C.I.M.E. Session on "Methods of Nonconvex Analysis"

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FONDAZIONE C.I.M.E.
CENTRO INTERNAZIONALE MATEMATICO ESTIVO
INTERNATIONAL MATHEMATICAL SUMMER CENTER

"Recent Developments in Geometric Topology and Related Topics"

is the subject of the First 1990 C.I.M.E. Session.

The Session, sponsored by the Consiglio Nazionale delle Ricerche and the Ministero della Pubblica Istruzione, will take place under the scientific direction of Prof. PAOLO DE BARTOLOMEIS (Università di Firenze), and Prof. FRANCO TRICERRI (Università di Firenze) at Villa "La Querceta", Montecatini Terme (Pistoia), from **June 4 to June 12, 1990.**

Courses

a) **Curvature Topology and Critical Points.** (8 lectures in English).
Prof. Jeff CHEEGER (NYU - Courant Institute).

Outline

In about 1976, K. Grove and K. Shiohama made a basic advance in riemannian geometry, by observing that the Isotopy Lemma of Morse Theory could be generalized to distance functions on riemannian manifolds.

In combination with Toponogov's comparison theorem, their observation has a number of very interesting applications which relate curvature and topology. The main goal of our lectures will be to expose three such results.

1) The theorem of Grove-Petersen, asserting that the collection of riemannian-manifolds with diameter $\leqslant$ d, and sectional curvature $\geqslant$ H., contains only finitely many homotopy types.
2) The theorem of Gromov asserting that there is a universal bound on the sum of the Betti numbers for riemannian n-manifolds with diameter $\leqslant$ d and sectional curvature $\geqslant$ H.
3) The theorem of Abresch-Gromoll asserting that a complete manifold with non-negative Ricci curvature, sectional curvature bounded below by H ($>-\infty$) and whose "size at infinity grows slowly", has finite topological type.

The prerequisites for these lectures are chapters 1 and 2 of [CE] (some of this material will be rapidly reviewed).

References

[AG] Abresch, U., Gromoll, D., On Complete Manifolds with Nonnegative Ricci Curvature, Gromoll, D., JAMS (to appear).

[CE] Cheeger, J., Ebin, D., Comparison theorems in Riemannian geometry, North-Holland, N.Y., 1975.

[G] Gromov, M., Curvature, diameter and Betti numbers, Comm. Math. Helv. 56 (1981), 179-195.

[GrP] Grove, K., Petersen, P., Bounding homotopy types by geometry, Annals of Mathematics, 128 (1988), 195-206.

[GrPW] Grove, K., Petersen, P., Wu, J.Y., Controlled Topology in Geometry, BAMS, Volume 20, Number 2, April 1989.

[GrS] Grove, K., Shiohama, K., A generalized sphere theorem, Ann. of Math. 106 (1977), 201-211.

[EH] Eschenberg, J., Heintze, E., An elementary proof of the Cheeger-Gromoll splitting theorem, Ann. Glob. Analysis and Geometry 2 (1984), 141-151.

b) **Rigidity Theory of Locally Symmetric Spaces.** (8 lectures in English).
Prof. Mikhail GROMOV (IHES)
Prof. Pierre PANSU (Ecole Polytechnique, Palaiseau)

Contents

1. Statement and discussion of basic rigidity theorems of Mostow and Margulis.
2. Behaviour maps at the ideal boundary.
3. Harmonic maps and their applications to rigidity.

Bibliography

G.D. Mostow, Strong Ridigity for locally symmetric spaces, Princeton University Press, 1973.
N. Mok, Metric Rigidity Theorems on Hermitian Locally Symmetric Manifolds, World Scientific, 1989.

c) **Instantons, stable bundles and the differential topology of algebraic surfaces.** (8 lectures in English).
Prof. Christian OKONEK (Universität Bonn)

Contents

1. Topology of algebraic surfaces
2. Stable vector bundles
3. Instantons
4. Hermitian - Einstein structures
5. Donaldson's invariants
6. C^{∞}-structures of algebraic surfaces

Basic literature (books only)

[B/P/V] Barth, W., Peters, C., Van de Ven, A.: "Compact complex surfaces", Erg. der Math. 3. Folge, Bd. 4. Berlin, Heidelberg, New York, Tokyo, Springer 1984.
[F/U] Freed, D., Uhlenbeck, K.: "Instantons and four-manifolds". M.S.R.I. publ. no. 1. New York, Berlin, Heidelberg, Tokyo, Springer 1984.
[K] Kobayashi, S.: "Differential geometry of complex vector bundles". Iwanami Shoten and Princeton University Press 1987.
[O/S/S] Okonek, C., Schneider, M., Spindler, H.: "Vector bundles over complex projective spaces". Progress in Math. 3. Boston, Basel, Stuttgart, Birkhäuser 1980.

