

Appendix

Lemma 13.0.3. (Peetre's inequality) Let $n \in \mathbb{N}^*$, $s \in \mathbb{R}$ and $k, k' \in \mathbb{R}^n$. Then

$$(1 + |k|^2)^{s/2} \leq 2^{|s|/2} (1 + |k - k'|^2)^{|s|/2} (1 + |k'|^2)^{s/2}. \quad (13.0.1)$$

Proof. If $s \geq 0$, it follows that

$$\begin{aligned} (1 + |k|^2)^{s/2} &\leq [1 + (|k - k'| + |k'|)^2]^{s/2} \leq [1 + 2|k - k'|^2 + 2|k'|^2]^{s/2} \\ &\leq [2(1 + |k - k'|^2)(1 + |k'|^2)]^{s/2} \\ &= 2^{s/2} (1 + |k - k'|^2)^{s/2} (1 + |k'|^2)^{s/2}. \end{aligned}$$

If $s \leq 0$, it follows from the previous inequality by exchanging k and k' that

$$(1 + |k'|^2)^{|s|/2} \leq 2^{|s|/2} (1 + |k - k'|^2)^{|s|/2} (1 + |k|^2)^{|s|/2}$$

and hence that

$$2^{-|s|/2} (1 + |k - k'|^2)^{-|s|/2} (1 + |k'|^2)^{|s|/2} \leq (1 + |k|^2)^{|s|/2}$$

and, finally, that

$$2^{|s|/2} (1 + |k - k'|^2)^{|s|/2} (1 + |k'|^2)^{s/2} \geq (1 + |k|^2)^{s/2}.$$

□

Lemma 13.0.4. (Sobolev's inequalities) Let $n \in \mathbb{N}^*$, $p \in \mathbb{R}$ such that $1 \leq p < n$ and $m \in \mathbb{N}^*$ such that $n/m > p$. Then

$$\|f\|_{np/(n-mp)} \leq \left[\prod_{m'=1}^m \frac{p(n-1)}{n(n-m'p)} \right] \sum_{\alpha \in \mathbb{N}^n, |\alpha|=m} \left\| \frac{\partial^m f}{\partial x^\alpha} \right\|_p \quad (13.0.2)$$

for all $f \in C_0^\infty(\mathbb{R}^n, \mathbb{C})$.

Proof. For this, let $n \in \mathbb{N}^*$, $f \in C_0^1(\mathbb{R}^n, \mathbb{C})$ and $j \in \{1, \dots, n\}$. We define $f_j : \mathbb{R}^{n-1} \rightarrow \mathbb{R}$ by

$$f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n) := \int_{-\infty}^{\infty} |f_{,j}(x_1, \dots, x_n)| dx_j$$

for all $(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n) \in \mathbb{R}^{n-1}$. Obviously, f_j is continuous with a compact support and

$$\begin{aligned} |f(x_1, \dots, x_n)| &= \left| \int_{-\infty}^{x_j} f_{,j}(x_1, \dots, x_{j-1}, t, x_{j+1}, x_n) dt \right| \\ &\leq f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n) \end{aligned}$$

for all $(x_1, \dots, x_n) \in \mathbb{R}^n$ and $j \in \{1, \dots, n\}$. Hence it follows that

$$|f(x_1, \dots, x_n)|^{n/(n-1)} \leq \prod_{j=1}^n [f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n)]^{1/(n-1)}$$

for all $(x_1, \dots, x_n) \in \mathbb{R}^n$, which by integration and application of the generalized Hölder inequality for $(n-1)$ -factors leads to

$$\begin{aligned} &\int_{\mathbb{R}} |f(x_1, \dots, x_n)|^{n/(n-1)} dx_1 \\ &\leq [f_1(x_2, \dots, x_n)]^{1/(n-1)} \int_{\mathbb{R}} \prod_{j=2}^n [f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n)]^{1/(n-1)} dx_1 \\ &\leq [f_1(x_2, \dots, x_n)]^{1/(n-1)} \prod_{j=2}^n \left(\int_{\mathbb{R}} f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n) dx_1 \right)^{1/(n-1)} \end{aligned}$$

for all $(x_2, \dots, x_n) \in \mathbb{R}^n$. Note that only $n-1$ of these factors in the last expression depend on x_2 . Hence it follows by integration, Fubini's theorem and application of the generalized Hölder inequality for $(n-1)$ -factors that

$$\begin{aligned} &\int_{\mathbb{R}^2} |f(x_1, \dots, x_n)|^{n/(n-1)} dx_1 dx_2 \\ &\leq \left(\int_{\mathbb{R}} f_1(x_2, \dots, x_n) dx_2 \right)^{1/(n-1)} \cdot \left(\int_{\mathbb{R}} f_2(x_1, x_3, \dots, x_n) dx_1 \right)^{1/(n-1)} \\ &\quad \cdot \prod_{j=3}^n \left(\int_{\mathbb{R}} f_j(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n) dx_1 dx_2 \right)^{1/(n-1)} \end{aligned}$$

for all $(x_3, \dots, x_n) \in \mathbb{R}^n$. Repeating these previous steps $(n-2)$ -times leads to

$$\begin{aligned} \int_{\mathbb{R}^n} |f|^{n/(n-1)} dv^n &\leq \prod_{j=1}^n \left(\int_{\mathbb{R}^{n-1}} f_j dv^{n-1} \right)^{1/(n-1)} = \left(\prod_{j=1}^n \|f_{,j}\|_1 \right)^{1/(n-1)} \\ &\leq \left(\frac{1}{n} \sum_{j=1}^n \|f_{,j}\|_1 \right)^{n/(n-1)} \end{aligned}$$

and hence, finally, to

$$\|f\|_{n/(n-1)} \leq \frac{1}{n} \sum_{j=1}^n \|f_j\|_1. \quad (13.0.3)$$

Now let $p \in \mathbb{R}$ such that $1 < p < n$,

$$r := \frac{p(n-1)}{n-p} = 1 + \frac{(p-1)n}{n-p} > 1$$

and $f \in C_0^1(\mathbb{R}^n, \mathbb{C})$. Note that $| \cdot |^r \in C^1(\mathbb{R}^2, \mathbb{R})$. Obviously, since $| \cdot |^r = (| \cdot |^2)^{r/2}$, it follows that $| \cdot |^r|_{\mathbb{R}^2 \setminus \{(0,0)\}} \in C^1(\mathbb{R}^2 \setminus \{(0,0)\}, \mathbb{R})$. Further,

$$\lim_{h \rightarrow 0, h \neq 0} \frac{|(h, 0)|^r}{h} = \lim_{h \rightarrow 0, h \neq 0} \frac{|(0, h)|^r}{h} = \lim_{h \rightarrow 0, h \neq 0} \frac{|h|}{h} |h|^{r-1} = 0.$$

