

HERIOT-WATT UNIVERSITY
DEPARTMENT OF MATHEMATICS
ANNUAL REPORT 1989-90

The number of undergraduate students in the Department of Mathematics continued to grow after a record intake into first year. New joint degrees in Mathematics with Economics and with a European Language were introduced, the latter course involving the third year of study at a university in the appropriate European country. A new degree in Mathematics with Statistics will be available from next year.

The department has increased its involvement in the popularisation of mathematics. For the first time a series of Masterclasses sponsored by Shell were held at Riccarton in which members of the department gave lectures to mathematically talented 12-14 year olds. In addition a workshop on 'Women in Mathematics' was held in early June.

The CALM (Computer Aided Learning in Mathematics) project under the direction of Dr C E Beevers has continued to flourish. Sales of software have increased significantly in the UK and a Spanish version of the material is being produced for use in Mexico.

New developments in research in the department have been made possible by substantial funding by SERC. A grant of £180,000 under the Instrumentation and Nonlinear Systems initiatives has enabled the department to instal a network of Sun workstations including a Meiko Computing Surface with 16 transputers for parallel processing; the new system will play a vital role within the department in the study of nonlinear partial differential equations arising in applied mathematics, physics and biology. A further grant of £175,000 under the Nonlinear Systems Initiative will provide financial support for a research associate and visitor programme over the next three years.

Links with research centres outwith the UK have been increased and strengthened during the year. In particular links have been established with the University of Athens and the National Technical University, Athens using support from the British Council and with the Laboratory of Applied Mathematical Physics, Lyngby, Denmark, the University of Crete and the University of Arizona using support from the EC and NATO. Collaboration involving mathematical modelling in physiology has been initiated with INSERM, Bordeaux. Professor Penrose organized a one day conference on Statistical Mechanics and Phase Transitions in July with invited speakers from America, France, Austria and Ireland. Dr Julian Lopez-Gomez of Universidad Complutense de Madrid spent six months in the department as a visiting research worker.

Two new appointments were made to lectureships. Dr Bryan Rynne with research interests in multiparameter and scattering theory will add to the department's expertise in applied analysis and Dr Des Johnston with research interests in string theory will strengthen the mathematical physics group.

K J Brown
Head of Department

Heriot-Watt University

Department of Mathematics

Annual Report 1989-90

STAFF

Head of Department

Professors

Professor Emeritus

Readers

Senior Lecturers

Lecturers

Research Associates

Programmer

Visiting Mathematicians

Secretaries

K J Brown

J M Ball

J Carr

J C Ellbeck¹R J Knops²

O Penrose

J H Williamson

M van den Berg

J Howie

A A Lacey

C E Beevers³

R N Hills

A R Prince⁴

L E Nicholas

C Noble

H U Rahmag

B P Rynne

W L Sweatman⁸

D G Wilkinson

M A Youngson

V Nesi¹²B Tóth¹³K Zhang¹⁴Dr H Shariati¹⁷Mrs L Hunter¹⁸Mrs V A McDonald¹⁹Miss A Sutton-Vane²⁰

- 1 - Dep. Head of Department until 31.7.90
- 2 Vice-Principal 1988-91
- 3 Dep. Head of Department from 1.8.90
- 4 on leave 1.7.90-30.6.92
- 5 from 1.9.90-31.8.92
- 6 from 1.9.90
- 7 Part-time
- 8 from 1.9.90-31.8.91
- 9 from 1988-91
- 10 from 1.10.88-30.9.90
- 11 until 13.11.90
- 12 until 31.10.90
- 13 from 1989-91
- 14 from 1.9.89-31.7.90
- 15 until 21.12.90
- 16 from 1.2.89-1.2.90
- 17 from 1.2.89-28.2.90
- 18 from 1.6.90
- 19 until 11.6.90
- 20 until 4.5.90

Visitors to the Department

The following made long-term visits:

H Feddersen (DTH, Denmark)

M Grinfel'd (Moscow)

J Lopez-Gomez (Madrid)

L Modica (Pisa)

M Molina (Cordoba)

J W Shearer (Berkeley)

V Sverák (Prague)

D E Tzanetis (Athens)

In addition short-term visits were made and seminars given by the following:

