

# Lecture Notes in Mathematics

**For information about Vols. 1–669, please contact your book-seller or Springer-Verlag.**

- Vol. 670: *Fonctions de Plusieurs Variables Complexes III*, Proceedings, 1977. Edité par F. Norguet. XII, 394 pages. 1978.
- Vol. 671: R. T. Smythe and J. C. Wierman, *First-Passage Percolation on the Square Lattice*. VIII, 196 pages. 1978.
- Vol. 672: R. L. Taylor, *Stochastic Convergence of Weighted Sums of Random Elements in Linear Spaces*. VII, 216 pages. 1978.
- Vol. 673: *Algebraic Topology*, Proceedings 1977. Edited by P. Hoffman, R. Piccinini and D. Sjerve. VI, 278 pages. 1978.
- Vol. 674: Z. Fiedorowicz and S. Priddy, *Homology of Classical Groups Over Finite Fields and Their Associated Infinite Loop Spaces*. VI, 434 pages. 1978.
- Vol. 675: J. Galambos and S. Kotz, *Characterizations of Probability Distributions*. VIII, 169 pages. 1978.
- Vol. 676: *Differential Geometrical Methods in Mathematical Physics II*, Proceedings, 1977. Edited by K. Bleuler, H. R. Petry and A. Reetz. VI, 626 pages. 1978.
- Vol. 677: *Séminaire Bourbaki*, vol. 1976/77, Exposés 489–506. IV, 264 pages. 1978.
- Vol. 678: D. Dacunha-Castelle, H. Heyer et B. Roynette. *Ecole d'Été de Probabilités de Saint-Flour*. VII-1977. Edité par P. L. Hennequin. IX, 379 pages. 1978.
- Vol. 679: *Numerical Treatment of Differential Equations in Applications*, Proceedings, 1977. Edited by R. Ansorge and W. Törnig. IX, 163 pages. 1978.
- Vol. 680: *Mathematical Control Theory*, Proceedings, 1977. Edited by W. A. Coppel. IX, 257 pages. 1978.
- Vol. 681: *Séminaire de Théorie du Potentiel Paris*, No. 3. Directeurs: M. Brelot, G. Choquet et J. Deny. Rédacteurs: F. Hirsch et G. Mokobodzki. VII, 294 pages. 1978.
- Vol. 682: G. D. James, *The Representation Theory of the Symmetric Groups*. V, 156 pages. 1978.
- Vol. 683: *Variétés Analytiques Compactes*, Proceedings, 1977. Edité par Y. Hervier et A. Hirschowitz. V, 248 pages. 1978.
- Vol. 684: E. E. Rosinger, *Distributions and Nonlinear Partial Differential Equations*. XI, 146 pages. 1978.
- Vol. 685: *Knot Theory*, Proceedings, 1977. Edited by J. C. Hausmann. VII, 311 pages. 1978.
- Vol. 686: *Combinatorial Mathematics*, Proceedings, 1977. Edited by D. A. Holton and J. Seberry. IX, 353 pages. 1978.
- Vol. 687: *Algebraic Geometry*, Proceedings, 1977. Edited by L. D. Olson. V, 244 pages. 1978.
- Vol. 688: J. Dydak and J. Segal, *Shape Theory*. VI, 150 pages. 1978.
- Vol. 689: *Cabal Seminar 76–77*, Proceedings, 1976–77. Edited by A.S. Kechris and Y. N. Moschovakis. V, 282 pages. 1978.
- Vol. 690: W. J. J. Rey, *Robust Statistical Methods*. VI, 128 pages. 1978.
- Vol. 691: G. Viennot, *Algèbres de Lie Libres et Monoïdes Libres*. III, 124 pages. 1978.
- Vol. 692: T. Husain and S. M. Khaleelulla, *Barrelledness in Topological and Ordered Vector Spaces*. IX, 258 pages. 1978.
- Vol. 693: *Hilbert Space Operators*, Proceedings, 1977. Edited by J. M. Bachar Jr. and D. W. Hadwin. VIII, 184 pages. 1978.
- Vol. 694: *Séminaire Pierre Lelong – Henri Skoda (Analyse) Année 1976/77*. VII, 334 pages. 1978.
- Vol. 695: *Measure Theory Applications to Stochastic Analysis*, Proceedings, 1977. Edited by G. Kallianpur and D. Kölzow. XII, 261 pages. 1978.
- Vol. 696: P. J. Feinsilver, *Special Functions, Probability Semigroups, and Hamiltonian Flows*. VI, 112 pages. 1978.