Seminars

A number of seminars and special lectures will be offered during the Session.

FONDAZIONE C.I.M.E.
CENTRO INTERNAZIONALE MATEMATICO ESTIVO
INTERNATIONAL MATHEMATICAL SUMMER CENTER

"Recent Developments in H_∞ Control Theory"

is the subject of the Second 1990 C.I.M.E. Session.

The Session, sponsored by the Consiglio Nazionale delle Ricerche and the Ministero della Pubblica Istruzione, will take place under the scientific direction of Prof. EDOARDO MOSCA (Università di Firenze) and Prof. LUCIANO PANDOLFI (Politecnico di Torino), at Villa Olmo, Como, Italy, ***from June 18 to June 26, 1990.***

Courses

a) **Commutant lifting techniques for computing optimal and suboptimal controllers.** (4 lectures in English).
Prof. Ciprian FOIAS (Indiana University, Bloomington, USA).

Contents

The aim of the 4 lectures is to give a self-contained presentation of some operator theoretical techniques for computing linear and nonlinear optimal controllers, developed in [1], [2], [3], [5], [6], and [7].

Lecture 1: The commutant lifting theorem paradigm
1. Interpolation problems (Caratheodory, Nevanlinna-Pick, Hermite-Fejer, Nehari, Feintuch-Francis) as operator theory statements.
2. The encompassing Commutant Lifting Theorem ([8], [9] and [10]).
3. The connection to the sensitivity problem in Control.

Lecture 2: Skew Toeplitz operators (Scalar case)
1. Reduction of the computation of an optimal controller to the kernel of a skew Toeplitz operator.
2. The reduction of the spectral study of a skew Toeplitz operator to linear algebra.
3. Effective algorithm for computing an optimal controller for transcendental plants.

Lecture 3: Skew Toeplitz operators in the H bloch problem
1. General facts on skew Toeplitz operators and their invertibility.
2. Effective algorithm for computing the optimal and suboptimal controllers in the 4 block problem with transcendental plants.

Lecture 4: Nonlinear plants and nonlinear controllers
1. The formulation of optimality for nonlinear analytic plants.
2. The iterative commutant lifting theorem method for constructing an optimal nonlinear analytic controller.
3. Explicit computation in the rational case.

References

[1] C. Foias, A. Tannenbaum and G. Zames, "Some explicit formula for the singular values of certain Hankel operators with factorizable symbol", SIAM J. of Math. Analysis, 19 (1988), 1081-1089.

[2] C. Foias, H. Bercovici and A. Tannenbaum, "On skew Toeplitz operators, I" Oper. Th.: Adv. and Appl., 29(c) (1988), 21-43.

[3] C. Foias and A. Tannenbaum, "Some remarks on optimal interpolation", Systems and Control Lett., 11 (1988), 259-265.

[4] C. Foias and A. Tannenbaum, "On the four block problem, I", Oper. Th.: Adv. and Appl., 32 (1988), 93-112.

[5] C. Foias and A. Tannenbaum, "On the four block problem, II: The singular system", Integral Equations and Oper. Th., 11 (1988), 726-767.
[6] C. Foias and A. Tannenbaum, "Weighted optimization theory for nonlinear systems", SIAM J. Control and Optim., 27 (1989), 842-860.
[7] C. Foias and A. Tannenbaum, "Iterative commutant lifting for systems with rational symbols", Oper. Th.: Adv. and Appl., 41 (1989), 255-277.
[8] D. Sarason, "Generalized interpolation in H_∞", Trans. Amer. Math. Soc., 127 (1967), 179-203.
[9] B. Sz.-Nagy and C. Foias, "Dilatation des commutants d'operateurs", C.R. Acad. Sci. Paris, Serie A, 266 (1968), 493-495.
[10] B. Sz.-Nagy and C. Foias, "Harmonic Analysis of Operators on Hilbert Space", North Holland, Amsterdam, 1970.

b) **On H_∞ control and sampled-data systems.** (6 lectures in English).
Prof. Bruce A. FRANCIS (University of Toronto, Canada).