Hence $| \cdot |^r$ is partially differentiable with continuous partial derivatives $(| \cdot |^r)_1, (| \cdot |^r)_2 : \mathbb{R}^2 \rightarrow \mathbb{R}$ given by

$$\begin{aligned} (| \cdot |^r)_1(x, y) &= \begin{cases} \frac{x}{|(x, y)|} |(x, y)|^{r-1} & \text{if } (x, y) \neq (0, 0) \\ 0 & \text{if } (x, y) = (0, 0). \end{cases} \\ (| \cdot |^r)_2(x, y) &= \begin{cases} \frac{y}{|(x, y)|} |(x, y)|^{r-1} & \text{if } (x, y) \neq (0, 0) \\ 0 & \text{if } (x, y) = (0, 0). \end{cases} \end{aligned}$$

for all $(x, y) \in \mathbb{R}^2$. As a consequence, $|f|^r \in C_0^1(\mathbb{R}^n, \mathbb{R})$ and by (13.0.3) and Hölder's inequality

$$\begin{aligned} (\|f\|_{np/(n-p)})^r &= \| |f|^r \|_{n/(n-1)} \leq \frac{1}{n} \sum_{j=1}^n \| (|f|^r)_j \|_1 \\ &= \frac{r}{n} \sum_{j=1}^n \| |f|^{r-2} |\operatorname{Re}(f^* f_j)| \|_1 \leq \frac{r}{n} \sum_{j=1}^n \| |f|^{r-1} |f_j| \|_1 \\ &\leq \frac{r}{n} \sum_{j=1}^n \| |f|^{r-1} \|_{p/(p-1)} \|f_j\|_p = \frac{r}{n} (\|f\|_{np/(n-p)})^{r-1} \sum_{j=1}^n \|f_j\|_p, \end{aligned}$$

where we use the conventions that the arguments of $\| \cdot \|_1$ are zero in all zeros of f , and hence

$$\|f\|_{np/(n-p)} \leq \frac{p(n-1)}{n(n-p)} \sum_{j=1}^n \|f_j\|_p. \quad (13.0.4)$$

For the final step, let $p \in \mathbb{R}$ such that $1 \leq p < n$ and $m \in \mathbb{N}^*$ such that $n/m > p$. Then

$$\|f\|_{np/(n-mp)} \leq \frac{[p(n-1)/n]^m}{\prod_{m'=1}^m (n-m'p)} \sum_{\alpha \in \mathbb{N}^n, |\alpha|=m} \left\| \frac{\partial^m f}{\partial x^\alpha} \right\|_p \quad (13.0.5)$$

for every $f \in C_0^\infty(\mathbb{R}^n, \mathbb{C})$. The proof proceeds by finite induction over m . The case $m = 1$ is a special case of the previously proved. Now let $m \in \mathbb{N}^*$ be such that

$n/m > p$ and such that (13.0.5) is true for every $f \in C_0^\infty(\mathbb{R}^n, \mathbb{C})$. Then, if $n/(m+1) > p$, it follows for $f \in C_0^\infty(\mathbb{R}^n, \mathbb{C})$

$$\begin{aligned} & \frac{p(n-1)}{n[n-(m+1)p]} \sum_{j=1}^n \|f_{,j}\|_{np/(n-mp)} \\ & \leq \frac{[p(n-1)/n]^{m+1}}{\prod_{m'=1}^{m+1} (n-m'p)} \sum_{j=1}^n \sum_{\alpha \in \mathbb{N}^n, |\alpha|=m} \left\| \frac{\partial}{\partial x^j} \frac{\partial^m f}{\partial x^\alpha} \right\|_p \\ & = \frac{[p(n-1)/n]^{m+1}}{\prod_{m'=1}^{m+1} (n-m'p)} \sum_{\alpha \in \mathbb{N}^n, |\alpha|=m+1} \left\| \frac{\partial^{m+1} f}{\partial x^\alpha} \right\|_p. \end{aligned}$$

We define $\bar{p} := np/(n-mp)$. Then

$$\bar{p} = p + \frac{mp^2}{n-mp} \geq p \geq 1, \bar{p} = \frac{n}{\frac{n}{p} - m} < \frac{n}{(m+1) - m} = n.$$

Hence it follows by (13.0.3), (13.0.4)

$$\|f\|_{n\bar{p}/(n-\bar{p})} \leq \frac{\bar{p}(n-1)}{n(n-\bar{p})} \sum_{j=1}^n \|f_{,j}\|_{\bar{p}}$$

and therefore, since

$$\begin{aligned} \frac{\bar{p}(n-1)}{n(n-\bar{p})} &= \frac{\frac{np}{n-mp}(n-1)}{n\left(n - \frac{np}{n-mp}\right)} = \frac{p(n-1)}{n[n-(m+1)p]} \\ \frac{n\bar{p}}{n-\bar{p}} &= \frac{\frac{n^2p}{n-mp}}{n - \frac{np}{n-mp}} = \frac{np}{n-(m+1)p}, \end{aligned}$$

it follows that

$$\|f\|_{np/[n-(m+1)p]} \leq \frac{[p(n-1)/n]^{m+1}}{\prod_{m'=1}^{m+1} (n-m'p)} \sum_{\alpha \in \mathbb{N}^n, |\alpha|=m+1} \left\| \frac{\partial^{m+1} f}{\partial x^\alpha} \right\|_p.$$

