Miércoles, 17 de febrero

Finite-length effects in Taylor-Couette flow

Prof. David G. Schaeffer

Duke University

Abstract

The term Taylor-Couette flow refers to fluid flow between rotating concentric cylinders. The onset of cellular motion in such flow (in particular, the remarkable agreement Taylor obtained between experiment and a theoretical stability analysis) played a central role in the history of fluid mechanics. More recently, this excellent agreement has come to seem confusing, in light of attempts to reconcile the fact that experiments are performed in an apparatus of finite length while Taylor's analysis considered an infinite apparatus. In an infinite apparatus, steady flows with secondary circulation in cells bifurcate from the trivial solution when the Reynolds number Re exceeds a critical value Re_c. Because of translational invariance, the bifurcation is symmetric, as sketched in Figure 1. Based on the feeling that in a long apparatus end effects ought to be small, researchers sought to understand experiments as a slightly perturbed bifurcation, such as sketched in Figure 2. Thus, in an experiment in a finite-length apparatus, the onset of cells is smeared out, compared to the abrupt onset in Figure 1, and only one of the two solution branches (the so-called normal modes) can evolve if the rotation speed is increased quasi-statically from rest. However, provided the apparatus is long, then one also expects that

1. The onset of cellular motion will be only slightly smeared out, with cells beginning close to Re_c, and
2. Anomalous-mode solutions should exist and be stable for Reynolds numbers slightly larger than Re_c.

Point 2 is not verified in experiments -anomalous modes are indeed observed, but only for large Re, two or three times Re_c. In other words, no matter how long the apparatus may be, end effects represent a large perturbation of the flow. By contrast, Point 1 is verified; thus, end effects are quite small for normal modes, but how this happens is somewhat mysterious. In this lecture we attempt to explain this situation in terms of a different broken symmetry, an approximate symmetry between two normal-mode flows with large, and nearly equal, numbers of cells.