- Vol. 697: *Topics in Algebra*, Proceedings, 1978. Edited by M. F. Newman. XI, 229 pages. 1978.
- Vol. 698: E. Grosswald, *Bessel Polynomials*. XIV, 182 pages. 1978.
- Vol. 699: R. E. Greene and H.-H. Wu, *Function Theory on Manifolds Which Possess a Pole*. III, 215 pages. 1979.
- Vol. 700: *Module Theory*, Proceedings, 1977. Edited by C. Faith and S. Wiegand. X, 239 pages. 1979.
- Vol. 701: *Functional Analysis Methods in Numerical Analysis*, Proceedings, 1977. Edited by M. Zuhair Nashed. VII, 333 pages. 1979.
- Vol. 702: Yuri N. Bibikov, *Local Theory of Nonlinear Analytic Ordinary Differential Equations*. IX, 147 pages. 1979.
- Vol. 703: *Equadiff IV*, Proceedings, 1977. Edited by J. Fábena. XIX, 441 pages. 1979.
- Vol. 704: *Computing Methods in Applied Sciences and Engineering*, 1977. I. Proceedings, 1977. Edited by R. Glowinski and J. L. Lions. VI, 391 pages. 1979.
- Vol. 705: O. Forster und K. Knorr, *Konstruktion verseller Familien kompakter komplexer Räume*. VII, 141 Seiten. 1979.
- Vol. 706: *Probability Measures on Groups*, Proceedings, 1978. Edited by H. Heyer. XIII, 348 pages. 1979.
- Vol. 707: R. Zielke, *Discontinuous Čebyšev Systems*. VI, 111 pages. 1979.
- Vol. 708: J. P. Jouanolou, *Equations de Pfaff algébriques*. V, 255 pages. 1979.
- Vol. 709: *Probability in Banach Spaces II*, Proceedings, 1978. Edited by A. Beck. V, 205 pages. 1979.
- Vol. 710: *Séminaire Bourbaki* vol. 1977/78, Exposés 507–524. IV, 328 pages. 1979.
- Vol. 711: *Asymptotic Analysis*. Edited by F. Verhulst. V, 240 pages. 1979.
- Vol. 712: *Equations Différentielles et Systèmes de Pfaff dans le Champ Complexe*. Edité par R. Gerard et J.-P. Ramis. V, 364 pages. 1979.
- Vol. 713: *Séminaire de Théorie du Potentiel*, Paris No. 4. Edité par F. Hirsch et G. Mokobodzki. VII, 281 pages. 1979.
- Vol. 714: J. Jacod, *Calcul Stochastique et Problèmes de Martingales* X, 539 pages. 1979.
- Vol. 715: Inder Bir S. Passi, *Group Rings and Their Augmentation Ideals*. VI, 137 pages. 1979.
- Vol. 716: M. A. Scheunert, *The Theory of Lie Superalgebras*. X, 271 pages. 1979.
- Vol. 717: Grosser, *Bidualräume und Vervollständigungen von Banachmoduln*. III, 209 pages. 1979.
- Vol. 718: J. Ferrante and C. W. Rackoff, *The Computational Complexity of Logical Theories*. X, 243 pages. 1979.
- Vol. 719: *Categorical Topology*, Proceedings, 1978. Edited by H. Herrlich and G. Preuß. XII, 420 pages. 1979.
- Vol. 720: E. Dubinsky, *The Structure of Nuclear Fréchet Spaces*. V, 187 pages. 1979.
- Vol. 721: *Séminaire de Probabilités XIII*. Proceedings, Strasbourg, 1977/78. Edité par C. Dellacherie, P. A. Meyer et M. Weil. VII, 647 pages. 1979.
- Vol. 722: *Topology of Low-Dimensional Manifolds*. Proceedings, 1977. Edited by R. Fenn. VI, 154 pages. 1979.
- Vol. 723: W. Brandal, *Commutative Rings whose Finitely Generated Modules Decompose*. II, 116 pages. 1979.
- Vol. 724: D. Griffeath, *Additive and Cancellative Interacting Particle Systems*. V, 108 pages. 1979.
- Vol. 725: *Algèbres d'Opérateurs*. Proceedings, 1978. Edité par P. de la Harpe. VII, 309 pages. 1979.
- Vol. 726: Y.-C. Wong, *Schwartz Spaces, Nuclear Spaces and Tensor Products*. VI, 418 pages. 1979.
- Vol. 727: Y. Saito, *Spectral Representations for Schrödinger Operators With Long-Range Potentials*. V, 149 pages. 1979.