□

References

1. Abramowitz M, Stegun I A (Eds.) 1984, *Pocketbook of Mathematical Functions*, Harri Deutsch: Thun.
2. Adams R A, Fournier J J F 2003, *Sobolev spaces*, 2nd ed., Academic Press: New York.
3. Alpert B, Greengard L, Hagstrom Thomas 2000, *Rapid evaluation of nonreflecting boundary kernels for time-domain wave propagation*, SIAM J. Numer. Anal. **37**, 1138–1164.
4. Altman M 1986, *A unified theory of nonlinear operator and evolution equations with applications. A new approach to nonlinear partial differential equations*, Monographs and Textbooks in Pure and Applied Mathematics **103**, Marcel Dekker: New York.
5. Anderson M T, Chrusciel P T 2005, *Asymptotically simple solutions of the vacuum Einstein equations in even dimensions*, Commun. Math. Phys. **260**, 557–577.
6. Arendt W 1987, *Vector valued Laplace transforms and Cauchy problems*, Israel J. Math. **59**, 327–352.
7. Arendt W 1989, *Integrated solutions of Volterra integrodifferential equations and applications*, Proceedings of the Conference on Volterra integro-differential equations in Banach spaces and applications, Trento 1987, G. Da Prato and M. Iannelli (Eds.), Pitman Research Notes in Mathematics Series **190**, 21–51.
8. Arendt W, Batty C, Hieber M, Neubrander F 2001, *Vector-valued Laplace transforms and Cauchy problems*, Monographs in Mathematics **96**, Birkhäuser: Basel.
9. Bachelot A 2000, *Creation of fermions at the charged black-hole horizon*, CR Acad. Sci. I-Math. **330**, 29–34.
10. Bachelot A 2000, *Creation of fermions at the charged black-hole horizon*, Ann. Henri Poincaré **1**, 1043–1095.
11. Bachelot A, Motet-Bachelot A 1993, *Les Resonances D'un Trou Noir De Schwarzschild*, Ann. Inst. Henri Poincaré physique theorique **59**, 3–68.
12. Batkai A, Piazzera S 2005, *Semigroups for delay equations*, A K Peters: Wellesley.
13. Baez J C, Segal I E, Zhou Z 1992, *Introduction to algebraic and constructive quantum field theory*, Princeton University Press: Princeton.
14. Bambusi D, Galgani L 1993, *Some rigorous results on the Pauli-Fierz model of classical electrodynamics*, Ann. I. H. Poincaré Phys. **58**, 155–171.
15. Barbu V 1976, *Nonlinear semigroups and differential equations in Banach spaces*, Noordhoff: Leyden.
16. Bayliss A, Turkel E 1980, *Radiation boundary conditions for wave-like equations*, Comm. Pure Appl. Math. **33**, 707–725.

17. Beig R, Schmidt B G 2003, *Relativistic elasticity*, Class. Quantum Gravity **20**, 889–904.
18. Belenkaya L, Friedlander S, Yudovich V 1999, *The unstable spectrum of oscillating shear flows*, Siam J. Appl. Math. **59**, 1701–1715.
19. Belleni-Morante A, McBride A C 1998, *Applied nonlinear semigroups: An introduction*, Wiley: New York.
20. Bers L, John F, Schechter M 1964, *Partial differential equations*, Wiley: New York.
21. Beyer H 1991, *Remarks on Fulling's quantization*, Class. Quantum Grav. **8**, 1091–1112.
22. Beyer H R 1995, *The spectrum of radial adiabatic stellar oscillations*, J. Math. Phys. **36**, 4815–4825.
23. Beyer H R 1995, *The spectrum of adiabatic stellar oscillations*, J. Math. Phys. **36**, 4792–4814.
24. Beyer H R, Schmidt B G 1995, *Newtonian stellar oscillations*, Astron. Astrophys. **296**, 722–726.
25. Beyer H R 1999, *On the Completeness of the Quasinormal modes of the Pöschl-Teller potential*, Commun. Math. Phys. **204**, 397–423.
26. Beyer H R, Kokkotas K D 1999, *On the r-mode spectrum of relativistic stars*, Mon. Not. R. Astron. Soc. **308**, 745–750.
27. Beyer H R 2001, *On the stability of the Kerr metric*, Commun. Math. Phys. **221**, 659–676.
28. Beyer H R 2002, *A framework for perturbations and stability of differentially rotating stars*, Proc. Roy. Soc. Lond. A **458**, 359–380.
29. Beyer H, Sarbach O 2004, *Well-posedness of the Baumgarte-Shapiro-Shibata-Nakamura formulation of Einstein's field equations*, Phys. Rev. D **70**, 104004.
30. Beyer H R 2006, *Results on the spectrum of R-Modes of slowly rotating, relativistic Stars*, Class. Quantum Gravity **23**, 2409–2425.
31. Bjorken J D, Drell S D 1964, *Relativistic quantum mechanics*, McGraw-Hill: New York.
32. Bjorken J D, Drell S D 1965, *Relativistic quantum fields*, McGraw-Hill: New York.
33. Brauer U 1992, *An existence theorem for perturbed Newtonian cosmological models*, J. Math. Phys. **33**, 1224–1233.
34. Braz e Silva B 2003, *Stability of plane Couette flow: The resolvent method*, Ph.D. thesis, The University of New Mexico, Albuquerque, 2003.
35. Brezis H 1983, *Analyse fonctionnelle: Theorie et applications*, Collection Mathematiques Appliques pour la Matrise, Masson: Paris.
36. McBride A C 1987, *Semigroups of linear operators: An introduction*, Longman: Harlow.
37. Brill D, Reula O, Schmidt B 1987, *Local linearization stability*, J. Math. Phys. **28**, 1844–1847.
38. Buchholz D 2000, *Algebraic quantum field theory: A status report*, Plenary talk given at XIIIth International Congress on Mathematical Physics, London, <http://xxx.lanl.gov/abs/math-ph/0011044>.
39. Butzer P L, Berens H 1967, *Semi-groups of operators and approximation*, Springer: New York.
40. Calderon A P 1965, *Commutators of singular integral operators*, Proc. Nat. Acad. Sci. USA **53**, 1092–1099.
41. Cannarsa P, Da Prato G, Zolesio J.-P. 1990, *The damped wave equation in a moving domain*, J. Differential Equations **85**, 1–16.
42. Carroll R W 1969, *Abstract methods in partial differential equations*, Harper & Row: New York.
43. Chandrasekhar S 1961, *Hydrodynamic and hydromagnetic stability*, Oxford University Press: Oxford.

