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Functional Analysis and Related Topics, 1991

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Preface

These notes are a collection of papers presented at the International Conference on Functional Analysis and Related Topics, 1991, held at the Research Institute for Mathematical Sciences, Kyoto University, Japan, on July 29 - August 2, 1991. Approximately 180 mathematicians from 7 countries attended the conference.

The conference was organized by the Research Institute for Mathematical Sciences as a special conference of the institute, and supported by the ICM-90 Commemorative Meeting Fund of the Mathematical Society of Japan, and by the Inoue Foundation. It was held in memory of Professor Kôzaku Yosida who passed away a year before, on June 20, 1990 after a short illness. The Organizing Committee, consisting of M. Sato, H. Fujita, Y. Kômura and H. Komatsu, invited 27 speakers who carry on Professor Yosida's research tradition.

As the attached list of publications shows, Professor Yosida had a very wide interest in analysis, and guided many students, not only through personal contact but also through his numerous books, including his famous textbook "Functional Analysis" of which six distinct editions appeared. His collected works in English will soon be published by Springer Verlag.

In 1969 an international conference of the same title was held in Tokyo on the occasion of his 60th anniversary. It covered Partial Differential Equations, Differential Equations on Manifolds, Hyperfunctions, Markov Processes and Potentials, and Ergodic Theory. This time the range of topics is more restricted, but we hope that some of these topics have deepened considerably since then. Professor Yosida was essentially a theorist but he always had applications in mind. Whenever he created a beautiful abstract theory, he was also the first to apply it to more concrete problems. The organizers of the conference will be delighted if the reader would recognize this flavor in the following pages.

Hikosaburo Komatsu

Program

July 29 (Monday)

- 11:00 - 12:00 Jacques-Louis Lions (Collège de France)*
Distributed systems with incomplete data and uniqueness theorems
- 13:30 - 14:25 Kiyosi Itô (Kyoto Univ.)
Semigroups in probability theory
- 14:30 - 15:25 Daisuke Fujiwara (Tokyo Inst. of Tech.)
Some Feynman path integrals as oscillatory integrals over a Sobolev space
- 15:30 - 16:25 Hikosaburo Komatsu (Univ. of Tokyo)
Operational calculus and semigroups of operators
- 16:30 - 16:45
Donation of the Yosida Library
- 17:30 -
Reception at Kyodai Kaikan

July 30 (Tuesday)

- 9:50 - 10:50 Haïm Brezis (Univ. of Paris VI)
Mathematical problems of liquid crystals
- 11:00 - 12:00 Yukio Kōmura - Kiyoko Furuya (Ochanomizu Univ.)
Wave equations in non-reflexive spaces
- 13:30 - 14:25 Ken-iti Sato (Nagoya Univ.)
Stochastic processes of Ornstein-Uhlenbeck type on Euclidean spaces
- 14:30 - 15:25 Takashi Suzuki (Tokyo Metropolitan Univ.)
Symmetry breaking: a variational approach
- 15:30 - 16:25 Hisashi Okamoto (RIMS, Kyoto Univ.)
Computer-assisted analysis of 2D Navier-Stokes equations
- 16:30 - 17:00 Yasuyuki Kawahigashi (Univ. of Tokyo)
Solvable orbifold models and operator algebras

July 31 (Wednesday)

- 9:50 - 10:50 Tosio Kato (Univ. of California, Berkeley)
Abstract evolution equations, linear and quasilinear, revisited
- 11:00 - 12:00 Alberto Venni (Univ. of Bologna)
Complex powers of operators and related problems of operator theory
- 13:30 - 14:25 Yoshikazu Giga (Hokkaido Univ.)
 L^p estimates for the Navier-Stokes system
- 14:30 - 15:25 Hitoshi Kitada (Univ. of Tokyo)
Completeness of N -body wave operators — long-range quantum systems
- 15:30 - 16:25 Minoru Murata (Kumamoto Univ.)
Nonnegative solutions of linear parabolic equations

16:30 - 17:00 Teruo Ushijima - Mihoko Matsuki (Univ. of Electro-Communications)
Fully discrete approximation of a second order linear evolution equation related to the water wave problem