F Kh Abdullaev (Uzbek Acad. of Sci.) R Melrose (MIT)
 P Aviles (Illinois) S Müller (Carnegie-Mellon)
 M Bellby (Birmingham) F Murat (Paris VI)
 M Berzins (Leeds) O A Oleinik (Moscow)
 Y Brenier (INRIA) N Owen (Bath/Sheffield)
 G Burton (Bath) F Papangelou (Manchester)
 G Capriz (Pisa) R Pardo (Madrid)
 P Coveney (Bangor) L Payne (Cornell)
 D G Crighton (Cambridge) R L Pego (Maryland)
 B Dacorogna (Lausanne) R Penrose (Oxford)
 E N Dancer (Arimdale, NSW) B Perthame (Orleans)
 P Davies (Alberta) R Pinch (Cambridge)
 B Derrida (Paris) J P Puel (Ecole Polytechnique, Paris)
 T C Dorlas (Swansea) Y G Reshetnyak (USSR Acad. of Sci.)
 V Drensky (Sofia) P Rippon (Open University)
 F Dunlop (Paris) G M Roberts (Aberystwyth/Bangor)
 D E Edmunds (Sussex) Y Engelbrecht (Estonian Acad. of Sci.)
 Y Engelbrecht (Estonian Acad. of Sci.) C Elliott (Sussex)
 C Elliott (Sussex) M J Esteban (Paris VI)
 M J Esteban (Paris VI) W D Evans (Cardiff)
 W D Evans (Cardiff) E Feireisl (Prague)
 I Fonseca (Carnegie-Mellon) P Fratzl (Vienna)
 P Fratzl (Vienna) J Furter (Warwick)
 L Halpenny (Edinburgh) J Hannay (Bristol)
 J Hannay (Bristol) P J Holmes (Cornell)
 P J Holmes (Cornell) R D James (Minnesota)
 R D James (Minnesota) Y Kannal (Weizmann Institute)
 Y Kannal (Weizmann Institute) V Kostov (Sofia)
 V Kostov (Sofia) J Lebovitz (Rutgers)
 J Lebovitz (Rutgers) T H Lenagan (Edinburgh)
 T H Lenagan (Edinburgh) J T Lewis (Dublin)
 J T Lewis (Dublin) P-L Lions (Paris-Dauphine)
 P-L Lions (Paris-Dauphine) K McKinnon (Edinburgh)
 K McKinnon (Edinburgh) P Marcellini (Florence)
 P Marcellini (Florence) A Meirmanov (Novosibirsk)
 A Meirmanov (Novosibirsk)

Invited Papers and Seminars given by members of staff

Professor J M Ball

- Seminar, University of Glasgow, 30 November 1989, 'Dynamics and minimizing sequences'.
 Lecture, Collège de France, 23 February 1990, 'Dynamique et calcul des variations'.
 Seminar, Technion, Haifa, Israel, 29 March 1990, 'Elastic crystals and the 2-well problem'.
 Seminar, Weizmann Institute, Rehovot, Israel, 3 April 1990, 'The 2-well problem for elastic crystals'.
 Seminar, Tel-Aviv University, Israel, 5 April 1990, 'Cavitation in elasticity'.
 Seminar, Brown University, Providence, R.I., 14 May 1990, 'Dynamics and minimizing sequences'.
 Invited lecture, International Conference on Modern Problems of the Calculus of Variations, Tbilisi, USSR, 15-21 November 1989, 'Static and dynamic variational problems related to phase transformations in solids'.
 Invited lecture at Optimization and Nonlinear Analysis Workshop, Technion, Haifa, 21-27 March 1990, 'Dynamics and variational principles'.
 Invited lecture, Mathematical Analysis and its Applications, Fritz John 80th Birthday Meeting, Courant Institute, New York University, 'Dynamics and the calculus of variations'.
 Contributed lecture at 3rd Annual EEC Project Meeting, Irsee, FRG, 16-18 May 1990, 'A characterization of plane strain'.
 Invited lecture at 11th Dundee Conference on Differential Equations, Dundee, 3-6 July 1990, 'Rank-one convexity and the multi-dimensional calculus of variations'.
 Invited presentation, SIAM Annual Meeting, 15-20 July 1990, Chicago, 'Crystal microstructure via elasticity theory'.
 Seminar, University of Nottingham, 23 November 1989, 'Statistical mechanics of convex bodies'.
 Seminar, Heriot-Watt University, 27 July 1990, 'Wetting and condensation for Vlasov systems'.
 Invited lecture, Conférence de Mécanique Statistique, Paris, 25-26 January 1990, 'Transitions de phase isopérimétriques'.
 Invited lecture, One-day Conference in Statistical Mechanics, King's College London, 24 May 1990, 'Isoperimetric phase transitions'.

Dr F Bavaud

Dr C E Beevers

- Seminar, University of Dundee, 5 March 1990, 'The Computers in Teaching Initiative and CALM'. (Joint with Maureen G Foster).
 Seminar, University of Strathclyde, May 1990, 'The use of computers in the education of engineers'.

Dr M van den Berg

- Seminar, University of Edinburgh, 4 December 1989, 'Mean curvature and the heat equation'.
 Seminar, Royal Society of Edinburgh, 3 March 1990, 'Gaussian lower bounds for the heat kernel'.
 Seminar, University College Swansea, 21 March 1990, 'On the spectrum of the Dirichlet Laplacian'.

Dr M van den Berg

- Seminar, Université de Paris-Sud, Orsay, 14 May 1990, 'On the spectrum of the Dirichlet Laplacian'.
 Seminar, Université de Paris-Sud, Orsay, 17 May 1990, 'Gaussian bounds for the Dirichlet heat kernel'.
 Seminar, Université Pierre et Marie Curie, Paris, 22 May 1990, 'Gaussian bounds for the Dirichlet heat kernel'.
 Invited lecture, Symposium on Mathematical Physics in Honour of Nlco Hugenholtz's Retirement, State University of Groningen, 2 October 1989, 'On the asymptotic distribution of eigenvalues of the Laplace operator'.
 Invited lecture, Conference on Diffusion Processes and Related Problems in Analysis, Northwestern University, Illinois, 24 October 1989, 'Dirichlet-Neumann bracketing and a theorem of Rellich'.
 Invited lecture, Workshop on Partial Differential Equations, University College Cardiff, 12 July 1990, 'On the spectrum of the Dirichlet Laplacian'.
 Invited lecture, Meeting on Mathematical Physics, University College Swansea, 6 August 1990, 'On the spectrum of the Dirichlet Laplacian'.