44. Claudel C M, Newman K P 1998, *The Cauchy problem for quasi-linear hyperbolic evolution problems with a singularity in the time*, Proc. Roy. Soc. A **454**, 1073–1107.
45. Cutler C, Wald R M 1989, *Existence of radiating Einstein-Maxwell solutions which are C^∞ on all of P^+ and P^-* , Class. Quantum Gravity **6**, 453–466.
46. Constantin A 2001, *The construction of an evolution system in the hyperbolic case and applications*, Math. Nachr. **224**, 49–73.
47. Davies E B 1980, *One-parameter semigroups*, Academic Press: London.
48. Davis E B, Pang M M H 1987, *The Cauchy problem and a generalization of the Hille-Yosida theorem*, Proc. London Math. Soc. **55**, 181–208.
49. Diestel J, Uhl J J 1977, *Vector measures*, AMS: Providence.
50. Dorroh J R 1975, *A simplified proof of a theorem of Kato on linear evolution equations*, J. Math. Soc. Japan **27**, 474–478.
51. Drazin P G, Reid W H 2004, *Hydrodynamic Stability*, 2nd ed., Cambridge University Press, Cambridge.
52. Dunford N, Schwartz J T 1957, *Linear operators, Part I: General theory*, Wiley: New York.
53. Dunford N, Schwartz J T 1963, *Linear operators, Part II: Spectral theory: Self adjoint operators in Hilbert space theory*, Wiley: New York.
54. Dyson J, Schutz B F 1979, *Perturbations and stability of rotating stars. I. Completeness of normal modes*, Proc. Roy. Soc. London Ser. A **368**, 389–410.
55. Eisner T, Zwart H 2006, *Continuous-time Kreiss resolvent condition on infinite-dimensional spaces*, Math. Comp. **75**, 1971–1985.
56. Engel K-J, Nagel R 1990, *Cauchy problems for polynomial operator matrices on abstract energy spaces*, Forum Math. **2**, 89–102.
57. Engel K-J, Nagel R 2000, *One-parameter semigroups for linear evolution equations*, Springer: New York.
58. Engquist B, Majda A 1977, *Absorbing boundary conditions for the numerical simulation of waves*, Math. Comp. **31**, 629–651.
59. Evans D E 1976, *Time dependent perturbations and scattering of strongly continuous groups on Banach spaces*, Math. Ann. **221**, 275–290.
60. Fattorini H O 1983, *The Cauchy problem*, Addison-Wesley: Reading, Massachusetts.
61. Fischer A E, Marsden J E: 1972, *The Einstein evolution equations as a first-order quasilinear symmetric hyperbolic system*, Commun. Math. Phys. **28**, 1–38.
62. Finster F, Kamran N, Smoller J, Yau S-T 2000, *Non-existence of time-periodic solutions of the Dirac equation in an axisymmetric black hole geometry*, Commun. Pure Appl. Math. **53**, 902–929.
63. Finster F, Kamran N, Smoller J, Yau S-T 2002, *Decay rates and probability estimates for massive Dirac particles in the Kerr-Newman black hole geometry*, Commun. Math. Phys. **230**, 201–244.
64. Finster F, Kamran N, Smoller J, Yau S-T 2005, *An integral spectral representation of the propagator for the wave equation in the Kerr geometry*, Commun. Math. Phys. **260**, 257–298.
65. Finster F, Kamran N, Smoller J, Yau S-T 2006, *Decay of solutions of the wave equation in the Kerr geometry*, Commun. Math. Phys. **264**, 465–503.
66. Flato M, Simon J, Taflin E 1994, *The Maxwell-Dirac equations - Asymptotic completeness and the infrared problem*, Rev. Math. Phys. **6**, 1071–1083.
67. Flato M, Simon J, Taflin E 1987, *On global-solutions of the Maxwell-Dirac equations*, Commun. Math. Phys. **1**, 21–49.
68. Folland G B 1999, *Real analysis*, 2nd ed., Wiley: New York.