August 1 (Thursday)

9:50 - 10:50 P. P. Narayanaswami (Memorial Univ. of Newfoundland)
The separable quotient problem for Banach and (LF) -spaces
11:00 - 12:00 D. C. Struppa (Univ. of Calabria) - T. Kawai (RIMS, Kyoto Univ.)
Interpolating varieties and the Fabry-Ehrenpreis-Kawai gap theorem
13:30 - 14:25 Shinnosuke Oharu (Hiroshima Univ.)
Characterization of nonlinearly perturbed semigroups
14:30 - 15:25 Yoshikazu Kobayashi (Niigata Univ.)
Semigroups of locally Lipschitzian operators and applications
15:30 - 16:25 Mitsuharu Otani (Waseda Univ.)
A priori estimates for some nonlinear parabolic equations via Lyapunov functions
16:30 - 17:00 Hiroko Morimoto (Meiji Univ.)
Asymptotic behavior of solutions of the convection equation

August 2 (Friday)

9:50 - 10:50 Philippe Clément (Delft Univ. of Technology)
Maximal regularity $L^p - L^q$ for a class of integro-differential equations
11:00 - 12:00 Giovanni Dore (Univ. of Bologna)
 L^p -regularity for abstract differential equations
13:30 - 14:25 Atsushi Yoshikawa (Kyushu Univ.)
Quasilinear oscillations and geometric optics
14:30 - 15:25 Atsushi Yagi (Himeji Inst. of Tech.)
Global solution to some quasilinear parabolic system in mathematical biology
15:30 - 16:25 Shigetake Matsuura (RIMS, Kyoto Univ.)
On non-convex curves of constant angle

*) Professor Lions was unable to attend the conference because of a minor accident.

List of Publications of Kôsaku Yosida

Books

- A. 連続群論 (= *Theory of Continuous Groups*), 岩波数学講座, Iwanami (岩波書店), Tokyo, 1934, iii+180 pp.
- B. リー環論 (= *Theory of Lie Rings*), 大阪帝国大学数学講演集 IV, Iwanami, Tokyo, 1939, 3+48 pp.
- C. 線型作用素 (= *Linear Operators*), 現代数学叢書, Iwanami, Tokyo, 1943, 2+118 pp.
- D. スペクトル解析 (= *Spectral Analysis*), 近代数学全書, Kyoritsu (共立出版), Tokyo, 1947, 1+2+125 pp.
- E. エルゴード諸定理 (= *Ergodic Theorems*), 確率統計叢書, Chubunkan (中文館書店), Tokyo, 1948, iii+82 pp.
- F. 物理数学概論 (= *Topics in Mathematical Physics*), Nihon Hyoron (日本評論社), Tokyo, 1949, 6+202+6 pp.
- G. 積分方程式論 (= *Theory of Integral Equations*), 岩波全書 117, Iwanami, Tokyo, 1950, 8+234 pp.
- H. 位相解析 I (= *Topological Analysis I*), 現代数学 8, Iwanami, Tokyo, 1951, 2+2+339 pp.
- I. ヒルベルト空間論 (= *Theory of Hilbert Spaces*), 共立全書 49, Kyoritsu, Tokyo, 1953, 2+4+215 pp.
- J. 微分方程式の解法 (= *Methods of Differential Equations*), 岩波全書 189, Iwanami, Tokyo, 1954, 9+263 pp.
- K. (With A. Amemiya, K. Itô, T. Kato, Y. Matsushima et al.) 応用数学便覧 (= *Handbook of Applied Mathematics*), Maruzen (丸善), Tokyo, 1954, 2+8+518 pp.
- L. 近代解析 (= *Modern Analysis*), 基礎数学講座 20, Kyoritsu, Tokyo, 1956, 1+3+121 pp.
- M. 超函数論 (= *Theory of Distributions*), 現代数学講座 13, Kyoritsu, Tokyo, 1956, v+169 pp.
- N. *Lectures on Semi-group Theory and its Application to Cauchy's Problem in Partial Differential Equations*, Lectures on Mathematics and Physics 8, Tata Inst. Fund. Research, Bombay, 1957, iv+127+iv pp.
- O. 位相解析 (= *Topological Analysis*), 岩波講座現代応用数学 A4, Iwanami, Tokyo, 1957, iv+234 pp.
- L_{II}. 近代解析 第2版 (= *Modern Analysis, 2nd ed.*), 基礎数学講座 20, Kyoritsu, Tokyo, 1958, 2+4+219+4 pp.
- P. (With K. Kunugui, S. Nakanishi and S. Itô) 積分論・位相解析 (= *Theory of Integrals, Topological Analysis*), 数学演習講座 15, Kyoritsu, Tokyo, 1958, Part 2, 2+105 pp.
- G_E. *Lectures on Differential and Integral Equations*, Pure and Applied Mathematics Vol. X, Interscience, New York-London, 1960, ix+220 pp.