Contents

Lecture 1: Introduction
1. Linear systems and their models; input-output and state-space
2. Norms for signals and systems
3. Input-output relationship
4. Motivation of performance spec $\| W_1 S \|_\infty < 1$
5. Motivation of robust stability spec $\| W_2 T \|_\infty < 1$
6. Statement of robust performance problem, minimize $\| \, |W_1 S| + |W_2 T| \, \|_\infty$
7. Statement of compromize problem, minimize $\left\| \begin{bmatrix} W_1 S \\ W_2 S \end{bmatrix} \right\|_\infty$
8. Statement of standard problem
9. Flexible beam example

Lecture 2: Model-Matching
1. Model-matching problem
2. Nevanlinna problem
3. Nevanlinna's algorithm
4. State-space solution

Lecture 3: Design
1. Design for performance, $\| W_1 S \|_\infty < 1$
2. Optimal robust stability
3. Gain and phase margin optimization

Lecture 4: State-space methods
1. Computing H_∞ norm
2. Solution of the optimal state-feedback problem

Lecture 5: New work on sampled-data system, part 1

Lecture 6: New work on sampled-data sustem, part 2

References

For Lectures 1-3:
J. Doyle, B. Francis, A. Tannenbaum, Feedback Control Theory, Macmillan, probably 1990.

For Lecture 4:
J. Doyle, K. Glover, P. Khargonekar, B. Francis, "State-space solutions to standard H_2 and H_∞ control problems", IEEE Trans. Auto. Control, AC-34, pp. 831-847, 1987.

c) **Basics of worst case design in the frequency domain and new directions.** (6 lectures in English)
Prof. J. William HELTON (University of California at San Diego, USA).

Contents

1. Introduction - will tie this lecture to the others and indicate new directions.
2. Sup norm optimization over stable functions - theory and numerical issues.
3,4. Non-linear system - factoring them and controlling them.

d) **Polynomial approach to H_∞ Control.** (6 lectures in English)
Prof. Huibert KWAKERNAAK (University of Twente, The Netherlands)

Contents

Lecture 1: The SISO minimum sensitivity problem.
1. The minimum sensitivity and complementary sensitivity problems
2. The equalizer principle
3. Polynomial solution of the minimum sensitivity and complementary sensitivity problems
4. The regulability number of SISO systems

Lecture 2: The SISO mixed sensitivity problem
1. Robustness optimization of SISO feedback system
2. Performance optimization and frequency response shaping
3. The SISO mixed sensitivity problem
4. Polynomial solution of the SISO mixed sensitivity problem

Lecture 3: Polynomial matrices and matrix fraction representation of transfer matrices.
1. Review of polynomial matrices and polynomial matrix fraction representations
2. Linear polynomial matrix equations
3. Spectral and J-spectral factorization of polynomial matrices

Lecture 4: The MIMO mixed sensitivity problem.
1. The MIMO equalizer principle
2. MIMO robustness and performance optimization and frequency response shaping
3. The MIMO mixed sensitivity problem
4. Polynomial solution of the MIMO mixed sensitivity problem

Lecture 5: The standard H_∞ optimal control problem.
1. The standard H_∞ optimal control problem
2. Special cases:
   i. the mixed-sensitivity problem,
   ii. the mixed sensitivity problem with measurement noise,
   iii. the two-degree-of-freedom problem with and without measurement noise
3. The extended MIMO equalizer principle
4. Parametrization of the closed-loop transfer matrix
5. Polynomial solution of the standard H_∞ optimal control problem

Lecture 6: Nonuniqueness and super-optimal solutions
1. Nonuniqueness of the solution of the H_∞ optimal problems
2. Super-optimal solutions
3. Polynomial approach to super-optimal solutions

References

Francis, B.A. (1987). A course in H_∞ Control Theory. Springer Lecture Notes in Control and Information Sciences 88, Springer-Verlag, Heidelberg

Kailath, Th. (1980). Linear System. Prentice Hall, Englewood Cliffs, NJ, USA

Kwakernaak, H. (1985). Minimax frequency domain performance and robustness optimization of linear feedback systems. IEEE Trans. Aut. Control, 30, 994-1004.