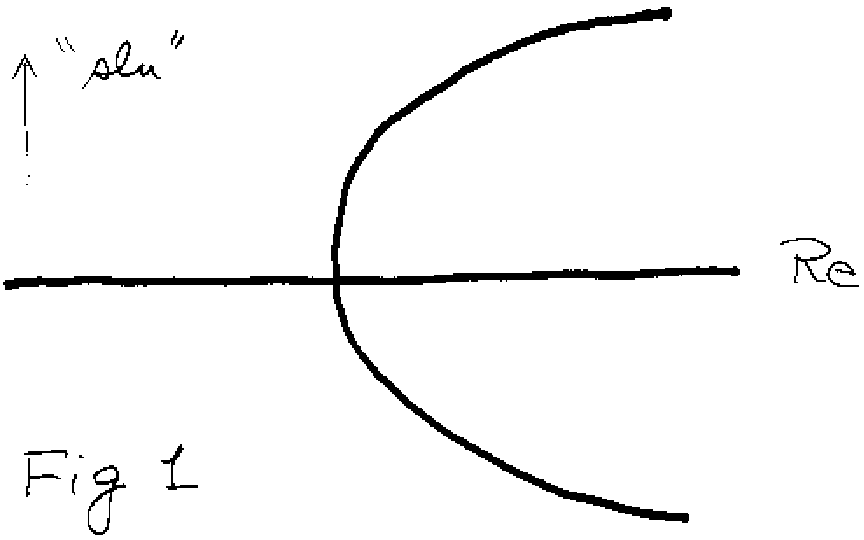

Fig 1

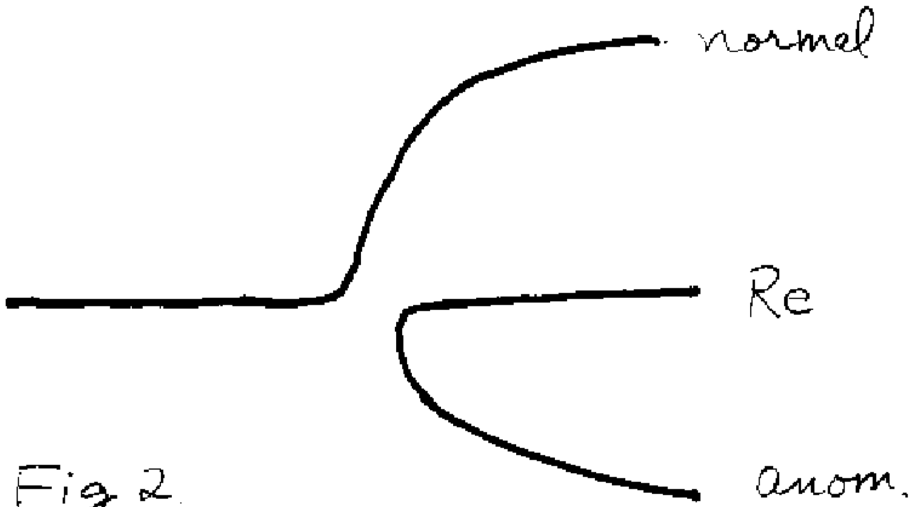

Fig 2

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Jueves, 18 de febrero

Some wonderful conjectures (but almost no theorems) at the boundary between analysis, combinatorics and probability.

Prof. Alan D. Sokal

New York University/University College London

Abstract

The function $F(x,y) = \Sigma_{n\geq 0}\ x^n/n!\ y^{n(n-1)/2}$ arises in statistical mechanics as the generating function of a single-site lattice gas, and in numerous problems in combinatorics, notably in the enumeration of connected graphs. It is in some ways the simplest entire function after the exponential function, to which it reduces when y=1. Nevertheless, it has been surprisingly little studied. I will present here some amazing conjectures concerning the roots $x_k(y)$ of F(x,y), discovered empirically with a little help from Mathematica. This talk is intended to be understandable to mathematicians, applied mathematicians and physicists from a wide variety of backgrounds.

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Martes, 23 de febrero

Estudio de modelos discretos de nucleación y formación de biopelículas

José Manuel Pueyo R. Carvalho

FCT/UNL

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Miércoles, 24 de febrero

Aerosol coagulation: General theory, mathematical methods and recent extensions for coagulation in expanding gases

M. Arias Zugasti

UNED

Abstract

The coagulation rate of a suspension of particles in a carrier gas is well explained by Smoluchowski's theory, which considers the diffusion of particles as the physical process that determines this rate, leading to the well known Smoluchowski's coagulation kernel.

Once the coagulation rate is known, the evolution equation that determines the PDF of the aerosol (particle number density in terms of particle volume) is a non-linear integro-differential equation, which in general is difficult to solve. One of the reasons for this, is because, with the usual coagulation rates, the "region of interest" (where the PDF is mainly located) grows very fast with time, which, on the other hand, produces a very fast decrease with time of the numerical accuracy of any given discretization. As a consequence, a very fine discretization is needed if one wants to have high numerical accuracy throughout the whole process. This makes this problem very time consuming, especially because one is usually interested in computing the evolution of the initial PDF until the self-preserving PDF is attained, which in many cases happens at long times. A mathematical method to deal with this problem will be introduced in the first part of the talk.

While several generalizations of Smoluchowski's theory have been known for some time, the influence of density variations of the carrier gas in the coagulation rate has not been considered before. A recent extension of Smoluchowski's theory that includes this effect will be the topic of the second part of the talk.

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Lunes, 22 de marzo

Multi-level Optical Imaging Algorithm Based on Radiative Transport Equation

Prof. Hongkai Zhao

UC Irvine

Abstract

In this talk I will first discuss a fast forward solver for radiative transport equation (RTE), the most accurate model for in vivo photon migration which is crucial for optical and molecular imaging. Our algorithm is based on a novel multigrid method in both physical and angular space that can effectively deal with different regimes of transport. Then I will introduce a few a multi-level optical imaging algorithms that can achieve high resolution with reduced computation cost and improved stability. Based on noise model and prior information we propose various combinations of fidelity and regularization.

Our recently developed fast multigrid RTE solver and imaging methods are available at http://sites.google.com/site/rtefastsolver.