- O_{II}. (With Y. Kawada and T. Iwamura) 位相解析の基礎 (= *Fundamental of Topological Analysis*), Iwanami, Tokyo, 1960, pp. 95-330.
- Q. (With T. Kato) 大学演習応用数学 I (= *Exercises in Applied Mathematics I*), 大学演習新書, Shokabo (裳華房), Tokyo, 1961, vii+347 pp.
- R. *Functional Analysis*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Göttingen-Heidelberg, 1965, XI+458 pp.
- R_R. *Funkcional'nyi Analiz*, Izdat. MIR, Moscow, 1967, 624 pp.
- K_{II}. (With A. Amemiya, K. Itô, T. Kato, Y. Matsushima, S. Furuya et al.) 応用数学便覧 新版 (= *Handbook of Applied Mathematics, New ed.*), Maruzen, Tokyo, 1967, 2+9+603 pp.
- R_{II}. *Functional Analysis, 2nd ed.*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Heidelberg-New York, 1968, XI+465 pp.
- R_{III}. *Functional Analysis, 3rd ed.*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Heidelberg-New York, 1971, XI+475 pp.
- G_F. *Equations Différentielles et Intégrals*, Dunod, Paris, 1971, xv+230 pp.
- F_{II}. 物理数学概論 (= *Topics in Mathematical Physics*), 数理解析とその周辺 5, Sangyo Tosho (産業図書), 1974, 6+198 pp.
- R_{IV}. *Functional Analysis, 4th ed.*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Heidelberg-New York, 1974, XI+496 pp.
- S. 測度と積分 (= *Measures and Integrals*), 岩波講座基礎数学, 解析学 (I) iii, Iwanami, Tokyo, 1976, vii+172 pp.
- T. (With S. Itô, A. Orihara and T. Muramatsu) 函数解析と微分方程式 (= *Functional Analysis and Differential Equations*), 現代数学演習叢書 4, Iwanami, Tokyo, 1976, xi+474 pp.
- R_V. *Functional Analysis, 5th ed.*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Heidelberg-New York, 1978, XII+501 pp.
- G_{II}. 積分方程式論 第2版 (= *Theory of Integral Equations, 2nd ed.*), 岩波全書 117, Iwanami, Tokyo, 1978, vi+292 pp.
- J_{II}. 微分方程式の解法 第2版 (= *Methods of Differential Equations, 2nd ed.*), 岩波全書 189, Iwanami, Tokyo, 1978, xiv+307 pp.
- R_{VI}. *Functional Analysis, 6th ed.*, Grundlehren Math. Wiss. Bd. 123, Springer, Berlin-Heidelberg-New York, 1980, XII+501 pp.
- U. 私の微分積分法 — 解析入門 (= *My Calculus — An Introduction to Analysis*), Kodansha (講談社), Tokyo, 1981, 250 pp.
- V. 演算子法 一つの超函数論 (= *Operational Calculus A Theory of Hyperfunctions*), UP 応用数学選書 5, Univ. of Tokyo Press (東京大学出版会), 1982, viii+171 pp.
- V_E. *Operational Calculus A Theory of Hyperfunctions*, Applied Mathematical Sciences Vol. 55, Springer, New York-Berlin-Heidelberg-Tokyo, 1984, x+170 pp.
- W. 19世紀の数学 解析学 I (= *Analysis I Mathematics in the 19th Century*), 数学の歴史 9, Kyoritsu, Tokyo, 1986, xii+256 pp.
- S_{II}. (With H. Fujita) 現代解析入門 (= *Introduction to Modern Analysis*), 岩波基礎数学選書, Iwanami, Tokyo, 1991, pp. 243-456.