Kwakernaak, H. (1986). A polynomial approach to minimax frequency domain optimization of multivariable feedback system. Int. J. Control, 44, 117-156.

Kwakernaak, H. (1987). A polynomial approach to H_∞ -optimization of control systems. In: R.F. Curtain (Ed.), Modelling, Robustness and Sensitivity Reduction in Control Systems. Springer Verlag, Heidelberg.

Kwakernaak, H. (1990). Progress in the polynomial solution of the standard H_∞ optimal control problem. IFAC Congress, Tallinn, USSR.

Kucera, V. (1979). Discrete Linear Control. John Wiley, Chichester.

e) **Lectures on l^1 Optimal Control.** (6 lectures in English).
Prof. J. Boyd PEARSON (Rice University, Houston, USA)

Contents

Lecture 1: Introduction
1. Dual Spaces
2. Hahn-Banach Theorem
3. Alignment and Orthogonal Complements
4. Duality Theorems

Lecture 2: l^1-Optimal Control - The Scalar Problem

Lecture 3: l^1-Optimal Control - The Multivariable Problem - Case I: "Good" Rank

Lecture 4: l^1-Optimal Control - The Multivariable Problem - Case II: "Bad" Rank

Lecture 5: Constrained Optimal Control using the l^1 Norm

Lecture 6: Robust Performance using the l^1 Norm

References

Lecture 1: Optimization by Vector Space Methods, D.G. Luenberger, New York, John Wiley and Sons, Chapter 5, 1969.

Lecture 2 and 3: l^1-Optimal Feedback Controllers for MIMO Discrete-Time System, M.A. Dahleh and J.B. Pearson, IEEE Trans. A-C, Vol. AC-32, No. 4, pp. 314-322, Apr. 1987.

Lecture 4: Optimal Rejection of Persistent Disturbances, Robust Stability and Mixed Sensitivity Minimization, M.A. Dahleh and J.B. Pearson, IEEE Trans. A-C, Vol. AC-33, No 8, pp. 722-731, Aug. 1988

Lecture 5 and 6: New material which is, as yet, unpublished.

Seminars

A number of seminars and special lectures will be offered during the Session.

FONDAZIONE C.I.M.E.
CENTRO INTERNAZIONALE MATEMATICO ESTIVO
INTERNATIONAL MATHEMATICAL SUMMER CENTER

"Continua with microstructures"

is the subject of the Third 1990 C.I.M.E. Session.

The Session, sponsored by the Consiglio Nazionale delle Ricerche and the Ministero della Pubblica Istruzione, will take place under the scientific direction of Prof. GIANFRANCO CAPRIZ (Università di Pisa) at Villa "La Querceta", Montecatini Terme (Pistoia), Italy, **from July 2 to July 10, 1990.**

Courses

a) **Invariants in the theory of crystal defects.** (6 lectures in English).
Prof. Cesare DAVINI (Università di Udine, Italy).

The course presents recent results on a continuum theory of defects in crystals. The theory is based on the notion that defects should be measured by descriptors which are additive over the parts of the crystal and which are invariant under elastic deformations. It is shown that there is an infinite list of descriptors with these properties with a finite functional basis. This complete list strictly includes the Burgers' vectors and the dislocation density tensor of the classical theory of dislocations. Connections with the basic mechanisms of crystal plasticity are also discussed.

Outline of the course

1. Crystal lattices. Old molecular theories of elasticity. Defects and their role in the mechanics of materials.
2. Continuous theories of defects: the contributions of Bilby and Kondo. A continuum model for defective crystals. Elastic invariants.
3. Characterization of the first order invariants and their interpretation. Invariants of higher order. Measures of local defectiveness.
4. Neutral deformations. Conjugacy and canonical states.
5. Characterization of canonical states. A complete list of invariants.
6. A connection with a classical theorem of Frobenius. Equidefective states. Slips and rearrangements.

Basic references

[1] Taylor, G.I., The mechanism of plastic deformation of crystals. Part I and II. Proc. Roy. Soc. A 145 (1934), 362-387, 388-404.