Mr J Bree

- Invited lecture, 28th Polish Solid Mechanics Conference, Kozubnik, 4-8 September 1990, 'Plastic deformation of a cylindrical pressure vessel subjected to cyclic thermal stresses'.

Dr K J Brown

- Series of talks, University of Athens and National Technical University of Athens, 19-30 March 1990, 'On various aspects of reaction-diffusion equations'.

Professor J Carr

- Seminars, University of Nice, December 1989, 'Phase transitions'.
 Invited lectures, Center for Nonlinear Studies, Georgia Institute of Technology, 'Nonlinear differential equations'.
 Invited lecture, Institute of Mathematics and its Applications Conference on Dynamics of Numerics, University of Bristol, 1 August 1990, 'Slow motion manifolds'.

Dr D E R Clark

- Seminar, Heriot-Watt University, Department of Mechanical Engineering, Solid Modellers Special Interest Group, 12 September 1990, 'Aspect graphs'.

Dr A J Duncan

- Seminar, Joint Edinburgh and Heriot-Watt University Algebra Seminar, 22 November 1989, 'Groups and the genus problem'.

Dr D B Duncan

- Talk, 3rd Annual EEC Project Meeting, Irsee, FRG, 17 May 1990, 'Parallel Hopscotch methods for the Ginzberg-Landau equation'.
 Poster, Nonlinear and Chaotic Phenomena Conference, University of Alberta, Canada, 16-27 July 1990, 'A parallel computation of fractal dimensions', (Joint with P J Davies, University of Alberta).

- Professor J C Eilbeck Master Class, Heriot-Watt University, 7 October 1989, 'Chaos and fractals'.
Invited lecture, One Day Conference on Spectral Methods and Applications in Computational Mechanics, University of Strathclyde, 18 September 1990, 'Reaction-diffusion equations'.
- Mrs M M G Foster Seminar, Dundee University, March 1990, 'The Computers in Teaching Initiative and CALM', (Joint with C E Beevers).
- Dr N D Gilbert Seminar, University of London Topology Seminar, 13 October 1989, 'Algebraic models of 3-types'.
Seminar, Queen Mary and Westfield College Mathematics Pro-Seminar, 20 November 1989, 'Groups, categories and groups of derivations'.
Talk, British Mathematical Colloquium, University of East Anglia, 9-12 April 1990, 'Some answers to a question of J.H.C. Whitehead'.
Talk, Groups in Galway 1990, University College Galway, 26-30 May 1990, 'Dependence among the relations in a group presentation'.
- Dr J H Howie Seminar, Heriot-Watt University, 8 February 1990, 'A tree-search algorithm in group theory'.
Seminar, University of Edinburgh, 2 March 1990, 'Fibonacci manifolds'.
Seminar, Heriot-Watt University, 7 March 1990, 'Isoperimetric inequalities'.
Seminar, University of Sussex, 22 June 1990, 'Fibonacci manifolds'.
Lecture, Edinburgh Mathematical Society, 2 June 1990, 'An algorithmic approach to solving equations over groups'.
Talk, Conference on Topological Methods in Group Theory, Oberwolfach, FRG, 2-6 October 1990, 'Decision problems in one-relator products'.
- Dr P K Jimack Seminar, Heriot-Watt University, January 1990, 'The finite element solution of a very large optimization problem'.
Seminar, University of Leeds, January 1990, 'The finite element solution of a very large optimization problem'.
Talk, 3rd Annual EEC Project Meeting, Irsee, FRG, 17 May 1990, 'Approximating the solution of a non-convex problem in the calculus of variations'.
- Dr D Johnston Seminar, University of Sussex, May 1990, 'Crumpling random surfaces'.
Seminar, University of Edinburgh, June 1990, 'Crumpling random surfaces'.
Seminar, University of London, June 1990, 'Spikes in Liouville theory'.
- Professor R J Knops Invited lecture, 5th Conference on Waves and Stability in Continuous Media, Sorrento, October 1989, 'Spatial behaviour in the dynamics of an elastic beam'.
Invited lecture, Mathematics Institute, Oberwolfach, 26-30 March 1990, 'Spatial behaviour of the vibrating elastic beam'.
- Dr A A Lacey Seminar, University of Aberdeen, 6 December 1989, 'Blow-up in some problems arising from Joule heating'.
Seminar, University of Oxford, 29 January 1990, 'Blow-up in some problems arising from Joule heating'.
Talk, Workshop on Nonlinear Diffusion and Filtration, Isle of Thorns, 3-5 May 1990, 'Local behaviour of a free boundary near a fixed boundary for a porous medium equation'.
Talk, ECOMI 90, Lahti, Finland, 5-9 June 1990, 'Formation of oscillation marks on continuously cast steel'.
- Dr Zhiping Li Seminar, Heriot-Watt University, 7 November 1989, 'Numerical calculation of minimizers in two or more dimensions'.
Seminar, Heriot-Watt University, 23 February 1990, 'Element removal method for singular minimizers involving Lavrentiev phenomenon'.
- Dr V Nesl Seminar, Heriot-Watt University, January 1990, 'The G-closure in the polycrystalline problem'.
Seminar, Heriot-Watt University, March 1990, 'Using null-lagrangians to bound effective moduli'.
Seminar, University of Bath, May 1990, 'Using null-lagrangians to bound effective moduli'.
Invited lecture, Workshop on Composite Media and Homogenization Theory, 15-26 January 1990, Trieste, 'Remarks on the G-closure'.
- Professor O Penrose Seminar, Heriot-Watt University, 31 January 1990, 'Large deviations for pedestrians'.
Seminar, Heriot-Watt University, 21 February 1990, 'Mean-field equations of motion for the dynamic Ising model'.
Seminar, Heriot-Watt University, 14 March 1990, 'Mean-field equations of motion for the dynamic Ising model'.
Seminar, Heriot-Watt University, 2 May 1990, 'Bose-Einstein condensation for a hard core system on a complete graph'.
Seminar, Heriot-Watt University, 30 May 1990, 'Bose-Einstein condensation for a hard core system on a complete graph'.
Invited lecture, Royal Society of Chemistry, Statistical and Thermodynamics Group Conference on Phase Transitions, UMIST, Manchester, 4 January 1990, 'Kinetics of phase transitions'.
Invited lecture, 63rd Statistical Mechanics Meeting, Rutgers University, New Brunswick, USA, 9-11 May 1990, 'An exactly soluble system of interacting bosons'.
Invited lecture, 3rd Annual EEC Project Meeting, Irsee, FRG, 16-18 May 1990, 'Kinetics of phase transitions'.
Talk, Statmech-6, One-Day Conference in Statistical Mechanics, King's College London, 24 May 1990, 'An exactly soluble system of interacting bosons'.

