

## LONDON MATHEMATICAL SOCIETY LECTURE NOTE SERIES

Managing Editor: Professor N.J. Hitchin, Mathematical Institute,  
 University of Oxford, 24–29 St Giles, Oxford OX1 3LB, United Kingdom

The titles below are available from booksellers, or, in case of difficulty, from Cambridge University Press.

- 88 PPF ring theory, C. FAITH & S. PAGE  
 90 Polytopes and symmetry, S.A. ROBERTSON  
 96 Diophantine equations over function fields, R.C. MASON  
 97 Varieties of constructive mathematics, D.S. BRIDGES & F. RICHMAN  
 99 Methods of differential geometry in algebraic topology, M. KAROUBI & C. LERUSTE  
 100 Stopping time techniques for analysts and probabilists, L. EGGHE  
 104 Elliptic structures on 3-manifolds, C.B. THOMAS  
 105 A local spectral theory for closed operators, I. ERDELYI & WANG SHENGWANG  
 107 Compactification of Siegel moduli schemes, C.-L. CHAI  
 109 Diophantine analysis, J. LOXTON & A. VAN DER POORTEN (eds)  
 113 Lectures on the asymptotic theory of ideals, D. REES  
 116 Representations of algebras, P.J. WEBB (ed)  
 119 Triangulated categories in the representation theory of finite-dimensional algebras, D. HAPPEL  
 121 Proceedings of *Groups - St Andrews 1985*, E. ROBERTSON & C. CAMPBELL (eds)  
 128 Descriptive set theory and the structure of sets of uniqueness, A.S. KECHRIS & A. LOUVEAU  
 130 Model theory and modules, M. PREST  
 131 Algebraic, extremal & metric combinatorics, M.-M. DEZA, P. FRANKL & I.G. ROSENBERG (eds)  
 138 Analysis at Urbana, II, E. BERKSON, T. PECK, & J. UHL (eds)  
 139 Advances in homotopy theory, S. SALAMON, B. STEER & W. SUTHERLAND (eds)  
 140 Geometric aspects of Banach spaces, E.M. PEINADOR & A. RODES (eds)  
 141 Surveys in combinatorics 1989, J. SIEMONS (ed)  
 144 Introduction to uniform spaces, I.M. JAMES  
 146 Cohen-Macaulay modules over Cohen-Macaulay rings, Y. YOSHINO  
 148 Helices and vector bundles, A.N. RUDAKOV *et al*  
 149 Solitons, nonlinear evolution equations and inverse scattering, M. ABLOWITZ & P. CLARKSON  
 150 Geometry of low-dimensional manifolds 1, S. DONALDSON & C.B. THOMAS (eds)  
 151 Geometry of low-dimensional manifolds 2, S. DONALDSON & C.B. THOMAS (eds)  
 152 Oligomorphic permutation groups, P. CAMERON  
 153 L-functions and arithmetic, J. COATES & M.J. TAYLOR (eds)  
 155 Classification theories of polarized varieties, TAKAO FUJITA  
 158 Geometry of Banach spaces, P.F.X. MÜLLER & W. SCHACHERMAYER (eds)  
 159 Groups St Andrews 1989 volume 1, C.M. CAMPBELL & E.F. ROBERTSON (eds)  
 160 Groups St Andrews 1989 volume 2, C.M. CAMPBELL & E.F. ROBERTSON (eds)  
 161 Lectures on block theory, BURKHARD KÜLSHAMMER  
 163 Topics in varieties of group representations, S.M. VOVSİ  
 164 Quasi-symmetric designs, M.S. SHRIKANDÉ & S.S. SANE  
 166 Surveys in combinatorics, 1991, A.D. KEEDWELL (ed)  
 168 Representations of algebras, H. TACHIKAWA & S. BRENNER (eds)  
 169 Boolean function complexity, M.S. PATERSON (ed)  
 170 Manifolds with singularities and the Adams-Novikov spectral sequence, B. BOTVINNIK  
 171 Squares, A.R. RAJWADE  
 172 Algebraic varieties, GEORGE R. KEMPF  
 173 Discrete groups and geometry, W.J. HARVEY & C. MACLACHLAN (eds)  
 174 Lectures on mechanics, J.E. MARSDEN  
 175 Adams memorial symposium on algebraic topology 1, N. RAY & G. WALKER (eds)  
 176 Adams memorial symposium on algebraic topology 2, N. RAY & G. WALKER (eds)  
 177 Applications of categories in computer science, M. FOURMAN, P. JOHNSTONE & A. PITTS (eds)  
 178 Lower K- and L-theory, A. RANICKI  
 179 Complex projective geometry, G. ELLINGSRUD *et al*  
 180 Lectures on ergodic theory and Pesin theory on compact manifolds, M. POLLICOTT  
 181 Geometric group theory I, G.A. NIBLO & M.A. ROLLER (eds)  
 182 Geometric group theory II, G.A. NIBLO & M.A. ROLLER (eds)  
 183 Shintani zeta functions, A. YUKIE  
 184 Arithmetical functions, W. SCHWARZ & J. SPILKER  
 185 Representations of solvable groups, O. MANZ & T.R. WOLF  
 186 Complexity: knots, colourings and counting, D.J.A. WELSH  
 187 Surveys in combinatorics, 1993, K. WALKER (ed)  
 188 Local analysis for the odd order theorem, H. BENDER & G. GLAUBERMAN  
 189 Locally presentable and accessible categories, J. ADAMEK & J. ROSICKY  
 190 Polynomial invariants of finite groups, D.J. BENSON  
 191 Finite geometry and combinatorics, F. DE CLERCK *et al*  
 192 Symplectic geometry, D. SALAMON (ed)  
 194 Independent random variables and rearrangement invariant spaces, M. BRAVERMAN  
 195 Arithmetic of blowup algebras, WOLMER VASCONCELOS  
 196 Microlocal analysis for differential operators, A. GRIGIS & J. SJÖSTRAND  
 197 Two-dimensional homotopy and combinatorial group theory, C. HOG-ANGELONI *et al*  
 198 The algebraic characterization of geometric 4-manifolds, J.A. HILLMAN  
 199 Invariant potential theory in the unit ball of  $C^n$ , MANFRED STOLL  
 200 The Grothendieck theory of dessins d'enfant, L. SCHNEPS (ed)  
 201 Singularities, JEAN-PAUL BRASSELET (ed)  
 202 The technique of pseudodifferential operators, H.O. CORDES  
 203 Hochschild cohomology of von Neumann algebras, A. SINCLAIR & R. SMITH  
 204 Combinatorial and geometric group theory, A.J. DUNCAN, N.D. GILBERT & J. HOWIE (eds)  
 205 Ergodic theory and its connections with harmonic analysis, K. PETERSEN & I. SALAMA (eds)  
 207 Groups of Lie type and their geometries, W.M. KANTOR & L. DI MARTINO (eds)  
 208 Vector bundles in algebraic geometry, N.J. HITCHIN, P. NEWSTEAD & W.M. OXBURY (eds)