69. Friedman J L, Morris, M S 2000, *Schwarzschild perturbations die in time*, J. Math. Phys. **41**, 7529–7534.
70. Friedrich H 1981, *The asymptotic characteristic initial value problem for Einstein's vacuum field equations as an initial value problem for a first-order quasilinear symmetric hyperbolic system*, Proc. Roy. Soc. London Ser. A **378**, 401–421.
71. Friedrich H 1983, *Cauchy problems for the conformal vacuum field equations in general relativity*, Commun. Math. Phys. **91**, 445–472.
72. Friedrich H 1985, *On the hyperbolicity of Einstein's and other gauge field equations*, Commun. Math. Phys. **100**, 25–543.
73. Friedrich H 1986, *On the existence of n -geodesically complete or future complete solutions of Einstein's field equations with smooth asymptotic structure*, Commun. Math. Phys. **107**, 587–609.
74. Friedrich H 1991, *On the global existence and the asymptotic behavior of solutions to the Einstein-Maxwell-Yang-Mills equations*, J. Differential Geom. **34**, 275–345.
75. Friedrich H 1998, *Gravitational fields near space-like and null infinity*, J. Geom. Phys. **24**, 83–163.
76. Friedrich H, Nagy, Gabriel 1999, *The initial boundary value problem for Einstein's vacuum field equation*, Commun. Math. Phys. **201**, 619–655.
77. Friedrich H 2005, *On the nonlinearity of subsidiary systems*, Classical Quant. Grav. **22**, L77–L82.
78. Friedrich H, Rendall A 2000, *The Cauchy problem for the Einstein equations*, in: Schmidt B ed., *Einstein's field equations and their physical implications*, Lecture Notes in Physics **540**, Springer: Berlin.
79. Friedrichs K O 1944, *The identity of weak and strong extensions of differential operators*, Trans. Amer. Math. Soc. **55**, 132–151.
80. Fring A, Kostrykin V, Schrader R 1997, *Ionization probabilities through ultra-intense fields in the extreme limit*, J. Phys. A **30**, 8599–8610.
81. Fulling S A 1989, *Aspects of quantum field theory in curved spacetime*, Cambridge University Press, Cambridge.
82. Gil M I 2001, *Solution estimates for nonlinear nonautonomous evolution equations in spaces with normalizing mappings*, Acta Appl. Math. **69**, 1–23.
83. Gill T L, Zachary W W 1987, *Time-ordered operators and Feynman-Dyson algebras*, J. Math. Phys. **28**, 1459–1470.
84. Gesztesy F, Mitter H 1981, *A note on quasi-periodic states*, J. Phys. A **14**, L79–L85.
85. Givoli D 1991, *Nonreflecting boundary conditions*, J. Comput. Phys. **94**, 1–29.
86. Goldberg S 1985, *Unbounded linear operators* Dover: New York.
87. Goldstein J A 1970, *Semigroups of operators and abstract Cauchy problems*, Tulane University: New Orleans.
88. Goldstein J A 1972, *Lectures on semigroups of nonlinear operators*, Tulane University: New Orleans.
89. Goldstein J A, Sandefur J T 1982, *Equipartition of energy for higher order abstract hyperbolic equations*, Comm. Partial Diff. Eqs. **7**, 1217–1251.
90. Goldstein J A 1985, *Semigroups of linear operators and applications*, Oxford University Press: New York.
91. Goldstein J A 1987, *An abstract d'Alembert formula*, SIAM J. Math. Anal. **18**, 842–856.
92. Hagstrom T, Hariharan S. I. A 1998, *Formulation of asymptotic and exact boundary conditions using local operators. Absorbing boundary conditions* Appl. Numer. Math. **27**, 403–416.

93. Hiroshima F 1999, *Weak coupling limit and removing an ultraviolet cutoff for a Hamiltonian of particles interacting with a quantized scalar field*, J. Math. Phys. **40**, 1215–1236.
94. Hiroshima F 2000, *Essential self-adjointness of translation-invariant quantum field models for arbitrary coupling constants*, Commun. Math. Phys. **211**, 585–613.
95. Haag R 1996, *Local quantum physics: Fields, particles, algebras*, Springer: New York.
96. Hawking S W, *Particle creation by black holes* 1975, Commun. Math. Phys. **43**, 199–220.
97. Heard M L 1984, *A quasilinear hyperbolic integrodifferential equation related to a nonlinear string*, Trans. Amer. Math. Soc. **285**, 805–823.
98. Hille E 1948, *Functional analysis and semi-groups*, AMS: New York.
99. Hille E, Phillips R S 1957, *Functional analysis and semi-groups*, Revised ed., AMS: Providence.
100. Hirschmann T, Schimming R 1986, *Generalized harmonic gauge conditions in General Relativity as field-equations for lapse and shift*, Astron Nachr **307**, 293–301.
101. Hirzebruch F, Scharlau W 1971, *Einführung in die Funktionalanalysis*, BI: Mannheim.
102. Hughes T J R, Kato T, Marsden J E 1977, *Well-posed quasi-linear second-order hyperbolic systems with applications to nonlinear elastodynamics and general relativity*, Arch. Rational Mech. Anal. **63**, 273–294.
103. Howland J S 1974, *Stationary scattering theory for time-dependent Hamiltonians*, Math. Ann. **207**, 315–335.
104. Ishii S 1982, *Linear evolution equations $du/dt + A(t)u = 0$: a case where $A(t)$ is strongly uniform-measurable*, J. Math. Soc. Japan **34**, 413–424.
105. Jörgens K 1962, *Spectral theory of second-order ordinary differential operators*, Lectures delivered at the University of Aarhus 1962/63.
106. Kato T 1966, *Perturbation theory for linear operators*, Springer: New York.
107. Kato T 1970, *Linear evolution equations of “hyperbolic” type*, J. Fac. Sci. Univ. Tokyo **17**, 241–258.
108. Kato T 1973, *Linear evolution equations of “hyperbolic” type, II*, J. Mat. Soc. Japan **25**, 648–666.
109. Kato T 1975, *Quasi-linear equations of evolution, with applications to partial differential equations*, Dold A, Eckmann B (Eds.), Spectral theory and differential equations, Proceedings of the symposium held at Dundee, Scotland, 1–19 July, 1974, Lecture Notes in Mathematics 448, Springer: Berlin.
110. Kato T 1975, *The Cauchy problem for quasi-linear symmetric hyperbolic systems*, Arch. Rat. Mech. Anal. **58**, 181–205.
111. Kato T 1976, *Linear and quasi-linear equations of evolution of hyperbolic type*, C.I.M.E., II Ciclo 1976, *Hyperbolicity*, Liguori Editore: Naples.
112. Kato T 1983, *Quasi-linear equations of evolution in nonreflexive Banach spaces*, Fujita H, Lax P D, Strang G (Eds.) 1983, *Nonlinear partial differential equations in applied science*; Proceedings of the U.S.-Japan Seminar, Tokyo, 1982, Lecture Notes in Numerical and Applied Analysis Vol. 5, North-Holland: Amsterdam.
113. Kato T, Ponce G 1988, *Commutator estimates and the Euler and Navier-Stokes equations*, Comm. Pure Appl. Math., **XLI**, 891–907.
114. Kato T 1993, *Abstract evolution equations, linear and quasilinear, revisited* in: Komatsu H (ed) 1993, *Functional analysis and related topics, 1991*, Proceedings of the International conference in memory of professor Kosaku Yosida held at RIMS, Kyoto University, Japan, July 29–Aug. 2, 1991, Lecture Notes in Mathematics 1540, Springer: Berlin.
115. Kato T, Yalima K 1991, *Dirac equations with moving nuclei*, Ann. I. H. Poincaré Phys. **54**, 209–221.

