the slowing-flying bats using immersed boundary method. The morphology and kinematics of bat are taken from experimental measurements. It is observed from our simulation that the stretching and collapse motions of wing determine the flow structures around the bat. The observation is further investigated by using a simple model: the flows around a spanwise oscillating plate, where the spanwise motion enhances the LEV and make it more stable. This result implies a link of bat kinematics with its unusual aerodynamic performances.

hgw@lnm.imech.ac.cn

11:30–211

Fluid transport induced by a flexible oscillating flapper in creeping flow

*Roberto Zenit**,†, *Roger Arco**, *Eric Lauga***
**Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, México*
***Department of Mechanical and Aerospace Engineering, University of California, San Diego, La Jolla, California, USA*

In this investigation, we study the fluid motion induced by a flexible flapper in the creeping flow regime. In this type of flows, the momentum conservation equation is time-reversible. Therefore, a simple reciprocal motion is not is not sufficient to induce mixing or propulsion. We introduce two aspects that can add a time dependence to the flow: a flexible flapper and a non-Newtonian liquid. Using a particle image velocimetry technique, we measure the amount of liquid motion induced in the fluid by a reciprocal flapper. As expected, when the flapper in rigid and the fluid is Newtonian, no net motion is produced for small Reynolds numbers. When the flapper is made of a flexible material (rubber), a net fluid motion is observed near the tip of the impeller. Likewise, when the fluid is viscoelastic, a remanent motion is observed. These results and their implication to biological systems are presented and discussed.

zenit@unam.mx

11:50–211

Settling induced formation of membrane tube on a vesicle

*Gwenn Boedec**,†, *Marc Jaeger**, *Marc Leonetti***
**M2P2, Aix-Marseille Univ., Ecole Centrale Marseille, Marseille, France*
***IRPHE, Aix-Marseille Univ., Ecole Centrale Marseille, Marseille, France*

Biological membranes often exhibits tubular structures, whose apparition is closely related to the mechanical properties of the membrane. Considering the model situation of a settling vesicle, we study numerically and theoretically the apparition of membrane tethers induced by hydrodynamic forcing. The existence of a stationary tether is reported and it is shown that both bending and tension forces are important in the understanding of tether formation.

gwenn.boedec@l3m.univ-mrs.fr

FS01: Acoustics
10:50–11:50, Wednesday, 22 August
Wolfgang Schroeder, Germany, Chair
Chuanzeng Zhang, Germany, Chair
Room: 212A

10:50–212A

Numerical modeling of laser generation of ultrasound by coupled thermoelasticity

*István A. Veres**,**,†, *Thomas Berer**,**, *Dieter M. Profunser*+, *Peter Burgholzer**,**
**Research Center for Non-Destructive Testing GmbH, Linz, Austria*
***Christian Doppler Laboratory for Photoacoustic Imaging and Laser Ultrasonics, Linz, Austria*
+*Hilti Corp., Schaan, Liechtenstein*

Laser generation of ultrasound is investigated by numerical techniques in the presented paper. The governing equations of thermoelasticity given by the coupled heat conduction and wave equations are solved with a finite difference technique using a combination of implicit and explicit integration techniques. The line-focused laser source is assumed to have a Gaussian temporal-spatial distribution which is modeled as a surface flux. The spatially discretised hyperbolic heat conduction equation is solved by an implicit temporal integration technique (Wilson Theta method). The resulting spatial distribution of the temperatures is applied to the wave equation for the excitation of elastic waves, whereby an explicit integration technique is used. The coupling of the two sets of equations considers both, the thermal expansion and the thermal feedback of the mechanical stresses. Laser generated wave fields are presented from pulsed laser sources with duration in the ps-ns range. In addition, the amplitude of the generated bulk longitudinal waves is investigated at constant energy.

isveres2002@yahoo.com

11:10–212A

Singular boundary method for radiation and wave scattering: numerical aspects and applications

*Zhuojia Fu**,†, *Wen Chen**, *Ching-Shyang Chen***
**Department of Engineering Mechanics, Hohai University, Nanjing, China*
***Department of Mathematics, University of Southern Mississippi, Hattiesburg, USA*

The singular boundary method (SBM) in conjunction with Burton and Miller's formulation for radiation and wave scattering is considered. In the method an analytical-numerical approach, combining null-field integral equations with inverse interpolation technique, is employed to remove the singularity of the fundamental solutions. It is a meshless boundary collocation method with the merits of mathematically simple and integration-free. Numerical illustrations demonstrate efficiency and accuracy of the present scheme on some benchmark examples. Moreover, it is applied to multi-body wave propagation problem. The near-trapped mode