[2] Bilby, B.A., Continuous distributions of dislocations. In: "Progress in solids mechanics", Vol. 1 (I.E. Sneddon, ed.), North-Holland Publishing Co., Amsterdam, 1960.

[3] Kroner, E., Allgemeine Kontinuumstheorie der Versetzungen und Eigenspannungen, Arch. Rational Mech. Anal. 4 (1960), 273-334.
[4] Davini, C., A proposal for a continuum theory of defective crystals, Arch. Rational Mech. Anal. 96 (1986), 295-317.
[5] Davini, C., Elastic invariants in crystal theory, In: "Material instabilities in continuum mechanics and related mathematical problems" (J.M. Ball, ed.), Clarendon Press, Oxford, 1988.
[6] Davini, C. and B.P. Parry, On defect-preserving deformations in crystals, Int. J. Plasticity 5 (1989), 337-369.
[7] Davini, C. and G.P. Parry, A complete list of invariants for defective crystals, (to appear).

b) **Microstructural theories for granular materials.** (6 lectures in English).
Prof. James T. JENKINS (Cornell University).

Outline

We outline the derivation of continuum theories for granular materials that are appropriate in the two extremes of their behavior: rapid flows involving particle collisions, and quasi-static deformations with enduring, frictional, interparticle contacts. In each extreme the microstructural variable that is important is a symmetric second rank tensor. For rapid flows this tensor is the second moment of the velocity fluctuations. In quasi-static situations it is a measure of the orientational distribution of the contact area. In each case we discuss the determination of the microstructure from the appropriate field equations and assess its influence on the stresses necessary to maintain a given flow or deformation. For rapid flows, boundary conditions may be derived using methods similar to those employed to obtain the field equations and constitutive relations. We indicate how the boundary conditions influence flows and illustrate this by employing the results of the theory in a simple hydraulic model for a rock debris slide.

References

Jenkins, J.T., Cundall, P.A. and Ishibashi, I., Micromechanical modeling of granular materials with the assistance of experiments and numerical simulations, in "Powders and Grains" (J. Biarez and R. Gourves, eds.), pp. 257-264, Balkema: Rotterdam, 1989.
Jenkins, J.T., Balance laws and constitutive relations for rapid flows of granular materials, in "Constitutive Models of Deformation" (J. Chandra and R.P. Srivastav, eds.), pp. 109-119, SIAM, Philadelphia, 1987.
Jenkins, J.T., Rapid flows of granular materials, in "Non-classical Continuum Mechanics" (R.J. Knops and A.A. Lacey, eds.), pp. 213-225, University Press, Cambridge, 1987.

c) **Defects and textures in liquid crystals.** (6 lectures in English).
Prof. Maurice KLEMAN (Université Paris-Sud).

Outline

1. Microstructure, the director $\vec{n}$, equations of equilibrium.
2. Layered phases: the equation $\mathrm{curl}\vec{n} = 0$ and the geometry of focal conics; topology of defects at the Sm A - Sm C transition, analogy with monopoles.
3. Columnar phases; the equation $\mathrm{div}\vec{n} = 0$ and the geometry of developable domains.
4. Double helical patterns in sinectics and cholesterics; presence of minimal surfaces, frustration, a model for the chromosome of dinoflagellate.
5. Cubic phases and minimal surfaces.
6. Some related aspects in ferromagnets.

d) **The topological theory of defects in ordered media.** (6 lectures in English).
Prof. David MERMIN (Cornell University).

Outline

1. Example of ordered media and their associated spaces of internal states.

2. Defects and their physical importance, classes of mutually homotopic loops in the state space, and the relation between the two.
3. The fundamental group of the state space and its relation to the combination laws for defects; media with non-abelian fundamental groups.
4. Some simple topological properties of continuous groups; group theoretic characterization of the state space in terms of broken symmetry.
5. How to deduce the fundamental group directly from the symmetry of the uniform medium.
6. The second homotopy group, its relation to point defects in 3 dimensions, the conversion of point defects by moving them around line defects, and how to deduce all this directly from the symmetry of the uniform medium.

Seminars

A number of seminars and special lectures will be offered during the Session.

FONDAZIONE C.I.M.E.
CENTRO INTERNAZIONALE MATEMATICO ESTIVO
INTERNATIONAL MATHEMATICAL SUMMER CENTER

"Mathematical Modelling of Industrial Processes"

is the subject of the Fourth 1990 C.I.M.E. Session.