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3. *A remark to a theorem due to Halphen*, Japan. J. Math. **9** (1932), 231–232.
4. *A generalisation of a Malmquist's theorem*, Japan. J. Math. **9** (1932), 253–256.
5. *Some remarks on the theory of Fredholm's integral equations*, Proc. Phys.-Math. Soc. Japan **14** (1932), 381–384.
6. *On the distribution of α -points of solutions for linear differential equation of the second order*, Proc. Imp. Acad. Tokyo **8** (1932), 335–336.
7. *A note on Riccati's equation*, Proc. Phys.-Math. Soc. Japan **15** (1933), 227–232.
8. *On the characteristic function of a transcendental meromorphic solution of an algebraic differential equation of the first order and of the first degree*, Proc. Phys.-Math. Soc. Japan **15** (1933), 337–338.
9. *On algebroid-solutions of ordinary differential equations*, Japan. J. Math. **10** (1933), 199–208.
10. *On a class of meromorphic functions*, Proc. Phys.-Math. Soc. Japan **16** (1934), 227–235.
11. *Wronskian* ニ就テ (= *On Wronskians*), Zenkoku Sizyo Sugaku Danwakai (全国紙上数学談話会) **3** (1934), 3–5.
12. *Algebroid function* ニ就テ (= *On algebroid functions*), Zenkoku Sizyo Sugaku Danwakai **6** (1934), 2–6 and **10** (1934), d-e.
13. *Picard ノ 定理* ニツイテ (= *On Picard's theorem*), Zenkoku Sizyo Sugaku Danwakai **18** (1934), 11–12.
14. *有理型函数ノ derivative* ニ就テ (= *On derivatives of meromorphic functions*), Zenkoku Sizyo Sugaku Danwakai **21** (1934), 7–10.
15. (With T. Shimizu and S. Kakutani) *On meromorphic functions. I*, Proc. Phys.-Math. Soc. Japan **17** (1935), 1–10.
16. *Beurling ノ 定理ノ 應用例* (= *An application of Beurling's theorem*), Zenkoku Sizyo Sugaku Danwakai **24** (1934), 28–30.
17. *Cartan-角谷-Selberg ノ 定理* ニ就テ (= *On the Cartan-Kakutani-Selberg theorem*), Zenkoku Sizyo Sugaku Danwakai **25** (1935), 11–14 and **30** (1935), 9–11.
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19. *Stone ノ 定理* ニ就テ (= *On Stone's theorem*), Zenkoku Sizyo Sugaku Danwakai **35** (1935), 9–12.
20. *A theorem concerning the derivatives of meromorphic functions*, Proc. Phys.-Math. Soc. Japan **17** (1935), 170–173.
21. (With S. Kakutani) *in kleinen affine 寫像* ニ就テ (= *On locally affine (quasi-conformal) mappings*), Zenkoku Sizyo Sugaku Danwakai **40** (1935), 5–8 and **41** (1935), 10–18.
22. *Fatou ノ 定理* ニ對スル小サナ注意 (= *A short remark on Fatou's theorem*), Zenkoku Sizyo Sugaku Danwakai **45** (1935), 6–8.