Series of seminars, Heriot-Watt University, Autumn 1989, 'Translation planes'.
 Invited lecture, Conference on Combinatorics 90, Gaeta, Italy, 20-27 May 1990, 'The flag-transitive translation planes of order 27'.

Dr B P Rynne

Talk, XXIII General Assembly of the International Union of Radio Science, Prague, 28 August - 5 September 1990, 'Stabilization of numerical methods for the time dependent magnetic or electric field integral equations'.

Dr Q Tang

Seminar, Heriot-Watt University, 24 October 1989, 'Friction problems in linear elasticity'.
 Talk, 3rd Annual EEC Project Meeting, Irsee, FRG, 16-18 May 1990, 'N-property, one-one mapping in nonlinear elasticity'.
 Talk, 5th International Colloquium on Free Boundary Problems, University of Montréal, Canada, June 1990, 'Friction problems in plasticity'.

Dr B Tóth

8 Seminars on Large Deviation, October 89 - March 90, Heriot-Watt University.
 Seminar, University of Edinburgh, 22 February 1990, 'On long time asymptotics of the Wiener sausage'.
 Seminar, North British Probability Seminar, April 1990, 'A mean-field model of Bose-Einstein condensation'.
 Seminar, IAS Dublin, 6 June 1990, 'Ventsel' and Freidlin's theory of large deviations applied to a model of quantum statistical mechanics'.
 Seminar, Mathematical Institute of the Hungarian Academy, Budapest, 24 August 1990, 'Exponential estimates for the repelling Wiener sausage'.
 Seminar, Mathematical Institute of the Hungarian Academy, Budapest, 31 August 1990, 'A mean-field model of Bose-Einstein condensation'.
 Talk, Conference on Statistical Mechanics, King's College, London, 24 May 1990, 'Phase transition in an interacting Bose system'.
 Talk, Workshop on Stochastic Calculus and Stat-mech, University College of Swansea, 2-7 July 1990, 'Phase transition in an interacting Bose system'.
 Talk, London Mathematical Society Symposium on Stochastic Calculus, University of Durham, 11-21 July 1990, 'Large deviation and phase transition'.
 Seminar, University College Dublin, 24 April 1990, 'Injective operator spaces'.

Dr K Zhang

Talk, 3rd Annual EEC Project Meeting, Irsee, FRG, 15-18 May 1990, 'Energy minimizers in nonlinear elastostatics and the implicit function theorem'.