The Session, sponsored by the Consiglio Nazionale delle Ricerche and the Ministero della Pubblica Istruzione, will be under the auspices of ECMI (European Consortium for Mathematics in Industry) and in collaboration with SASIAM (School for Advanced Studies in Industrial and Applied Mathematics).

It will take place under the Scientific direction of Prof. VINCENZO CAPASSO (Director of SASIAM) and Prof. ANTONIO FASANO (Università di Firenze), in TECNOPOLIS (Valenzano, Bari), from **September 24 to September 29, 1990.**

Courses

a) **Case studies of Industrial Mathematics Projects.** (7 lectures in English).
Prof. Stavros BUSENBERG (Harvey Mudd College, Claremont, USA).

Outline

These lectures will describe several industrial projects in which I have been involved over the past twenty years. A number of these projects originated in the Claremont Mathematics Clinic Program where small teams of students and faculty study problems sponsored and funded by industrial concerns. The other projects originated in consulting activities or in different University-Industry mathematics programs.

The first lecture will give an overview of a variety of Industrial Mathematics problems and of the settings in which they arose. Each of the remaining lectures will be organized about a particular mathematical area which has been useful in specific projects. However, it is the nature of Industrial Mathematics that it cannot be easily encapsulated in tidy mathematical fields which are defined for the convenience of academics, and we will end up touching upon a variety of techniques and theories.

- Case Studies of Industrial Mathematics Problems
- Semiconductor Contact Resistivity: Inverse Elliptic Problems
- Inverse Problems: Examples, Theory, and Computation
- Adaptive Pattern Recognition via Neural Networks: Optimization
- Static and Dynamic Optimization Problems
- Agricultural and Animal Resource Management: Dynamical Systems.

General References

1. H.T. Banks and K. Kunisch, Estimation Techniques for Distributed Parameter Systems, Birkhauser, Boston, 1989.
2. D.P. Bertsekas, Constrained Optimization and Lagrange Multiplier Methods, Academic Press, New York, 1982.
3. Tarun Khanna, Foundations of Neural Networks, Addison-Wesley, Reading, Massachusetts, 1990.
4. C. Castillo-Chavez, S.A. Levin and C.A. Shoemaker (Eds.) - Mathematical Approaches to Problems in Resource Management and Epidemiology, Lecture Notes in Biomathematics 81, Springer Verlag, New York, 1989.

b) **Inverse Problems in Mathematics for Industry.** (7 lectures in English).
Prof. Bruno FORTE (University of Waterloo, Ontario, Canada).

Outline

The process of deriving a deterministic mathematical model from the knowledge of particular solutions(s) and/or global properties of solutions will be analyzed. Examples of inverse problems related to some typical industrial process will be presented. Mainly we will be dealing with: inverse problems in classical mechanics (dynamical systems), inverse problems in diffusion processes.

References

1. A.S. Galiullin, Inverse problems of dynamics, Mir Publisher, Moscow, 1984
2. Frederic Y.M. Wan, Mathematical models and their analysis, Harper and Row, New York, 1989.

c) **Mathematical Aspects of Some Industrial Problems.** (7 lectures in English).
Prof. Hendrik K. KUIKEN (Philips Research Lab., Eindhoven).

Lectures 1 and 2: The determination of surface tension and contact angle from the shape of a sessile drop.

Literature

C.A. Smolders and E.M. Duyvis, Contact angles and de-wetting of mercury. Recueil 80 (1961), 635-649.
C.J. Lyons, E. Elbing and I.R. Wilson, A general selected plane method for measuring interfacial tensions from the shape of pendant and sessile drops. J. Chem. Soc. Farad. Trans. 81 (1985), 327-339.
Y. Rotenberg, L. Buruvka and A.W. Newman, Determination of surface tension and contact angle from the shape of axisymmetric fluid interfaces. J. Coll. Interf. Sci. 93 (1983), 169-183.
H.K. Kuiken, The determination of surface tension and contact angle from shape of a sessile drop revisited. To be published.