# Lecture Notes in Mathematics

Edited by A. Dold and B. Eckmann

891

---

## Logic Symposia Hakone 1979, 1980

Proceedings of Conferences Held in Hakone, Japan  
March 21–24, 1979 and February 4–7, 1980

Edited by G. H. Müller, G. Takeuti, and T. Tugué

---



Springer-Verlag  
Berlin Heidelberg New York 1981

**Editors**

Gert H. Müller

Mathematisches Institut, Universität Heidelberg

Im Neuenheimer Feld 294, 6900 Heidelberg, Federal Republic of Germany

Gaisi Takeuti

Department of Mathematics, University of Illinois

Urbana, IL 61801, USA

Tosiyuki Tugué

Department of Mathematics, College of General Education

Nagoya University, Chikusa-ku

Nagoya 464, Japan

AMS Subject Classifications (1980): 03Cxx, 03Dxx, 03Exx, 03Fxx, 03Hxx

ISBN 3-540-11161-1 Springer-Verlag Berlin Heidelberg New York

ISBN 0-387-11161-1 Springer-Verlag New York Heidelberg Berlin

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically those of translation, reprinting, re-use of illustrations, broadcasting, reproduction by photocopying machine or similar means, and storage in data banks. Under § 54 of the German Copyright Law where copies are made for other than private use, a fee is payable to "Verwertungsgesellschaft Wort", Munich.

© by Springer-Verlag Berlin Heidelberg 1981

Printed in Germany

Printing and binding: Beltz Offsetdruck, Hemsbach/Bergstr.

2141/3140-543210

## Preface

Symposia on the Foundations of Mathematics, supported by a Grant-in-Aid for Co-operative Research, Proj. no. 234002 ('79) and 434007 ('80), were held at Gōra, Hakone in Japan, on March 21-24, 1979 and February 4-7, 1980.

These Proceedings record the numerous and extensive discussions that took place at the two meetings.

The Editors express their warmest thanks to the institutions and persons concerned. Their generous support enabled us twice to bring together almost all logicians of Japan for lively exchanges of ideas. We hope that everybody who was present was inspired to initiate new research.

The symposia were planned, convened and directed by the third Editor. The two first mentioned Editors - also in the name of all participants - express their heartfelt thanks for all the help and guidance they received from the third Editor!

The first Editor acknowledges the financial help of various universities in Japan, first of all Sophia University through Professor M. Yanase S. J. and Nagoya University through the third Editor. The Deutsche Forschungsgemeinschaft Bonn-Bad Godesberg provided for the travel expenses of the first Editor. He is most grateful for all the help and the overwhelming hospitality he received in Japan. He apologizes for not having been able - due to heavy administrative burdens - to include extended versions of the two papers

"Axiom of Choice Far Apart" and "Hierarchies and Closure Properties" which he gave at the Hakone-Symposium.