- 209 Arithmetic of diagonal hypersurfaces over finite fields, F.Q. GOUVÊA & N. YUI  
 210 Hilbert  $C^*$ -modules, E.C. LANCE  
 211 Groups 93 Galway / St Andrews I, C.M. CAMPBELL *et al* (eds)  
 212 Groups 93 Galway / St Andrews II, C.M. CAMPBELL *et al* (eds)  
 214 Generalised Euler-Jacobi inversion formula and asymptotics beyond all orders, V. KOWALENKO *et al*  
 215 Number theory 1992–93, S. DAVID (ed)  
 216 Stochastic partial differential equations, A. ETHERIDGE (ed)  
 217 Quadratic forms with applications to algebraic geometry and topology, A. PFISTER  
 218 Surveys in combinatorics, 1995, PETER ROWLINSON (ed)  
 220 Algebraic set theory, A. JOYAL & I. MOERDIJK  
 221 Harmonic approximation, S.J. GARDINER  
 222 Advances in linear logic, J.-Y. GIRARD, Y. LAFONT & L. REGNIER (eds)  
 223 Analytic semigroups and semilinear initial boundary value problems, KAZUAKI TAIRA  
 224 Computability, enumerability, unsolvability, S.B. COOPER, T.A. SLAMAN & S.S. WAINER (eds)  
 225 A mathematical introduction to string theory, S. ALBEVERIO, J. JOST, S. PAYCHA, S. SCARLATTI  
 226 Novikov conjectures, index theorems and rigidity I, S. FERRY, A. RANICKI & J. ROSENBERG (eds)  
 227 Novikov conjectures, index theorems and rigidity II, S. FERRY, A. RANICKI & J. ROSENBERG (eds)  
 228 Ergodic theory of  $\mathbb{Z}^d$  actions, M. POLLICOTT & K. SCHMIDT (eds)  
 229 Ergodicity for infinite dimensional systems, G. DA PRATO & J. ZABCZYK  
 230 Prolegomena to a middlebrow arithmetic of curves of genus 2, J.W.S. CASSELS & E.V. FLYNN  
 231 Semigroup theory and its applications, K.H. HOFMANN & M.W. MISLOVE (eds)  
 232 The descriptive set theory of Polish group actions, H. BECKER & A.S. KECHRIS  
 233 Finite fields and applications, S. COHEN & H. NIEDERREITER (eds)  
 234 Introduction to subfactors, V. JONES & V.S. SUNDER  
 235 Number theory 1993–94, S. DAVID (ed)  
 236 The James forest, H. FETTER & B. GAMBOA DE BUEN  
 237 Sieve methods, exponential sums, and their applications in number theory, G.R.H. GREAVES *et al*  
 238 Representation theory and algebraic geometry, A. MARTSINKOVSKY & G. TODOROV (eds)  
 239 Clifford algebras and spinors, P. LOUNESTO  
 240 Stable groups, FRANK O. WAGNER  
 241 Surveys in combinatorics, 1997, R.A. BAILEY (ed)  
 242 Geometric Galois actions I, L. SCHNEPS & P. LOCHAK (eds)  
 243 Geometric Galois actions II, L. SCHNEPS & P. LOCHAK (eds)  
 244 Model theory of groups and automorphism groups, D. EVANS (ed)  
 245 Geometry, combinatorial designs and related structures, J.W.P. HIRSCHFELD *et al*  
 246  $p$ -Automorphisms of finite  $p$ -groups, E.I. KHUKHRO  
 247 Analytic number theory, Y. MOTOHASHI (ed)  
 248 Tame topology and  $o$ -minimal structures, LOU VAN DEN DRIES  
 249 The atlas of finite groups: ten years on, ROBERT CURTIS & ROBERT WILSON (eds)  
 250 Characters and blocks of finite groups, G. NAVARRO  
 251 Gröbner bases and applications, B. BUCHBERGER & F. WINKLER (eds)  
 252 Geometry and cohomology in group theory, P. KROPHOLLER, G. NIBLO, R. STÖHR (eds)  