Lecture 3 and 4: The mathematical modelling of viscous sintering processes

Literature

H.E. Exnor, Principles of single phase sintering. Revs. Powder Metall. Phys. Chem. 1 (1979), 7-251
H.K. Kuiken, Viscous sintering: the surface-tension-driven flow of a liquid form under the influence of curvature gradients at its surface. To appear in J. Fluid Mech.
H.K. Kuiken, Deforming surfaces and viscous sintering. To appear in Proc. Conf. on the Math. and Comp. of Deforming Surfaces. Cambridge 1988. Oxford U. Press 1990.

Lectures 5, 6 and 7: Mathematical modelling of etching processes

Literature

H.K. Kuiken, Etching: a two-dimensional mathematical approach. Proc. R. Soc. London A392 (1984), 199-225.
H.K. Kuiken, Etching through a slit. Proc. R. Soc. London A396 (1984), 95-117.
H.K. Kuiken, J.J. Kelly and P.H.L. Notten, Etching at resist edges. J. Elchem. Soc. 133 (1986), 1217-1226 (part 1), 1227-1232 (part 2).
H.K. Kuiken, Mathematical modelling of etching processes. Proc. 1987 Irsee Conf. on Free and Moving Boundaries. Pitman 1990.

Seminars

A number of seminars and special lectures will be offered during the Session.

LIST OF C.I.M.E. SEMINARS Publisher

1954 -	1. Analisi funzionale	C.I.M.E.
	2. Quadratura delle superficie e questioni connesse	"
	3. Equazioni differenziali non lineari	"
1955 -	4. Teorema di Riemann-Roch e questioni connesse	"
	5. Teoria dei numeri	"
	6. Topologia	"
	7. Teorie non linearizzate in elasticità, idrodinamica,aerodinamica	"
	8. Geometria proiettivo-differenziale	"
1956 -	9. Equazioni alle derivate parziali a caratteristiche reali	"
	10. Propagazione delle onde elettromagnetiche	"
	11. Teoria della funzioni di più variabili complesse e delle funzioni automorfe	"
1957 -	12. Geometria aritmetica e algebrica (2 vol.)	"
	13. Integrali singolari e questioni connesse	"
	14. Teoria della turbolenza (2 vol.)	"
1958 -	15. Vedute e problemi attuali in relatività generale	"
	16. Problemi di geometria differenziale in grande	"
	17. Il principio di minimo e le sue applicazioni alle equazioni funzionali	"
1959 -	18. Induzione e statistica	"
	19. Teoria algebrica dei meccanismi automatici (2 vol.)	"
	20. Gruppi, anelli di Lie e teoria della coomologia	"
1960 -	21. Sistemi dinamici e teoremi ergodici	"
	22. Forme differenziali e loro integrali	"
1961 -	23. Geometria del calcolo delle variazioni (2 vol.)	"
	24. Teoria delle distribuzioni	"
	25. Onde superficiali	"
1962 -	26. Topologia differenziale	"
	27. Autovalori e autosoluzioni	"
	28. Magnetofluidodinamica	"

1963 -	29.	Equazioni differenziali astratte	C.I.M.E.
	30.	Funzioni e varietà complesse	"
	31.	Proprietà di media e teoremi di confronto in Fisica Matematica	"
1964 -	32.	Relatività generale	"
	33.	Dinamica dei gas rarefatti	"
	34.	Alcune questioni di analisi numerica	"
	35.	Equazioni differenziali non lineari	"
1965 -	36.	Non-linear continuum theories	"
	37.	Some aspects of ring theory	"
	38.	Mathematical optimization in economics	"
1966 -	39.	Calculus of variations	Ed. Cremonese, Firenze
	40.	Economia matematica	"
	41.	Classi caratteristiche e questioni connesse	"
	42.	Some aspects of diffusion theory	"
1967 -	43.	Modern questions of celestial mechanics	"
	44.	Numerical analysis of partial differential equations	"
	45.	Geometry of homogeneous bounded domains	"
1968 -	46.	Controllability and observability	"
	47.	Pseudo-differential operators	"
	48.	Aspects of mathematical logic	"
1969 -	49.	Potential theory	"
	50.	Non-linear continuum theories in mechanics and physics and their applications	"
	51.	Questions of algebraic varieties	"
1970 -	52.	Relativistic fluid dynamics	"
	53.	Theory of group representations and Fourier analysis	"
	54.	Functional equations and inequalities	"
	55.	Problems in non-linear analysis	"
1971 -	56.	Stereodynamics	"
	57.	Constructive aspects of functional analysis (2 vol.)	"
	58.	Categories and commutative algebra	"

NOTE: Volumes 1 to 38 are out of print. A few copies of volumes 23,28,31,32,33,34, 36,38 are available on request from C.I.M.E.