Research and other grants reported during the year ended 30 September 1990

£175,568	from Science and Engineering Research Council, for the period 1 September 1990 to 31 August 1993, for investigation in applied analysis and nonlinear systems, under the direction of Professor J M Ball, Professor J Carr and Professor J C Eilbeck.
300,000 Bfr	from MATO for the period 1 June 1990 to 31 May 1991, for a study of Classical and Quantum Chaos in Coupled, Nonlinear Oscillators, under the direction of Professor J C Eilbeck.
£16,442	from Science and Engineering Research Council, for the period 1 August 1989 to 31 July 1991, for investigation into weak-convergence methods and regularity in nonlinear elasticity and in the calculus of variations, under the direction of Professor J M Ball and Dr K Zhang.
£5367	from Science and Engineering Research Council for two-day undergraduate conference on 'Solid Mechanics' at the University of Nottingham, December 1989, organised by Professor R J Knops and Professor L Morland.
£3,793	from Science and Engineering Research Council, for the period 1 October 1990 to 30 November 1990, to support a Visiting Fellowship for Professor S D Brodskii, awarded to Dr J Howie.
£1,600	from Italian National Research Council (C.N.R.S.) for the period 5 May to 5 June 1990, for Visiting Professorship at University of Rome, "La Sapienza", awarded to Dr A R Prince.
£1,500	from the Post Office Research Centre, for the period 1 April 1990 to 30 March 1991, for Computer Aided Learning in Mathematics, under the direction of Dr C E Beavers.
£1,011	from British Council, travel grant for visit to South Korea, awarded to Dr J Howie.
£1,000	from Ferranti, for the period 1 October 1989 to 30 September 1990, for the CALM project, phase 2, under the direction of Dr C E Beavers.
£1,000	from Niels Bohr Institute, for the period of 25 July - 23 August 1990, for a research visit, awarded to Dr D A Johnston.
£580	from London Mathematical Society, for Scottish Algebra Day, awarded to Professor K A Brown, Dr J Howie and Dr T H Lenagan.
£550	from the Royal Society, to attend a conference at the University of Alberta, Canada in July 1990, awarded to Dr D B Duncan.
£450	from Royal Society, for attendance at Fifth International Colloquium on Free Boundary Problems, Montreal, Canada, June 1990, awarded to Q Tang.
£315	from Edinburgh Mathematical Society, for visit of H Short, awarded to Dr J Howie and Dr S J Pride.
£270	from the Royal Society of Edinburgh, to attend a research conference at the Institute for Mathematics and its Applications, University of Minnesota, awarded to Professor J Carr.

from the Royal Society of London for travel to attend a conference at Rutgers University, USA, May 1990, awarded to Professor O Penrose.

from Edinburgh Mathematical Society Centenary Fund for the 'Women in Mathematics Day', 29 May 1990, awarded jointly to Professor J Carr and Dr D B Duncan.

from British Council, for travel and accommodation for visit to Trinity College, Dublin during April 1990, awarded to Dr M A Youngson.

from Science and Engineering Research Council for travel to University College, Galway, May 1990, awarded to Dr N D Gilbert.

PUBLICATIONS - OCTOBER 1989 - SEPTEMBER 1990

Theses

P Lin (PhD), 'Topics in nonlinear elasticity.'

S Müller (PhD), 'Variational problems in mechanics and analysis.'

Papers

- C Ballie, D JOHNSTON and R Williams
 'Crumpling in dynamically triangulated random surfaces with extrinsic curvature.' *Nucl. Phys.*, 1990, *B335*, 469-501.
 'Computing aspects of simulating dynamically triangulated random surfaces.' *Comp. Phys. Comm.*, 1990, *58*, 105-117.
 'Crumpling dynamically triangulated random surfaces in higher dimensions.' *Phys. Lett.*, 1990, *B243*, 358-365.
 'Non-universality in dynamically triangulated random surfaces.' *Mod. Phys. Lett.*, 1990, *A5*, 1671-1680.

J M BALL

- 'Dynamics and minimizing sequences.' In 'Problems Involving Change of Type', Springer Lecture Notes in Physics, vol. 359. Ed. K Kirchgässner. Springer Verlag, New York, Heidelberg, Berlin, 1990, pp 3-16.

J M BALL and R D James

- 'Remarks on Chacon's Biting Lemma.' *Proc. Amer. Math. Soc.*, 1989, *107*, 655-663.

J M BALL and G Knowles

- 'Young measures and minimization problems of mechanics.' In 'Elasticity: Mathematical Methods and Applications. The Ian N Sneddon 70th Birthday Volume. Eds. G Eason and R W Ogden, Ellis Horwood, Chichester, 1990, pp 1-20.

J M BALL and K-W ZHANG

- 'Lower semicontinuity of multiple integrals and the Biting Lemma.' *Proc. Roy. Soc. Edin.*, 1990, *114A*, 367-379.

F BAVAUD

- 'Statistical mechanics of convex bodies.' *J. Stat. Phys.*, 1989, *57*, 1059-1068.
 'Continuum models of two-dimensional random droplets.' *Letters Math. Phys.*, 1990, *20*, 75-84.

C E BEEVERS, M G FOSTER and G R MCGUIRE

- 'CALM for engineering and science undergraduates.' *Mathematics Teaching Conference Report*, 1989, 26-27.

M van den BERG

- 'Heat equation and the principle of not feeling the boundary.' *Proc. Roy. Soc. Edinburgh*, 1989, *112A*, 257-262.
 'Large time asymptotics of the heat flow.' *Quart. J. of Math. Oxford (2)*, 1990, *41*, 245-253.
 'Gaussian bounds for the Dirichlet heat kernel.' *J. Funct. Anal.*, 1990, *88*, 267-278.

M van den BERG and E B Davies

- 'Heat flow out of regions in R^m .' *Math. Zeit.*, 1989, *202*, 463-482.