The second Editor visited Japan in 1979 as a visiting professor on a grant from the Gakujutsu Shinkokai (Japan Society for the Promotion of Science) through the third Editor and participated in symposia on the

IV

Foundations of Mathematics held at Hakone '79 and at Kyoto University, Research Institute for Mathematical Sciences, May 30 - June 2, '79. Meeting old friends and younger logicians in Japan revived many happy memories for him. It is his happy duty to express his gratitude to the Gakujutsu Shinkokai, Nagoya University and his many friends in Japan.

We all hope that these Proceedings be stepping-stones for further research activities in mathematical logic in Japan.

G.H. Müller (Heidelberg)

G. Takeuti (Urbana, Ill.)

T. Tugué (Nagoya)

August 1981

## まえがき

(PREFACE)

本報告集の Preface に、必ずしも「英文和訳」ではない日本語の、しかも肉筆の「序」を付する、という異例のことを行うこととなったのは、編者の一人である Heidelberg 大学教授 Gert H. Müller 博士の強い示唆に基づくものであつて、わかれわかれ（その一人はこれがそのままオフセット印刷となつて世に出ることにはいささかのしゆう恥を感じないわけではないが）は同教授の機知に富んだ発想と好意に満ちた配慮に従ふこととしたのである。思うに、この報告集が Springer-Verlag 社の Lecture Notes の一つとして刊行される企てはそもそも Müller 教授の日本における数学基礎論グループに対する温かい好意から発したものであつて、その実現は同教授の並々ならぬ熱意と御援助のたまものである。

1979年、文部省科学研究費補助金総合研究(A)、課題番号234002のもとでの分担研究による集会として、3月21日～3月24日箱根町強羅において数学基礎論シンポジウムが開催された。この研究集会は編者の一人である竹内外史が、同年3月より4月間、日本学術振興会による昭和53年度招へい教授として、訪日した際もたされたものであつて、3回にわたる招待講演のほか、集会の全日程にわたつて出席して意見の交換及び助言を行った。次いで、1980年上智大学からの招へいによる Müller 教授の訪日があり、これにあわせて2月4日より2月7日までの間、同上総合研究(A)課題番号434007による研究の一環として、同じく箱根町強羅において数学基礎論シンポジウムが開催された。同教授は心よく招待講演及び座長を引き受けられたのみならず、終始熱心に討論に参加、幾多の情報の提供、助言など多大な貢献をされた。

この報告集はこれから兩年度の二つのシンポジウムにおける講演及び関連する研究の成果の中から集録したものである。これらの多くは上述の科学研究費課題番号434007による助成に負っている。また、兩研究集会で

はここに登載したもののほかに多くの講演者による貢献があつた。その中にはすでに他の雑誌に掲載ないしは投稿されたものもある。

下記の編者の一人である竹内は、1979年に日本を訪れて、多くの数学基礎論の専門家と再会して親しく議論をする機会が得られ、また若い優秀な研究者の動向を知ることができて何よりもうれしく思ったのである。こうした機会を与えられた日本学術振興会会長茅誠司先生はじめ同会関係者各位、また受入研究者の所属大学として種々の便宜供与をいただいた名古屋大学をはじめお招きを受けた諸大学の関係者各位に対して、ここに改めて感謝の意を表するものである。

また、その翌年には Müller 教授の来日があつて、日本の数学基礎論は大きな影響を受けた。同教授の訪日に多大な御援助を頂いた Deutsche Forschungsgemeinschaft Bonn-Bad Godesberg、並びに上智大学の関係者各位、とりわけ上智大学理事長（当時、現学長）柳瀬睦男先生、同大学教授河田敬義先生に深じんなる謝意を表する。いま一人の編者である柘植が思うに、Müller、竹内両教授の引き続き来日という出来事がないればこの種の報告集が世に現れることは決してなかった。

