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Ramage, A. (2002) *Math biology and quantum chaos highlight sixth annual meeting of SIAM's UKIE section*. SIAM Journal on Mathematical Analysis, 35 (4). ISSN 0036-1410

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Math Biology, Quantum Chaos Highlight Sixth Annual Meeting of SIAM's UKIE Section

May 3, 2002

Allison Ramage

The sixth annual meeting of the UKIE Section of SIAM, held at Leeds University on January 11, provided a taste of the diversity of industrial and applied mathematics activity in the UK and the Republic of Ireland. Organised by the section officers--- David Parker (president), Ivan Graham (vice-president), and Peter Jimack (secretary/treasurer)-the meeting brought together more than 50 people to hear talks on subjects ranging from mathematical biology to quantum chaos.

Brian Sleeman (University of Leeds) opened the meeting with a discussion of mathematical modelling of tumour angiogenesis. Beginning with the question "What is a tumour?", he outlined the basic biology of vascular tumours and the mechanism by which blood flow from nearby capillaries stimulates their growth. The mathematical model he presented, based on reinforced random walks, begins with the creation of a capillary sprout by penetration of a growth factor through the capillary wall, and then describes the growth of this sprout through the extracellular matrix to join with the tumour and enhance its blood supply. In conclusion, he briefly discussed angiostats, which cut off this blood supply to the tumour, as a promising alternative to cancer treatments like chemotherapy.

Fortunately, the organisers were able to obtain the services of an excellent late replacement for SIAM president Tom Manteuffel, who was unable to give the scheduled second talk. In a talk on structured eigenvalue problems, Nick Higham (University of Manchester) discussed how to test for the presence of a particular type of structure in a matrix problem, and how close the given problem was to one without this structure.

Beginning with the idea of testing for definiteness in a generalised eigenvalue problem, Higham introduced the notion of the Crawford number, which can be used to characterise definite pairs of matrices. He then presented two methods for calculating the Crawford number of a given matrix pair--first a simple bisection algorithm and then a more sophisticated level set method. He concluded with a discussion of hyperbolic and elliptic structure in the quadratic eigenvalue problem, which can also be identified by means of the Crawford number.

Concluding the morning session was a talk by Jens Marklof (University of Bristol), who also had kindly agreed to speak at short notice after a late cancellation. In his talk, "Pseudo-Random Numbers, Spectra and Waves," he considered aspects of quantum chaos relating to the statistical properties of the eigenstates of quantum systems.

After demonstrating numerically the pseudorandom nature of the eigenmodes of the Helmholtz equation in a rectangular domain with a circular hole, Marklof introduced the concept of quantum ergodicity; it is generally not understood, he explained, whether all (and not just almost all) highly excited eigenfunctions of an ergodic quantum system will become equidistributed in the classical limit on the available

classical phase space. Turning to the question of whether random properties of ray dynamics can be seen via properties of the eigenvalues, he described the Berry-Tabor conjecture, which states that the eigenvalues have a spacing distribution of independent random variables from a Poisson process. This has been proved for some special cases, he pointed out.

After lunch, John Willis (University of Cambridge) discussed the propagation of cracks through three-dimensional solids, in particular, what happens when such a crack hits an obstacle and creates a disturbance that does not disperse with time. After setting up an equation for the crack surface, he showed how a model can be formulated and solved for the unperturbed problem, with perturbation techniques then used to model the effects caused by the obstacle.

Willis then illustrated how a dispersion relation can be obtained for a crack front wave—that is, a disturbance associated with a constant energy release rate. He ended with another application of this technique—assessment of the stability of a crack to an out-of-plane disturbance for an elastic medium in two dimensions.

Completing the mathematical part of the day, John Gibbon (Imperial College, London) spoke about singularity formation in stretched three-dimensional solutions of the Euler equations. After introducing the incompressible Navier-Stokes and Euler equations, he raised the question of when there are alignments of vorticity with eigenvectors of the strain matrix in the vortex stretching term; this phenomenon would not be expected from "random" turbulence, but is observed in practice, with, for example, a Burgers vortex tube.

Gibbon then introduced the idea of "stretching" a two-dimensional Navier-Stokes solution with a linear z -dependence to obtain a vortex tube with more space dependence, and described methods for characterising its horizontal and axial variation. Which of these two spatial variations will dominate depends on a particular parameter whose dynamics can be studied to give insight into the fluid behaviour. In conclusion, he briefly described the application of these ideas to the incompressible ideal MHD equations.

At a brief business meeting, section president David Parker commented on the continuing high standard of talks and good attendance at the annual meetings, although he expressed disappointment in the number of postgraduate attendees. Members were encouraged to be more vigorous about promoting the event among graduate students.

Trevor Stuart (Imperial College, London), president of the London Mathematical Society, reported that he had not made progress with his enquiries about a reciprocal LMS/SIAM membership deal, but that he would continue to pursue the issue. [*SIAM is currently investigating a variety of reciprocal membership programs.---*ed.] After a report on section activities throughout the year, Peter Jimack asked for suggestions for future projects. One possibility, a mainstream SIAM conference hosted by the UK or Republic of Ireland, was raised once again and is clearly something that UKIE members are very keen to see happen.

The day was rounded off by a splendid meal for those whose travel arrangements permitted. Overall, this was another well-organised and well-attended meeting in a

series that reflects the continuing high quality and range of work in applied mathematics being done in the UK and Republic of Ireland.

Further details about the UKIE SIAM section can be found at <http://www.ma.hw.ac.uk/~gabriel/ukiesiam/>.

Alison Ramage is a lecturer in mathematics at the University of Strathclyde and was recently elected secretary/treasurer of the SIAM UKIE Section.