- M van den BERG, T C DORLAS, J T LEWIS and J V PULE
'The existence of the pressure in the Huang-Yang-Luttinger model of an interacting boson gas.' *Comm. Math. Phys.*, 1990, 128, 231-245.
'Large time asymptotics of the heat flow.' *Quart. J. of Math. Oxford* (2), 1990, 41, 245-253.
'A perturbed mean field model of an interacting boson gas and the large deviation principle.' *Comm. Math. Phys.*, 1990, 127, 41-69.
- M van den BERG and S SRISATKUNARAJAH
'Heat flow and brownian motion for a region in \mathbb{R}^2 with a polygonal boundary.' *Prob. Theory Rel. Fields*, 1990, 86, 41-52.
- L Bernstein J C EILBECK and A C SCOTT
'The quantum theory of local modes in a coupled system of nonlinear oscillators.' *Nonlinearity*, 1990, 3, 293-323.
- J BREE
'Plastic deformation of a closed tube due to introduction of pressure stresses and cyclic thermal stresses.' *Int. J. Mech. Sci.*, 1989, 31, 865-892.
'Elastic-plastic behaviour of thin tubes subjected to internal pressure and cyclic thermal stresses.' In 'Applied Solid Mechanics - 3'. Eds. I M Allison and C Ruiz, Elsevier, London, New York, 1990, pp 322-335.
'Non-equilibrium thermodynamics of heterogeneous systems and history dependent materials.' *Appl. Sci. Res.*, 1990, 47, 65-96.
'Plastic deformation of a cylindrical pressure vessel subjected to cyclic thermal stresses'. In 'Proceedings of 28th Polish Solid Mechanics Conference, Kozubnic', 1990, pp 35-38.
- K J BROWN, A Castro and R Shivaji
'Non-existence of radially symmetric non-negative solutions for a class of semi-positive problems.' *Differential and Integral Eqns.*, 1989, 2, 541-545.
- K J BROWN, C Cosner and J Fleckinger
'Principal eigenvalues for problems with indefinite weight function on \mathbb{R}^n .' *Proc. Amer. Math. Soc.*, 1990, 109, 147-155.
- K J BROWN and P Hess
'Stability and uniqueness of positive solutions for a semi-linear elliptic boundary value problem.' *Differential and Integral Eqns.*, 1990, 3, 201-207.
- K J BROWN and A A LACEY
Eds. K J Brown and A A Lacey. 'Reaction-Diffusion Equations.' Clarendon Press, Oxford, 1990, 224pp.
- R Brown and N D GILBERT
'Algebraic models of 3-types and automorphism structures for crossed modules.' *Proc. London Math. Soc.* (3), 1989, 59, 51-73.
- J CARR
'Dynamics of cluster growth.' Springer Lecture Notes in Physics, vol. 359. In 'Problems Involving Change of Type'. Ed. K Kirchgässner. Springer-Verlag, Berlin, Heidelberg, New York, 1990, pp 47-53.
'Very slow phase separation in one dimension.' In 'PDEs and Continuum Models of Phase Transitions', Springer Lecture Notes in Physics, vol. 344. Eds. M Rascle, D Serre and M Slemrod, Springer-Verlag, New York, Berlin, Heidelberg, 1990, pp 216-226.

- D J COLLINS and N D GILBERT
'Structure and torsion in the automorphism group of a free product.' *Quart. J. Math. (Oxford)* (2), 1990, 41, 155-178.
- L Cruzeiro-Hansson, H Feddersen, R FLESCHE, P L Christiansen and A C Scott
'Classical and quantum analysis of chaos in the discrete self-trapping equation'. *Phys. Rev. B*, 1990, 42, 522-526.
- F Demengel and Q TANG
'Justification of elastoplastic plate models.' *Asymptotic Analysis*, 1990, 3, 57-76.
- M H Dodson, B P RYNNÉ and J A G Vickers
'Diophantine approximation and a lower bound for Hausdorff dimension.' *Mathematika*, 1990, 37, 59-73.
'Metric diophantine approximation and Hausdorff dimension on manifolds.' *Math. Proc. Camb. Phil. Soc.*, 1989, 105, 547-558.
- A J DUNCAN
'Infinite coverings of ideals by cosets with applications to regular sequences and balanced big Cohen-Macaulay modules.' *Math. Proc. Camb. Phil. Soc.*, 1990, 107, 443-460.
- A J DUNCAN and L O'Carroll
'On Zarisky-regularity, the vanishing of Tor and a uniform Artin-Rees theorem.' Banach Center Publications, Topics in Algebra, Vol. 26, part 2, pp 49-55. PWN Polish Scientific Publishers, Warsaw 1990.
- J C EILBECK and R FLESCHE
'Calculation of families of solitary waves on discrete lattices.' *Phys. Lett. A*, 1990, 149, 200-202.
- J C EILBECK and J E FURTER
'Understanding steady-state bifurcation diagrams for a model reaction-diffusion system.' In 'Continuation and Bifurcations: Numerical Techniques and Applications'. Eds. D Roose, B De Dier and A Spence, Kluwer, London, 1990, pp 25-42.
- H K Feddersen, R FLESCHE, M Salerno and P L Christiansen
'Comment on "Theory of the Liapunov exponents of Hamiltonian systems and a numerical study on the transition from regular to irregular classical motion"'. *J. Chem. Phys.*, 1990, 92, 2117-2118.
- P C Fife and O PENROSE
'Thermodynamically consistent models of phase-field type for the kinetics of phase transitions.' *Physica D*, 1990, 43, 44-62.
- J N Flavin, R J KNOPS and L E Payne
'Energy bounds in dynamical problems for a semi-infinite elastic beam.' In 'Elasticity: Mathematical Methods and Applications. The Ian N Sneddon 70th Birthday Volume'. Eds. G Eason and R W Ogden, Ellis Horwood, Chichester, 1990, pp 101-112.
- R N HILLS and P H Roberts
'A macroscopic model of phase coarsening.' *Int. J. Nonlin. Mech.*, 1990, 25, 319-329.