ここに、われわれは二つのシンポジウムが日本の数学基礎論の発展に寄与したことの記念として、この報告集が出ることを心からの喜びとするものである。

1981年 8月

イリノイ大学 竹内外史  
Takeuti, Gaisi

名古屋大学 柘植利之  
Tugué, Tosi-yuki

## TABLE OF CONTENTS

Masazumi HANAZAWA	
Various kinds of Aronszajn tree with no subtree of a different kind ..	1
Susumu HAYASHI	
On set theories in toposes .....	23
Ken HIROSE, Fujio NAKAYASU	
A representation for Spector second order classes in computation theories on two types .....	31
Yuzuru KAKUDA	
Precipitousness of the ideal of thin sets on a measurable cardinal ...	49
Toru KAWAI	
Axiom systems of nonstandard set theory .....	57
Shôji MAEHARA	
Semi-formal finitist proof of the transfinite induction in an initial segment of Cantor's second number class .....	67
Tohru MIYATAKE	
On the length of proofs in a formal system of recursive arithmetic ...	81
Nobuyoshi MOTOHASHI	
Homogeneous formulas and definability theorems .....	109
Kanji NAMBA	
Boolean valued combinatorics .....	117



VIII

Hiroakira ONO, Akira NAKAMURA Undecidability of extensions of the monadic first-order theory of successor and two-dimensional finite automata .....	155
Juichi SHINODA Sections and envelopes of type 2 objects .....	175
Gaisi TAKEUTI, Satoko TITANI Heyting valued universes of intuitionistic set theory .....	189
Tosiyuki TUGUÉ, Hisao NOMOTO Independence of a problem in elementary analysis from set theory .....	307
Tadahiro UESU Intuitionistic theories and toposes .....	323
Mariko YASUGI The Hahn - Banach theorem and a restricted inductive definition .....	359

Joint List of Participants in the Hakone  
Symposia '79 and '80

Norio ADACHI: Dept. Math., Coll. Sci. & Eng., Waseda Univ.,  
Nishi-Okubo, Shinjuku-ku, Tokyo 160

Katsuya EDA: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305

Masazumi HANAZAWA: Dept. Math., Fac. Sci., Saitama Univ.,  
Urawa 338

Susumu HAYASHI: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305

Shigeru HINATA: Coll. Gen. Educ., Hosei Univ., Fujimi,  
Chiyoda-ku, Tokyo 102

Sachio HIROKAWA: Fac. Eng., Shizuoka Univ., Johoku, Hamamatsu  
432

Ken HIROSE: Dept. Math., Coll. Sci. & Eng., Waseda Univ.,  
Nishi-Okubo, Shinjuku-ku, Tokyo 160

Hiroshi HORIGUTI: Dept. Math., Fac. Sci., Rikkyo Univ.,  
Nishi-Ikebukuro, Tokyo 171

Tsutomu HOSOI: Dept. Math., Coll. Sci. & Eng., Tokyo Sci.  
Univ., Yamazaki, Noda 278

Yoshinobu INOUE: Dept. Math., Coll. Gen. Educ., Kobe Univ.,  
Nada-ku, Kobe 657

Tsurane IWAMURA: Dept. Math., Fac. Sci., Rikkyo Univ.,  
Nishi-Ikebukuro, Tokyo 171

Yuzuru KAKUDA: Dept. Math., Coll. Gen. Educ., Kobe Univ.,  
Nada-ku, Kobe 657

Shigetoku KAWABATA: Fac. Eng., Kyushu Univ., Hakozaki, Fukuoka 812

Kenji KAWADA: Dept. Math., Aichi Univ., Machihata, Toyohashi  
440

Toru KAWAI: Dept. Math., Fac. Sci., Kagoshima Univ.,  
Kagoshima 890

Moto-o KINOSHITA: Dept. Math., Coll. Sci. & Eng., Waseda Univ.,  
Nishi-Okubo, Shinjuku-ku, Tokyo 160

Yuichi KOMORI: Dept. Math., Fac. Sci., Shizuoka Univ.,  
Shizuoka 422

Reijiro KURATA: Fac. Eng., Kyushu Univ., Hakozaki, Fukuoka 812

Shoji MAEHARA: Tokyo Inst. of Tech., Oh-okayama, Tokyo 152

Kazuo MATSUMOTO: Fac. Eng., Univ. of Osaka Pref., Mozuume,  
Sakai 591

Tohru MIYATAKE: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305

Chiharu MIZUTANI: "