116. Kay B S, Wald R M 1987, *Linear stability of Schwarzschild under perturbations which are nonvanishing on the bifurcation 2-sphere*, Classical Quant. Grav. **4**, 893–898.
117. Klainerman S, Nicolò F 1999, *On local and global aspects of the Cauchy problem in general relativity*, Classical Quant. Grav. **16**, R73–R157.
118. Kobayasi K 1979, *On a theorem for linear evolution equations of hyperbolic type*, J. Math. Soc. Japan **31**, 647–654.
119. Kobayasi K, Sanekata N 1989, *A method of iterations for quasi-linear evolution equations in nonreflexive Banach spaces*, Hiroshima Math J. **19**, 521–540.
120. Krein S G 1971, *Linear differential equations in Banach space*, AMS: Providence.
121. Krein S G, Khazan M I 1985, *Differential equations in a Banach space*, J. Soviet Math. **30**, 2154–2239.
122. Krein M G, Langer H 1978, *On some mathematical principles in the linear theory of damped oscillations of continua I*, Integral Eqs. Operator Th. **1**, 364–399.
123. Kreiss H O 1970, *Initial Boundary value problems for hyperbolic systems*, Comm. Pure Appl. Math., XXIII (1970), 277–298.
124. Gustafsson B, Kreiss H-O, Olgier J 1995, *Time dependent problems and difference methods*, Wiley: New York.
125. Kreiss H-O, Lorenz J 2000, *Resolvent estimates and quantification of nonlinear stability*, Acta Math. Sin. (Engl. Ser.) **16**, 1–20.
126. Krein M G, Langer H 1978, *On some mathematical principles in the linear theory of damped oscillations of continua I*, Integral Eqs. Operator Th. **1**, 539–566.
127. Ladas G E, Lakshmikantham V 1972, *Differential equations in abstract spaces*, Academic Press: New York.
128. Lang S 1969, *Real analysis*, Addison-Wesley: Reading, Mass.
129. DeLaubenfels R 1994, *Existence families, functional calculi and evolution equations*, Lecture Notes in Mathematics 1570, Springer: Berlin.
130. Lax P D, Phillips R S 1960, *Local boundary conditions for dissipative symmetric linear differential operators*, Comm. Pure Appl. Math. **13**, 427–455.
131. Leray J 1953, *Hyperbolic differential equations*, Institute for Advanced Study: Princeton.
132. Lions J L, Magenes E 1972, 1972, 1973, *Non-homogeneous boundary value problems and applications*, Vols. I - III, Springer: Berlin.
133. Lions J L 1957, *Une remarque sur les applications du theoreme de Hille-Yosida*, J. Math. Soc. Japan **9**, 62–70.
134. Mackey G W 2004, *Mathematical foundations of quantum mechanics*, Dover Publications: Dover.
135. Makino T, Ukai, S 1995, *Local smooth solutions of the relativistic Euler equation*, J. Math. Kyoto U. **35**, 105–114.
136. Marsden J E, Weinstein A 1982, *The Hamiltonian-Structure of the Maxwell-Vlasov equations*, Physica D **4**, 394–406.
137. Markus A S 1988, *Introduction to the spectral theory of operator pencils*, AMS: Providence.
138. Martin R H 1976, *Nonlinear operators and differential equations*, Wiley: New York.
139. Massey Frank J III 1972, *Abstract evolution equations and the mixed problem for symmetric hyperbolic systems*, Trans. Amer. Math. Soc. **168**, 165–188.
140. Meyer Y 1992, *Wavelets and operators*, Cambridge University Press: Cambridge.
141. Meyer Y, Coifman R 1997, *Wavelets: Calderon-Zygmund and multilinear operators*, Cambridge University Press: Cambridge.
142. Mikhlin S G 1970, *Mathematical physics, an advanced course*, North-Holland: Amsterdam.

143. Milani A 1982, *em* Local in time existence for the complete Maxwell equations with monotone characteristic in a bounded domain, *Ann. Mat. Pur. Appl.* **131**, 233–254.
144. Misiulek G 2002, *Classical solutions of the periodic Camassa-Holm equation*, *Geom. Funct. Anal.* **12**, 1080–1104.
145. Mitter H, Thaller B 1985, *Particles in spherical electromagnetic-radiation fields*, *Phys. Rev. A* **31**, 2030–2037.
146. Miyadera I 1992, *Nonlinear semigroups*, AMS: Providence.
147. Mizohata K 1994, *Global weak solutions for the equation of isothermal gas around a star*, *J. Math. Kyoto U.* **34**, 585–598.
148. Nagel R 1985, *Well-posedness and positivity for systems of linear evolution equations*, *Confer. Sem. Mat. Univ. Bari* No. 203.
149. Nagel R 1995, *Semigroup methods for non-autonomous Cauchy problems*, In: Ferreyra G, Goldstein G R, Neubrander F (eds.): *Evolution Equations. Lect. Notes Pure Appl. Math.* **168**, 301–316.
150. Nagel R, Sinestrari E 1996, *Nonlinear hyperbolic Volterra integrodifferential equations*, *Nonlinear Analysis* **27**, 167–186.
151. Nagel R, Nickel G 2002, *Wellposedness for nonautonomous abstract Cauchy problems*, in: Neumann W R ed., *Evolution equations, semigroups and functional analysis* (Milano, 2000), 279–293, *Progr. Nonlinear Differential Equations Appl.* **50**, Birkhuser: Basel.
152. Nagy G, Sarbach O 2006, *A minimization problem for the lapse and the initial-boundary value problem for Einstein's field*, <http://arxiv.org/abs/gr-qc/0601124>.
153. Neidhardt H 1981, *On abstract linear evolution-equations. I*, *Math. Nachr.* **103**, 283–298.
154. Neubrander F 1988, *Well-posedness of higher order abstract Cauchy problems*, *Trans. Amer. Math. Soc.* **295**, 257–290.
155. Neubrander F 1988, *Integrated semigroups and their applications to the abstract Cauchy problem*, *Pacific J. Math.* **135**, 111–155.
156. Neubrander F 1989, *Integrated semigroups and their application to complete second order Cauchy problems*, *Semigroup Forum* **38**, 233–251.
157. von Neumann J 1932, *Mathematische Grundlagen der Quantenmechanik*, Springer: Berlin.
158. Nishitani T, Takayama M 1996, *A characteristic initial-boundary value problem for a symmetric positive system*, *Hokkaido Math. J.* **25**, 167–182.
159. Nickel G, Schnaubelt R 1998, *An extension of Kato's stability condition for nonautonomous Cauchy problems*, *Taiwan J. Math.* **2**, 483–496.
160. Nickel G 2000, *Evolution semigroups and product formulas for nonautonomous Cauchy problems*, *Math. Nachr.* **212**, 101–116.
161. Nishitani T, Takayama M 1998, *Characteristic initial-boundary value problems for symmetric hyperbolic systems*, *Osaka J. Math.* **35**, 29–657.
162. Obrecht E 1991, *Phase space for an n-th order differential equation in Banach spaces*, in: *Semigroup theory and evolution equations*, eds. Clement P, Mitidieri E and de Pagter B, *Lecture notes in pure and applied mathematics* **135**, Marcel Dekker: New York, 391–399.
163. Oka H, Tanaka N 1997, *Abstract quasilinear integrodifferential equations of hyperbolic type*, *Nonlinear Anal-Theor.* **29**, 903–925.
164. Oka H 1997, *Abstract quasilinear Volterra integrodifferential equations*, *Nonlinear Anal-Theor.* **28**, 1019–1045.
165. Oka H, Tanaka N 2005, *Evolution operators generated by non-densely defined operators*, *Math. Nachr.* **278**, 1285–1296.