- J HOWIE
 'The quotient of a free product of groups by a single high-powered relator. I. Pictures. Fifth and higher powers.' *Proc. London Math. Soc.*, 1989, 59, 507-540.
 'The quotient of a free product of groups by a single high-powered relator. II. Fourth powers.' *Proc. London Math. Soc.*, 1990, 61, 33-62.
- S D HOWISON, A A LACEY, J R Ockendon and P Hilmott
 'Irregular morphologies in unstable Hele-Shaw free-boundary problems.' *Q. J. Mech. Appl. Maths.*, 1990, 43, 387-405.
- D JOHNSTON
 'Phase transition in Liouville theory.' *Phys. Rev.*, 1989, D40, 3402-3406.
 'Putting Liouville into superstrings.' *Phys. Lett.*, 1989, B232, 180-183.
 'Tubes and supertubes.' *Phys. Lett.*, 1990, B241, 41-46.
- R J KNOFS, L E Payne and S Rionero
 'Saint-Venant's Principle on unbounded domains.' *Proc. Roy. Soc. Edinburgh*, 1990, 115A, 319-336.
- O PENROSE
 'Dynamical systems: a renewal of mechanism.' Book review. *Bull. L.M.S.*, 1990, 22, 203-204.
- A R PRINCE
 'The commutative ring of a symmetric design.' *Discrete Mathematics*, 1990, 80, 101-103.
- B P RYNNÉ
 'A lower bound for the Hausdorff dimension of sets of singular n-types.' *Math. Proc. Camb. Phil. Soc.*, 1990, 107, 387-394.
 'Uniform convergence of multiparameter eigenfunction expansions.' *J. Math. Anal. Appl.*, 1990, 147, 340-350.
 'The Hausdorff dimension of certain sets of singular n-types.' *Math. Proc. Camb. Phil. Soc.*, 1990, 108, 105-110.
- B P RYNNÉ and P D Smith
 'Transient scattering from a perfectly conducting cube.' In 'The Applied Computational Electromagnetics Society Collection of Canonical Problems. Set 1'. Ed. H Sabbagh. The Applied Computational Electromagnetics Society, 1990, pp 95-97.
- A C Scott, L Bernstein and J C EILBECK
 'Local modes in molecules.' *J. Molec. Liquids*, 1989, 41, 105-111.
- Q TANG
 'Convex function of measures obtained from homogenization.' *SIAM J. Math. Anal.*, 1990, 21, 409-435.
 'Friction with contact of two linear elastic bodies.' *Physica D*, 1990, 43, 220-228.
- K-W ZHANG
 'Polyconvexity and stability of equilibria in nonlinear elasticity.' *Q. J. Mech. Appl. Math.*, 1990, 43(2), 215-221.
- Papers submitted for publication 1989-90
- C Baillie, D JOHNSTON, R Williams and S Catterall
 'Further investigations of the crumpling transition in dynamically triangulated random surfaces', *Nuclear Phys. B*.
- J M BALL and J CARR
 'The discrete coagulation-fragmentation equations: existence, uniqueness, and density conservation', *J. Statist. Phys.*
- J M BALL and R D James
 'A characterization of plane strain', *Proc. Roy. Soc. London A*.
- J M BALL, P J Holmes, R D James, R L Pego and P Smart
 'On the dynamics of fine structure'.
- F BAVAUD
 'Isoperimetric phase transition of two-dimensional droplets', *Commun. Math. Phys.*
 'Adjoint transform, overconvexity and sets of constant width'.
 'Equilibrium Properties of the Vlasov functional: the generalized Poisson-Boltzmann-Eden equation'.
- C E BEEVERS, B Cherry, M G FOSTER and G R MCGUIRE
 'Software Tools for Computer Aided Learning in Mathematics', Gower Publishing Company.
- C E BEEVERS, M G FOSTER, A A Korabinski and G R MCGUIRE
 'The use of CAL in mathematical education', *Collegiate Microcomputing*.
- J Bell, A Friedman and A A LACEY
 'On solutions to a quasilinear diffusion problem from the study of soft tissue', *SIAM J. Appl. Maths.*
- M van den BERG
 'A gaussian lower bound for the Dirichlet heat kernel'.
 'On the spectral counting function for the Dirichlet laplacian'.
 'On the trace of the difference of Schrödinger heat semigroups'.
- M van den BERG and B TOTH
 'Exponential estimates for the Wiener sausage', *Prob. Theor. Rel. Fields*.
- A R Bishop, R FLESCH, M G Forest, D W McLaughlin and E A Overman, II.
 'Correlations between chaos in a perturbed sine-Gordon equation and a truncated model system'.
- K J BROWN and J Furter
 'A singularity theory approach to a semilinear boundary value problem'.
- K J BROWN and P Hess
 'Positive periodic solutions of predator-prey reaction-diffusion systems', *Nonlinear Anal.*
- K J BROWN and R Shivaji
 'Instability of non-negative solutions for a class of semi-positive problems', *Proc. Amer. Math. Soc.*
- J CARR and R L Pego
 'Self-similarity in a coarsening model in one dimension'.