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Miércoles, 7 de abril

Mathematical modeling of rate independent hysteresis and criticality in martensites

Prof. Lev Truskinovsky

École Polytechnique

Abstract

We show that singular dissipative potential describing rate-independent plasticity in shape memory alloys can be obtained by homogenization of a micro-model with quadratic (viscous) dissipation. The essential ingredient making this reduction possible is a rugged energy landscape at the micro-scale, generating under external loading a regular cascade of subcritical bifurcations. The rate-independent plastic deformation emerges in this description as a continuous succession of infinitesimal viscous events; the limiting procedure presumes the elimination of small time and length scales. Our prototypical model reproduces most of the experimental observations in martensites including self organization to criticality and power law acoustic emission. Criticality is currently attracting a great deal of interest due to its ubiquity in nature from turbulence to earthquakes. Our explanation of the emergence of criticality in martensites is based on the idea that the disorder needed for criticality is not quenched but is acquired by the system in the process of cyclic deformation.

Miércoles, 28 de abril

Simulation of sedimentary patterns (dunes): emergence of dune fields and dune stabilization driven by vegetation growth

Orencio Durán Vinent

Laboratoire de Physique et Mécanique des Milieux Hétérogènes, ESPCI

Abstract

Much alike sea waves, dunes are formed at desert surfaces by the action of the wind. The existence of a minimal size for Aeolian dunes of about 10m long, and thus, the impossibility of generate them in wind tunnel experiments, has led to a strong emphasis in numerical simulations as the simplest, and sometimes the only, tool to get insight into the dune emergence and evolution under controlled conditions. In this talk, I'll focus on two main applications of dune modeling: first, the emergence of dune fields under different external conditions, as a result of the coupling of longitudinal and transversal instabilities; and second, the inactivation of fully developed dunes. In the latter case, by including vegetation growth into the model, we are able to obtain a transition from active barchans to inactive parabolic dunes, and hence, to uncover the mechanisms underlying dune desactivation.

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Miércoles, 26 de mayo

A new perspective on the moment closure problem in radiative transfer

Benjamin Seibold

Temple University

Abstract

Radiative transfer can be modeled by a kinetic equation that describes the evolution of the particle intensity function in a high dimensional phase space of (at least) time, position, and angle of flight. While a direct simulation of the mesoscopic kinetic equation is possible, many computational scientists prefer a description by macroscopic equations. An expansion in the angular variable yields an equivalent system of infinitely many macroscopic moment equations. The fundamental question how to best truncate this system is the moment closure problem. Various closure strategies exist. These are typically based on an asymptotic analysis or assume higher moments be quasi-stationary.
We present an alternative approach to derive moment closures, based on the Mori-Zwanzig formalism of irreversible statistical mechanics. The influence of the truncated moments on the revolved moments is modeled by a memory term. Suitable approximations to this memory term allow us to re-derive existing closures, such as PN, SPN, and diffusion correction closures. In addition, new closures can be derived. We propose a crescendo-diffusion closure, which improves classical diffusion closures at no extra cost, as well as a new class of parabolic-type closures.

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Jueves, 28 de octubre

Convergent Power Series for Waves in Periodic Metamaterials

Prof. Stephen Shipman

Louisiana State University

Abstract

Fields in sub-wavelength periodic composite materials are typically expanded in formal power series, with the variable of expansion being the ratio of cell size to wavelength. These series are typically only formal, or, at best, asymptotic. But for Bloch waves in infinite periodic media with high contrast, we prove that they are actually convergent. We foresee utilizing the method of convergent power series as a rigorous framework for the analysis of the role of higher-order multipoles in the creation of certain curious bulk properties of metamaterials that have been observed in numerical simulations. To this end, one must obtain a quantitative lower bound on the radius of convergence of the series, and this presents one of the major challenges. I will begin by describing foundational work of H. Schwarz, in which he used convergent power series to devise the first general proof of the existence of a Dirichlet eigenvalue, and then point out the difficulties presented in the context of metamaterials.
Joint work with R. Lipton and S. Fortes, Department of Mathematics, Louisiana State University, USA.