166. Pan R, Smoller J A 2006, *Blowup of smooth solutions for relativistic Euler equations*, Commun. Math. Phys. **262**, 729–755.
167. Pavel N H 1987, *Nonlinear evolution operators and semigroups*, Springer: Berlin.
168. Pazy A 1983, *Semigroups of linear operators and applications to partial differential equations*, Springer: New York.
169. Phillips R S, Sarason L 1966, *Singular symmetric positive first order differential operators*, J. Math. Mech., 235–272.
170. Da Prato G 1966, *Semigrupperi regolarizzabili*, Ricerche Mat. **15**, 223–248.
171. Da Prato G, Grisvard, P 1975, *Sommes d'opérateurs lineaires et equations differentielles operationnelles* J. Math. Pures Appl. **54**, 305–387.
172. Da Prato G, Iannelli M 1976, *On a method for studying abstract evolution equations in the hyperbolic case*, Comm. Partial Differential Equations **1**, 585–608.
173. Da Prato G, Grisvard P 1994, *The damped wave equation in a noncylindrical domain*, Differential Integral Equations **7**, 735–746.
174. Da Prato G, Zolesio J P 1990, *Existence and optimal-control for wave-equation in moving domain*, Lect. Notes Contr. Inf. **147**, 167–190.
175. Prugovecki E 1981, *Quantum Mechanics in Hilbert Space*, Academic Press: New York.
176. Rauch J 1985, *Symmetric positive systems with boundary characteristic of constant multiplicity*, Trans. Amer. Math. Soc. **291**, 167–187.
177. Rauch J, Massey Frank J III 1974, *Differentiability of solutions to hyperbolic initial-boundary value problems*, Trans. Amer. Math. Soc. **189**, 303–318.
178. Rauch J 1994, *Boundary value problems with nonuniformly characteristic boundary*, J. Math. Pures Appl. **73**, 347–353.
179. Reed M and Simon B, 1980, 1975, 1979, 1978, *Methods of modern mathematical physics*, Volume I, II, III, IV, Academic: New York.
180. Renardy M and Rogers R C 1993, *An introduction to partial differential equations*, Springer: New York.
181. Reula O, Sarbach O 2005, *A model problem for the initial-boundary value formulation of Einstein's field equations*, Journal of Hyperbolic Differential Equations, 397–435.
182. Riesz F and Sz-Nagy B 1955, *Functional analysis*, Unger: New York.
183. Rodman L 1989, *An Introduction to Operator Polynomials*, Birkäuser: Basel.
184. Romanov V A 1973, *Stability of plane-parallel Couette flow*, Funct. Anal. Appl. **7**, 137–146.
185. Rudin W 1962, *Fourier analysis on groups*, Interscience Publishers: New York.
186. Rudin W 1991, *Functional analysis*, 2nd ed., MacGraw-Hill: New York.
187. Sarbach O, Heusler H, Brodbeck O 2001, *Self-adjoint wave equations for dynamical perturbations of self-gravitating fields*, Phys. Rev. D **63**, 104015.
188. Sanekata N 1989, *Abstract quasi-linear equations of evolution in nonreflexive Banach spaces*, Hiroshima Math. J. **19**, 109–139.
189. Sandefur J 1977, *Higher order abstract Cauchy problems*, J. Math. Anal. Appl. **60**, 728–742.
190. Sandefur J 1984, *Convergence of solutions of a second-order Cauchy problem*, J. Math. Anal. Appl. **100**, 470–477.
191. Schroer B 2001, *Lectures on algebraic quantum field theory and operator algebras*, <http://xxx.lanl.gov/abs/math-ph/0102018>.
192. Schutz B F 2004, *The art and science of black hole mergers*, Proceedings of 'Growing Black Holes', Garching 21–25 June 2004, <http://arxiv.org/abs/gr-qc/0410121>.
193. Secchi P 1995, *Linear symmetric hyperbolic systems with characteristic boundary*, Math. Methods Appl. Sci. **18**, 855–870.