- J Corney and D E R CLARK
'A method for finding holes and pockets in 2.5D objects which connect multiple faces', *Computer-Aided Design*.
- P J Davies and D B DUNCAN
'A parallel computation of fractal dimensions', *Proc. Nonlinear and Chaotic Phenomena Conference, July 1990, Edmonton, Canada*.
'Mathematical Models in Ecology - a workshop for secondary school students', *Teaching Mathematics and its Applications*.
- G Dell'Antonio and V NESI
'A scalar inequality which bounds the effective conductivity of composites', *Proc. Roy. Soc. London A*.
- M M Dodson, B P RYNNE and J A G Vickers
'Khintchine-type theorems on manifolds', *Acta Arith.*
'Dirichlet theorem and diophantine approximation on manifolds', *J. Number Theory*.
'Diophantine approximation by linear forms on manifolds', *Proc. Indian Acad. Sciences (Maths)*.
- A J DUNCAN
'Zariski regularity and the Nullstellensatz with nilpotents'.
- A J DUNCAN and J HOWIE
'The genus problem for one-relator products of locally indicable groups', *Math. Z.*
'The nonorientable genus problem for one-relator products'.
- D B DUNCAN
'A simple and effective self-adaptive moving mesh for enthalpy formulations of phase change problems', *IMA J. Numer. Anal. (vol. 9)*.
- D B DUNCAN and M A M LYNCH
'Jacobi iteration in implicit difference schemes for the wave equation'.
- R FLESCH, M G Forest and A Sinha
'Numerical inverse spectral transform for the periodic sine-Gordon equation: theta function solutions and their linearized stability'.
- P Fratzi, J L Lebowitz, O PENROSE and J Amar
'Scaling functions and morphology of phase separating systems'.
- N D GILBERT
'Derivations, automorphisms and crossed modules', *Comm. in Algebra*.
'Identities between sets of relations', *Central extensions of groups and an embedding question of J.H.C. Whitehead*.
- J HOWIE
'The quotient of a free product of groups by a single high-powered relator. III. The word problem', *Proc. London Math. Soc.*
'Nonsingular systems of two length three equations over a group', *Math. Proc. Camb. Phil. Soc.*
- J HOWIE and R M Thomas
'The groups $(2,3,p,q)$; asphericity and a conjecture of Coxeter'.
- P K JIMACK
'Large time solutions of the moving finite element equations for linear diffusion problems in one dimension', *IMA J. Numer. Anal.*
- P K JIMACK and A J Wathen
'Temporal derivatives in the finite element method on continuously deforming grids', *SIAM J. Numer. Anal.*
- R J KNOPS
'Spatial decay estimates in the vibrating elastic beam', *Proc. of 5th International Conference on Waves and Stability in Continuous Media, Sorrento 1990*.
'A Phragmén-Lindelöf theorem for the free elastic cylinder', *Rendiconti di Matematica. Serie VII, 90, 1990*.
'On isolated point singularities in classical elasticity', *Anniversary volume in honour of Professor Horst Lippmann's 70th birthday*.
- R J KNOPS, S Rionero and R Russo
'Stability and related results in linear elastodynamics on unbounded regions'.
- V NESI
'Multiphase Interchange inequality'.
'On the G-closure in the polycrystalline problem'.
- V NESI and G W Milton
'Polycrystalline configurations that maximise electrical resistivity', *J. Mech. Ph. of Solids*.
- V NESI and Q TANG
'New bounds in plasticity'.
- L E NICHOLAS
'The solution of ordinary differential equations by a first order method', *Teaching Mathematics and its Applications*.
- O PENROSE
'Bose-Einstein condensation in an exactly soluble system of interacting particles', *J. Stat. Phys.*
- M Penrose, O PENROSE, G Stell and R Penantle
'Quantum-mechanical sticky spheres'.
- A R PRINCE
'The flag-transitive affine planes of order 27'.
- H U RAHMAN
'Analytical formulae for n-dimensional integrals'.
- B P RYNNE
'Time domain scattering from arbitrary surfaces using the electric field integral equation', *J. EM Waves and Applications*.
- B P RYNNE and B D Sleeman
'The interior transmission problem and inverse scattering from inhomogeneous media'.
- B P RYNNE and P D Smith
'Stability of time marching algorithms for the electric field integral equation', *J. EM Waves and Applications*.
- R J Tait, K A Abdella and D B DUNCAN
'Approximate Riemann solvers and waves on a nonlinear elastic string', *Computers and Mathematics with Applications*.