23. 等角寫像ニ於ケル *metrical* ナ一定理 (= *A metrical theorem on conformal mappings*), Zenkoku Sizyo Sugaku Danwakai **47** (1935), 5-8.
24. *Picard-Vessiot* ノ理論ニ就テ (= *On the theory of Picard-Vessiot*), Zenkoku Sizyo Sugaku Danwakai **51** (1935), 8-14, **52** (1935), 1-3, **53** (1935), 9-10, **63** (1935), 28-33 and **67** (1935), 19-22.
25. *Closure* ニ関スル一問題ヘノ *Stone* ノ定理ノ應用 (= *An application of Stone's theorem to a problem of closure*), Zenkoku Sizyo Sugaku Danwakai **60** (1935), 15-17.
26. *On the groups of rationality for linear differential equations*, Proc. Phys.-Math. Soc. Japan **17** (1935), 498-510.
27. 距離付ケラレタ環ニ於テ閉ヂタ連續群 (= *Closed continuous groups in metrical rings*), Zenkoku Sizyo Sugaku Danwakai **68** (1935), 1-9, **69** (1935), 15-18, **70** (1935), 5-7 and **77** (1935), 4-9.
28. " $\det A \neq 0$ ナル *Matrix* ハ $A = \exp B$ " ノ正田教授ニヨル証明其ノ他 (= *A matrix $A = \exp B$ if $\det A \neq 0$; Prof. Shoda's proof and other topics*), Zenkoku Sizyo Sugaku Danwakai **72** (1935), 1-6.
29. *On the group embedded in the metrical complete ring*, Japan J. Math. **13** (1936), 7-26.
30. *Locally compact* ナ *topological group* ノ連續表現 (= *Continuous representations of locally compact topological groups*), Zenkoku Sizyo Sugaku Danwakai **87** (1936), 1-8, **88** (1936), 6-8, **99** (1936), 1-3 and **101** (1936), 8-9.
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33. *Topological group* ノ連續表現 (= *Continuous representations of topological groups*), Zenkoku Sizyo Sugaku Danwakai **107** (1936), 5-7.
34. *H. Auerbach* ノ定理ニツイテ (= *On a theorem of H. Auerbach*), Zenkoku Sizyo Sugaku Danwakai **110** (1936), 5-6.
35. *Homomorphie* ニヨル次元ノ關係 (= *Dimension relations under homomorphisms*), Zenkoku Sizyo Sugaku Danwakai **111** (1936), 16-18.
36. *A note on the continuous representation of topological groups*, Proc. Imp. Acad. Tokyo **12** (1936), 329-331.
37. *Riemann* 空間ノ等長変換ノ解析性 (= *Analyticity of isometric transformations of Riemannian spaces*), Zenkoku Sizyo Sugaku Danwakai **120** (1937), 33-35.
38. 完閉群ニ於ケル線狀移動可能微分演算子 (= *Linear translatable differential operators in compact groups*), Zenkoku Sizyo Sugaku Danwakai **123** (1937), 87-91 and **124** (1937), 118-119.
39. *A remark on a theorem of B. L. van der Waerden*, Tôhoku Math. J. **43** (1937), 411-413.
40. 單純群ノ一ツノ *class* ニ就テ (= *On a class of simple groups*), Zenkoku Sizyo Sugaku Danwakai **126** (1937), 143-146.
41. *Lie* ノ第二基本定理ニ關聯シタ一ツノ問題 (= *A problem concerning the second fundamental theorem of Lie*), Zenkoku Sizyo Sugaku Danwakai **128** (1937), 179-185.
42. *A problem concerning the second fundamental theorem of Lie*, Proc. Imp. Acad. Tokyo **13** (1937), 152-155.

