

16 FEBRUARY 2000: NEW DIRECTIONS IN MATHEMATICAL MODELLING IN NWP

Professor J Gibbon, Imperial College - How much do we understand about the behaviour of vorticity in the 3D Euler and Navier-Stokes equations?

The challenges posed by the incompressible 3D Euler and Navier-Stokes equations remain as formidable as ever. In this short lecture he wants to review how far we have got in understanding (i) how vorticity stretches and compresses locally in a 3D Euler flow (ii) the mechanisms behind the (suspected) formation of spontaneous singularities in the Euler vorticity field. This is one of the outstanding classes of problems in modern applied mathematics. While far from being understood, he will discuss these problems in the context of the work of Beale, Kato and Majda and its more recent generalizations -- this result allows us to monitor singular behaviour, telling us when a suspected singularity is real and when it is a numerical artefact. For the 3D Navier-Stokes equations the challenge is the opposite; namely, to show that the vorticity field remains regular for arbitrarily large times.

Professor E Titi, University of California, Irvine - Approximating Dynamics for Dissipative Evolution Systems

Many dissipative evolution systems, such as the Navier-Stokes equations, exhibit a finite dimensional long-time behavior. Therefore, it is natural to search for reduced lower dimensional systems that model this finite dimensional asymptotic dynamics. In this talk we will discuss some of the systematic approaches, which are based on the theory of invariant manifolds and invariant "slaps", to derive such reduced models. In particular, we will address the validity and limitations of the models induced by the theory of inertial manifolds, approximate inertial manifolds, the proper orthogonal decomposition (Karhunen-Loeve expansion) method, and the re-normalization group approach. Furthermore, we will discuss the connection of these reduced models to the concept of "slow manifold".

Professor J Hunt, UCL - Developments in turbulence and unsteady effects in mesoscale flows

Both on large, synoptic scale and on small inertial-range turbulence scale random motions and turbulence consists of characteristic types of velocity field on many scales and with random phases and locations located (as any observation of satellite imagery, or cloud behaviour or computer simulation demonstrates). Drawing on results of the Newton Institute ocean/atmosphere and turbulence programmes, it is shown how the Navier-Stokes equation not only determines how these structures form --- usually, and most significantly for energy transfer, by interactions between large and small scale motions -- - but also how they can be sheltered from larger scale motions, thus retaining their characteristic form, so as not to be 'the sport of winds'(Howard 1803). Geometrical and statistical descriptions of these forms (spectra, capacity dimension...) and analyses of their distributions lead to new insights, and models for the overall statistical spatial and

temporal properties of large scale motions and turbulence, and their response to perturbations. Illustrations will be given of synoptic eddies and turbulence in the atmospheric boundary layer.

Professor A Iserles, DAMTP, Cambridge - Geometric integration, numerical conservation and the computation of Lyapunov exponents

In this talk he will review the new discipline of geometric integration, that is computation that respects known invariants and geometric features of the underlying differential system. In particular, he will survey methods that evolve on Lie groups, explain their relevance in a range of applications and emphasise their role in the computation of Lyapunov exponents of large systems.

Dr P Lynch, Met Eireann - Atmospheric Balance and Initialization for Numerical Weather Prediction

From the very beginning of numerical prediction, the corrupting effects of spurious high-frequency oscillations on the forecast has posed problems. Indeed, they were the cause of the failure of Richardson's forecast. There are two methods of attacking this problem: simplify the forecast equations to eliminate high frequency solutions (this was the method chosen by Charney, Fjortoft and Von Neumann); or adjust the initial data to minimize high frequency components (this is the process of initialization). In this talk he will explain the need for initialization, illustrating what happens if this is not done. He will present an outline of currently popular methods, in particular the digital filtering technique and he will say something about the establishment of balance in 4DVAR.

Dr M Cullen, ECMWF - Large scale atmospheric dynamics and the design of operational numerical models

He will illustrate some generic behaviours of nonlinear evolution equations. He will apply these to the compressible Euler equations used for atmospheric models, particularly discussing properties of the anelastic and hydrostatic approximations to them. He will then discuss large scale averaging of the equations, which is more representative of the problem being solved. He will relate these averages to balanced models, and use the latter to discuss and illustrate several design criteria for operational numerical models