 253 The  $q$ -Schur algebra, S. DONKIN  
 254 Galois representations in arithmetic algebraic geometry, A.J. SCHOLL & R.L. TAYLOR (eds)  
 255 Symmetries and integrability of difference equations, P.A. CLARKSON & F.W. NIJHOFF (eds)  
 256 Aspects of Galois theory, HELMUT VÖLKLEIN *et al*  
 257 An introduction to noncommutative differential geometry and its physical applications 2ed, J. MADORE  
 258 Sets and proofs, S.B. COOPER & J. TRUSS (eds)  
 259 Models and computability, S.B. COOPER & J. TRUSS (eds)  
 260 Groups St Andrews 1997 in Bath, I, C.M. CAMPBELL *et al*  
 261 Groups St Andrews 1997 in Bath, II, C.M. CAMPBELL *et al*  
 263 Singularity theory, BILL BRUCE & DAVID MOND (eds)  
 264 New trends in algebraic geometry, K. HULEK, F. CATANESE, C. PETERS & M. REID (eds)  
 265 Elliptic curves in cryptography, I. BLAKE, G. SEROUSSI & N. SMART  
 267 Surveys in combinatorics, 1999, J.D. LAMB & D.A. PREECE (eds)  
 268 Spectral asymptotics in the semi-classical limit, M. DIMASSI & J. SJÖSTRAND  
 269 Ergodic theory and topological dynamics, M.B. BEKKA & M. MAYER  
 270 Analysis on Lie Groups, N.T. VAROPOULOS & S. MUSTAPHA  
 271 Singular perturbations of differential operators, S. ALBEVERIO & P. KURASOV  
 272 Character theory for the odd order function, T. PETERFALVI  
 273 Spectral theory and geometry, E.B. DAVIES & Y. SAFAROV (eds)  
 274 The Mandelbrot set, theme and variations, TAN LEI (ed)  
 275 Computational and geometric aspects of modern algebra, M. D. ATKINSON *et al* (eds)  
 276 Singularities of plane curves, E. CASAS-ALVERO  
 277 Descriptive set theory and dynamical systems, M. FOREMAN *et al* (eds)  
 278 Global attractors in abstract parabolic problems, J.W. CHOLEWA & T. DLOTKO  
 279 Topics in symbolic dynamics and applications, F. BLANCHARD, A. MAASS & A. NOGUEIRA (eds)  
 280 Characters and automorphism groups of compact Riemann surfaces, T. BREUER  
 281 Explicit birational geometry of 3-folds, ALESSIO CORTI & MILES REID (eds)  
 282 Auslander-Buchweitz approximations of equivariant modules, M. HASHIMOTO  
 283 Nonlinear elasticity, R. OGDEN & Y. FU (eds)  
 284 Foundations of computational mathematics, R. DEVORE, A. ISERLES & E. SULI (eds)  
 285 Rational points on curves over finite fields: theory and applications, H. NIEDERREITER & C. XING  
 286 Clifford algebras and spinors 2nd edn, P. LOUNESTO  
 287 Topics on Riemann surfaces and Fuchsian groups, E. BUJALANCE, A.F. COSTA & E. MARTINEZ (eds)  
 288 Surveys in combinatorics, 2001, J.W.P. HIRSCHFELD (ed)  
 289 Aspects of Sobolev-type inequalities, L. SALOFF-COSTE  
 290 Quantum groups and Lie theory, A. PRESSLEY  
 291 Tits buildings and the model theory of groups, K. TENT  
 292 A quantum groups primer, S. MAJID  
 293 Second order partial differential equations in Hilbert spaces, G. DA PRATO & J. ZABCZYK  
 294 Introduction to operator space theory, G. PISIER  
 296 Lectures on invariant theory, I. DOLGACHEV  
 297 The homotopy category of simply connected 4-manifolds, H.-J. BAUES