43. 準單純りい群ニ関スル一定理 (= *A theorem on semi-simple Lie groups*), Zenkoku Sizyo Sugaku Danwakai **133** (1937), 267-272.
44. *Locally bicomact* ナ *topological group* ノ 連續表現 (= *Continuous representations of locally bicomact topological groups*), Zenkoku Sizyo Sugaku Danwakai **135** (1937), 37-43.
45. *Lie* ノ 第二基本定理ニ就テ (= *On the second fundamental theorem of Lie*), Zenkoku Sizyo Sugaku Danwakai **137** (1937), 75-78.
46. *A theorem concerning the semi-simple Lie groups*, Tôhoku Math. J. **44** (1938), 81-84.
47. 豊田浩七氏ノ論文ヲ讀ミテ (= *On a paper of Toyoda*), Zenkoku Sizyo Sugaku Danwakai **139** (1937), 138-140.
48. *Topological group* ノ 微分可能性ニ就テ (= *On the differentiability of topological groups*), Zenkoku Sizyo Sugaku Danwakai **141** (1937), 185-189.
49. *On the exponential-formula in the metrical complete ring*, Proc. Imp. Acad. Tokyo **13** (1937), 301-304.
50. *A note on the differentiability of the topological group*, Proc. Phys.-Math. Soc. Japan **20** (1938), 6-10.
51. *A characterisation of the adjoint representations of the semi-simple Lie-rings*, Japan J. Math. **14** (1938), 169-173.
52. 單純且準單純ナ環ノ表現ノ *reduction* ニ就テ (= *On the reduction of representations of simple and semi-simple Lie rings*), Zenkoku Sizyo Sugaku Danwakai **153** (1937), 56-60.
53. *Lie* 環ノ *derivation* (= *Derivations of Lie rings*), Zenkoku Sizyo Sugaku Danwakai **156** (1938), 125-129 and **157** (1938), 167-170.
54. *On the fundamental theorem of the tensor calculus*, Proc. Imp. Acad. Tokyo **14** (1938), 211-213.
55. 確率論ヘノ積分方程式ノ應用 (= *Applications of integral equations to probability theory*), Zenkoku Sizyo Sugaku Danwakai **160** (1938), 245-254, **161** (1938), 282-295, **162** (1938), 296-306, **163** (1938), 358-364, **164** (1938), 394-397 and **165** (1938), 429-441.
56. *Birkhoff-Khintchine* ノ *ergodic theorem* (= *The ergodic theorem of Birkhoff-Khintchine*), Zenkoku Sizyo Sugaku Danwakai **166** (1938), 476-485.
57. *Abstract integral equations and the homogeneous stochastic process*, Proc. Imp. Acad. Tokyo **14** (1938), 286-291.
58. *Mean ergodic theorem in Banach spaces*, Proc. Imp. Acad. Tokyo **14** (1938), 292-294.
59. *Mean ergodic theorem* ノ 應用 (= *Applications of mean ergodic theorems*), Zenkoku Sizyo Sugaku Danwakai **167** (1938), 543-549.
60. (With Y. Mimura and S. Kakutani) 有界且ツ可測ナ核ニヨル積分 *operator* ニ就イテ (= *On integral operators with bounded measurable kernels*), Zenkoku Sizyo Sugaku Danwakai **168** (1938), 631-637 and **169** (1938), 681-684.
61. (With S. Kakutani) *Application of mean ergodic theorem to the problems of Markoff's process*, Proc. Imp. Acad. Tokyo **14** (1938), 333-339.
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63. (With Y. Mimura and S. Kakutani) *Integral operator with bounded kernel*, Proc. Imp. Acad. Tokyo **14** (1938), 359–362.
64. *Operator-theoretical treatment of the Markoff's process*, Proc. Imp. Acad. Tokyo **14** (1938), 363–367.
65. 完全連続ナ対稱作用素ノ固有値存在ノ証明 (= *A proof of the existence of eigenvalues for completely continuous symmetric operators*), Zenkoku Sizyo Sugaku Danwakai **171** (1938), 756–758.
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69. (With S. Kakutani) *Markoff process with an enumerable infinite number of possible states*, Japan. J. Math. **16** (1940), 47–55.
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72. *Operator-theoretical treatment of Markoff's process, II*, Proc. Imp. Acad. Tokyo **15** (1939), 127–130.
73. (With S. Kakutani) *Birkhoff ergodic theorem ト maximal ergodic theorem* (= *Birkhoff's ergodic theorem and the maximal ergodic theorem*), Zenkoku Sizyo Sugaku Danwakai **179** (1939), 216–221 and **181** (1939), 267–291.
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75. 漸近的概週期性ト ergodic theorems (= *Asymptotic almost periodicities and ergodic theorems*), Zenkoku Sizyo Sugaku Danwakai **185** (1939), 407–414 and **186** (1939), 450–461.
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