Nobuyoshi MOTOHASHI: "

- Akira NAKAMURA: Fac. Eng., Hiroshima Univ., Higashi-Senda,  
Hiroshima 730
- Kanji NAMBA: Dept. Math., Coll. Gen. Educ., Univ. of  
Tokyo, Komaba, Meguro-ku, Tokyo 153
- Toshio NISHIMURA: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305
- Shigeo ŌHAMA: Dept. Math., Toyota Tech. Coll., Toyota 471
- Masao OHNISHI: Dept. Math., Fac. Educ., Kobe Univ.,  
Nada-ku, Kobe 657
- Minolu OHTA: Dept. Math., Aichi Univ. of Educ., Kariya 448
- Takemasa OHYA: Dept. Math., Fac. Sci., Tokai Univ.,  
Hiratsuka 259-12
- Hiroakira ONO: Dept. Math., Integr. Arts & Sci., Hiroshima  
Univ., Hiroshima 730
- Takeshi OSHIBA: Nagoya Inst. of Tech., Showa-ku, Nagoya 466
- Masahiko SAITO: Dept. Math., Coll. Gen. Educ., Univ. of  
Tokyo, Komaba, Meguro-ku, Tokyo 153
- Masahiko SATO: Dept. Inf. Sci., Fac. Sci., Univ. of Tokyo,  
Hongo, Bunkyo-ku, Tokyo 113
- Mamoru SHIMODA: Fac. Eng., Kyushu Univ., Hakozaki, Fukuoka 812
- Juichi SHINODA: Dept. Math., Coll. Gen. Educ., Nagoya Univ.,  
Chikusa-ku, Nagoya 464
- Kokio SHIRAI: Dept. Math., Fac. Sci., Shizuoka Univ.,  
Shizuoka 422
- Takakazu SIMAUTI: Dept. Math., Fac. Sci., Rikkyo Univ.,  
Nishi-Ikebukuro, Tokyo 171
- Masayuki TAKADA: Dept. Math., Tokyo Univ. of Agr. and Tech.,  
Fuchu 183
- Makoto TAKAHASHI: Dept. Math., Coll. Sci. & Eng., Waseda Univ.,  
Nishi-Okubo, Shinjuku-ku, Tokyo 160
- Moto-o TAKAHASHI: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305
- Saburo TAMURA: Dept. Math., Fac. Educ., Kobe Univ.,  
Nada-ku, Kobe 657
- Hisao TANAKA: Dept. Math., Fac. Eng., Hosei Univ., Kajino,  
Koganei 184
- Nobutaka TSUKADA: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305
- Tosiyuki TUGUÉ: Dept. Math., Coll. Gen. Educ., Nagoya Univ.,  
Chikusa-ku, Nagoya 464
- Tadahiro UESU: Dept. Math., Fac. Sci., Kyushu Univ.,  
Hakozaki, Fukuoka 812
- Toshio UMEZAWA: Dept. Math., Fac. Sci., Shizuoka Univ.,  
Shizuoka 422

Mariko YASUGI: Inst. Information Sci., Univ. of Tsukuba,  
Sakura, Niiharu-gun, Ibaraki 305

Masahiro YASUMOTO: Dept. Math., Fac. Sci., Nagoya Univ.,  
Chikusa-ku, Nagoya 464

Tsuyoshi YUKAMI: Inst. Math., Univ. of Tsukuba, Sakura,  
Niiharu-gun, Ibaraki 305

Nobuo ZAMA: Dept. Math., Coll. Gen. Educ., Rikkyo Univ.,  
Nishi-Ikebukuro, Tokyo 171

---

Guests

1979 B.C. RAO: Indian Statistical Inst.

Gaisi TAKEUTI: Dept. Math. Univ. of Illinois at Urbana

1980 Gert H. MÜLLER: Math. Inst., Univ. of Heidelberg