Cambridge University Press  
978-0-521-54012-4 — Surveys in Combinatorics 2003  
Edited by C. D. Wensley  
Frontmatter  
[More Information](#)

---

London Mathematical Society Lecture Note Series. 307

# Surveys in Combinatorics 2003

Edited by

C. D. Wensley  
*University of Wales, Bangor*



CAMBRIDGE  
UNIVERSITY PRESS

Cambridge University Press  
978-0-521-54012-4 — Surveys in Combinatorics 2003  
Edited by C. D. Wensley  
Frontmatter  
[More Information](#)

## CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom  
One Liberty Plaza, 20th Floor, New York, NY 10006, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India  
103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521540124](http://www.cambridge.org/9780521540124)

© Cambridge University Press 2003

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2003

*A catalogue record for this publication is available from the British Library*

ISBN 978-0-521-54012-4 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

## Contents

	<i>Preface</i>	<i>page vii</i>
	W.T. Tutte, 1917–2002 <i>Norman Biggs</i>	1
1	Decompositions of complete graphs: embedding partial edge-colourings and the method of amalgamations <i>L. D. Andersen and C. A. Rodger</i>	7
2	Combinatorial schemes for protecting digital content <i>Simon R. Blackburn</i>	43
3	Matroids and Coxeter groups <i>A. V. Borovik</i>	79
4	Defining sets in combinatorics: a survey <i>D. M. Donovan, E. S. Mahmoodian, C. Ramsay and A. P. Street</i>	115
5	Finite projective planes with a large abelian group <i>D. Ghinelli and D. Jungnickel</i>	175
6	Algorithmic aspects of graph homomorphisms <i>P. Hell</i>	239
7	Counting lattice triangulations <i>V. Kaibel and G. M. Ziegler</i>	277
8	Partition regular equations <i>I. Leader</i>	309
9	Kostka–Foulkes polynomials and Macdonald spherical functions <i>K. Nelsen and A. Ram</i>	325

## Preface

The British Combinatorial Committee invited nine distinguished combinatorial mathematicians to give survey talks on the latest developments in their own fields at the 19th British Combinatorial Conference held at the University of Wales, Bangor, in July 2003. This volume contains the survey articles on which these talks were based, together with a memoir of Bill Tutte.

The conference was held in Bangor to honour the 100th anniversary of the birth of Professor D.E. Littlewood, Professor of Mathematics at Bangor from 1948 to 1970. The talk by Arun Ram, which dealt with recent developments in generalized Hall–Littlewood and Kostka–Foulkes polynomials, was designated the *Littlewood Anniversary Lecture*.

The customary *Rado Lecture*, this year given by Imre Leader, described recent developments in Ramsey Theory for infinite systems. The nine articles in this volume provide a splendid source of reference to the current state of the art in combinatorics.

In coordinating this volume I have been greatly assisted by previous local organisers, by members of the British Combinatorial Committee, and by Jonathan Walthoe of Cambridge University Press. The delivery on schedule of this volume was made possible by the careful attention to detail, and by the prompt response to requests, of all the authors and referees.

The conference is grateful for financial support from the London Mathematical Society.

Christopher D. Wensley  
Bangor, March 2003  
[c.d.wensley@bangor.ac.uk](mailto:c.d.wensley@bangor.ac.uk)