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Viernes, 12 de noviembre

Steepest-decent method for integrable systems (Part 1 of 2)

Prof. Stephanos Venakides

Duke University

Abstract

We examine integrable nonlinear systems, in particular KdV (the Korteweg-de Vries equation) and NLS (the focusing nonlinear Schrödinger equation). The equations display their dispersive character particularly well in a scaling of small dispersion often referred to as the semiclassical scaling. The initial profile breaks into fully nonlinear modulated oscillations that are often multi-phase. We will describe recent methods for solving the initial value problem in this scaling, using rigorous asymptotics. Conceptually, the process is analogous to linear PDE, where one can derive the geometrical optics approximation by applying the steepest descent method to the calculation of the integral that expresses the field. In the nonlinear case the object on which steepest descent is applied is not an integral. It is a Riemann-Hilbert problem that relates to the scattering theory of a linear operator. This operator is associated to the nonlinear problem and effects the solution of the nonlinear problem. We will start with numerical results on the emergence of oscillations and we will give an outline of the basic ideas behind the the method of solution of integrable systems and of the asymptotic calculation.

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Jueves, 18 de noviembre

Steepest-decent method for integrable systems (Part 2 of 2)

Prof. Stephanos Venakides

Duke University

Abstract

We examine integrable nonlinear systems, in particular KdV (the Korteweg-de Vries equation) and NLS (the focusing nonlinear Schrödinger equation). The equations display their dispersive character particularly well in a scaling of small dispersion often referred to as the semiclassical scaling. The initial profile breaks into fully nonlinear modulated oscillations that are often multi-phase. We will describe recent methods for solving the initial value problem in this scaling, using rigorous asymptotics. Conceptually, the process is analogous to linear PDE, where one can derive the geometrical optics approximation by applying the steepest descent method to the calculation of the integral that expresses the field. In the nonlinear case the object on which steepest descent is applied is not an integral. It is a Riemann-Hilbert problem that relates to the scattering theory of a linear operator. This operator is associated to the nonlinear problem and effects the solution of the nonlinear problem. We will start with numerical results on the emergence of oscillations and we will give an outline of the basic ideas behind the the method of solution of integrable systems and of the asymptotic calculation.

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Jueves, 2 de diciembre

The hanging thin rod: A singularly perturbed eigenvalue problem

Prof. Yossi Farjoun

UC3M

Abstract

We study the vibrations of a hanging thin flexible rod, in which the dominant restoring force in most of the domain is tension due to the weight of the rod, while bending elasticity plays a small but non-negligible role. We consider a linearized description, which we may reduce to an eigenvalue problem. We solve the resulting singularly perturbed problem asymptotically up to the first modification of the eigenvalue. On the way, we illustrate several important problem-solving techniques: modeling, nondimensionalization, scaling, and especially use of asymptotic series.

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Jueves, 9 de diciembre

Extraordinary optical transmission from a microwave engineering perspective

Prof. Francisco Medina y Prof. Francisco Mesa

Universidad de Sevilla

Abstract

Extraordinary transmission of electromagnetic radiation through tiny holes (meaningfully smaller than the wavelength of the involved radiation) made in opaque metal screens was reported 12 years ago in the optical regime. The phenomenon was soon explained in terms of the interaction of the planar uniform impinging waves with surface plasmon polaritons (SPP's) excited at both sides of the metal screen. In a first stage the phenomenon was thought to be characteristic of the optical regime, since only at optical frequencies metals support that kind of waves. However it was theoretically and experimentally verified that the phenomenon also happens at other frequency ranges after proper scaling of the linear dimensions of the system. Although the terminology extraordinary transmission has been used for several diferent situations, the most relevant case corresponds to the frequency selective enhanced transmissivitty through periodic arrays of subwavelength holes or slits. The speakers have considered this case using the point of view of microwave engineers, which is used to deal with generalized transmission systems with discontinuities. The use of the classical theory of waveguides leads to simple models which are surprisingly accurate both from the qualitative and quantitative perspectives. The talk will illustrate how this approach explains the essential physics behind extraordinary transmission and provides a useful tool to design practical devices based on this phenomenon. A review of published and unpublished results will be presented to the audience.