1972 -	59. Non-linear mechanics		Ed Cremonese, Firenze
	60. Finite geometric structures and their applications		"
	61. Geometric measure theory and minimal surfaces		"
1973 -	62. Complex analysis		"
	63. New variational techniques in mathematical physics		"
	64. Spectral analysis		"
1974 -	65. Stability problems		"
	66. Singularities of analytic spaces		"
	67. Eigenvalues of non linear problems		"
1975 -	68. Theoretical computer sciences		"
	69. Model theory and applications		"
	70. Differential operators and manifolds		"
1976 -	71. Statistical Mechanics		Ed Liguori, Napoli
	72. Hyperbolicity		"
	73. Differential topology		"
1977 -	74. Materials with memory		"
	75. Pseudodifferential operators with applications		"
	76. Algebraic surfaces		"
1978 -	77. Stochastic differential equations		"
	78. Dynamical systems		Ed Liguori, Napoli and Birhäuser Verlag
1979 -	79. Recursion theory and computational complexity		Ed Liguori, Napoli
	80. Mathematics of biology		"
1980 -	81. Wave propagation		"
	82. Harmonic analysis and group representations		"
	83. Matroid theory and its applications		"
1981 -	84. Kinetic Theories and the Boltzmann Equation	(LNM 1048)	Springer-Verlag
	85. Algebraic Threefolds	(LNM 947)	"
	86. Nonlinear Filtering and Stochastic Control	(LNM 972)	"
1982 -	87. Invariant Theory	(LNM 996)	"
	88. Thermodynamics and Constitutive Equations	(LN Physics 228)	"
	89. Fluid Dynamics	(LNM 1047)	"

1983 -	90. Complete Intersections	(LNM 1092)	"
	91. Bifurcation Theory and Applications	(LNM 1057)	"
	92. Numerical Methods in Fluid Dynamics	(LNM 1127)	"
1984 -	93. Harmonic Mappings and Minimal Immersions	(LNM 1161)	"
	94. Schrödinger Operators	(LNM 1159)	"
	95. Buildings and the Geometry of Diagrams	(LNM 1181)	"
1985 -	96. Probability and Analysis	(LNM 1206)	"
	97. Some Problems in Nonlinear Diffusion	(LNM 1224)	"
	98. Theory of Moduli	(LNM 1337)	"
1986 -	99. Inverse Problems	(LNM 1225)	"
	100. Mathematical Economics	(LNM 1330)	"
	101. Combinatorial Optimization	(LNM 1403)	"
1987 -	102. Relativistic Fluid Dynamics	(LNM 1385)	"
	103. Topics in Calculus of Variations	(LNM 1365)	"
1988 -	104. Logic and Computer Science	(LNM 1429)	"
	105. Global Geometry and Mathematical Physics	to appear	"
1989 -	106. Methods of nonconvex analysis	(LNM 1446)	"
	107. Microlocal Analysis and Applications	to appear	"
1990 -	108. Recent Developments in Geometric Topology and Related Topics	to appear	"
	109. Recent Developments in H_∞ Control Theory	to appear	"
	110. Continua with microstructures	to appear	"
	111. Mathematical Modelling of Industrical Processes	to appear	"

LECTURE NOTES IN MATHEMATICS

Edited by A. Dold, B. Eckmann and F. Takens

Some general remarks on the publication of monographs and seminars

In what follows all references to monographs, are applicable also to multiauthorship volumes such as seminar notes.

§1. Lecture Notes aim to report new developments - quickly, informally, and at a high level. Monograph manuscripts should be reasonably self-contained and rounded off. Thus they may, and often will, present not only results of the author but also related work by other people. Furthermore, the manuscripts should provide sufficient motivation, examples and applications. This clearly distinguishes Lecture Notes manuscripts from journal articles which normally are very concise. Articles intended for a journal but too long to be accepted by most journals, usually do not have this "lecture notes" character. For similar reasons it is unusual for Ph.D. theses to be accepted for the Lecture Notes series.

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