194. Secchi P 1996, *The initial boundary value problem for linear symmetric hyperbolic systems with characteristic boundary of constant multiplicity*, J. Diff. Int. Eq. **9**, 671–700.
195. Secchi P 1996, *Well-posedness of characteristic symmetric hyperbolic systems*, Arch. Rational Mech. Anal. **134**, 155–197.
196. Secchi P 1997, *Characteristic symmetric hyperbolic systems with dissipation. Global existence and asymptotics*, Math. Meth. Appl. Sci. **20**, 583–597.
197. Secchi P 1998, *A symmetric positive system with nonuniformly characteristic boundary*, Differential Integral Equations **11**, 605–621.
198. Secchi P 2000, *Full regularity of solutions to a nonuniformly characteristic boundary value problem for symmetric positive systems*, Adv. Math. Sci. Appl. **10**, 39–55.
199. Showalter R E 1997, *Monotone operators in Banach space and nonlinear partial differential equations*, Mathematical Surveys and Monographs, 49. American Mathematical Society: Providence.
200. Stein E M 1970, *Singular integrals and differentiability properties of functions*, Princeton University Press: Princeton.
201. Stein E M 1993, *Harmonic analysis: Real-variable methods, orthogonality and oscillatory integrals*, Princeton University Press: Princeton.
202. Streater R F, Wightman A S 2000, *PCT, Spin and statistics, and all that*, Princeton University Press: Princeton.
203. Tanabe H 1979, *Equations of evolution*, Pitman: London.
204. Tanabe H 1997, *Functional analytic methods for partial differential equations*, Marcel Dekker: New York.
205. Tanaka N, Okazawa N 1990, *Local C-semigroups and local integrated semigroups*, Proc. London Math. Soc. **61**, 63–90.
206. Tanaka N 2000, *Generation of linear evolution operators*, Proc. Am. Math. Soc. **128**, 2007–2015.
207. Tanaka N 2000, *A class of abstract quasi-linear evolution equations of second order*, J. Lond. Math. Soc. **62**, 198–212.
208. Tanaka N 2001, *A characterization of evolution operators*, Stud. Math. **146**, 285–299.
209. Tanaka N 2004, *Abstract Cauchy problems for quasi-linear evolution equations in the sense of Hadamard*, Proc. Lond. Math. Soc. **89**, 123–160.
210. Tanaka N 2004, *Nonautonomous abstract Cauchy problems for strongly measurable families*, Math. Nachr. **274–275**, 130–153.
211. Tarfulea N 2005, *Constraint Preserving Boundary Conditions for Hyperbolic Formulations of Einstein's Equations*, <http://arxiv.org/abs/gr-qc/0508014>.
212. Wald R M 1979, *Note on the stability of the Schwarzschild metric*, J. Math. Phys. **20**, 1056–1058.
213. Wald R M 1980, *Erratum: "Note on the stability of the Schwarzschild metric" (J. Math. Phys. 20 (1979), 1056–1058)*, J. Math. Phys. **21**, 218.
214. Wald R M 1994, *Quantum field theory in curved spacetime and black hole thermodynamics*, University of Chicago Press: Chicago.
215. Walton R A 2005, *A symmetric hyperbolic structure for isentropic relativistic perfect fluids*, Houston J. Math. **31**, 145–160.
216. Weidmann J 1980, *Linear Operators in Hilbert spaces*, Springer: New York.
217. Wloka J 1987, *Partial differential equations*, Cambridge: Cambridge.
218. Xiao T, Liang J 1998, *The Cauchy problem for higher order abstract differential equations*, Lecture Notes in Mathematics **1701**, Springer: New York.
219. Yagi A 1980, *Remarks on proof of a theorem of Kato and Kobayasi on linear evolution equations*, Osaka J. Math. **17**, 233–243.

- 220. Yakubov S, Yakubov Y 2000, *Differential-operator equations: Ordinary and partial differential equations*, Chapman & Hall: London.
- 221. Yamada Y 1987, *Some nonlinear degenerate wave equations*, Nonlinear Anal. **11**, 1155–1168.
- 222. Yamazaki T 2000, *Bounded solutions of quasilinear hyperbolic equations of Kirchhoff type with dissipative and forcing terms*, Funkcial. Ekvac. **43**, 511–528.
- 223. Yosida K 1956, *An operator-theoretical integration of the wave equation*, J. Math. Soc. **8**, 79–92.
- 224. Yosida K 1957, *Lectures on semi-group theory and its application to Cauchy's problem in partial differential equations*, Tata Institute of Fundamental Research: Bombay.
- 225. Yosida K 1968, *Functional analysis*, 2nd ed., Springer: Berlin.
- 226. Zheng Q 1994, *Strongly continuous M , N -families of bounded operators*, Integral Eqs. Operator Th. **19**, 105–119.
- 227. Ziemer W P 1989, *Weakly differentiable functions*, Springer: New York.

Index of Notation

- $\text{Ran } f$, range of a map f , 1
 $\ker f$, kernel of a linear map f , 1
 id_S , The identity map on a set S , 1
 \mathbb{N} , Set of natural numbers, 1
 \mathbb{R} , Set of real numbers, 1
 \mathbb{C} , Set of complex numbers, 1
 $\mathbb{N}^*, \mathbb{N} \setminus \{0\}$, 1
 $\mathbb{R}^*, \mathbb{R} \setminus \{0\}$, 1
 $\mathbb{C}^*, \mathbb{C} \setminus \{0\}$, 1
 strictly positive, 1
 strictly negative, 1
 e_1, \dots, e_n , canonical basis of \mathbb{R}^n , 1
 $M(n \times n, \mathbb{K})$, $n \times n$ matrices, 1
 $\det A$, determinant of a matrix A , 1
 $C^k(M, \mathbb{K})$, 1
 $C_0^k(M, \mathbb{K})$, 1
 $C^k(\tilde{M}, \mathbb{K})$, 1
 $f_{,j}$, 1
 $f_{,\alpha}$, 1
 $f'(x)$, derivative of f in x (matrix), 2
 ∇f , gradient of f , 2
 $'$, ordinary derivative, 2
 $BC(\mathbb{R}^n, \mathbb{C})$, 2
 $C_\infty(\mathbb{R}^n, \mathbb{C})$, 2
 ν^n , Lebesgue measure on \mathbb{R}^n , 2
 $L_C^p(M, \rho)$, weighted L^p -space, 2
 $\|\cdot\|_p$, L^p -norm, 2
 $\langle \cdot | \cdot \rangle_2$, L^2 -scalar product, 2
 $L_C^\infty(M)$, 3
 $\|\cdot\|_\infty$, Infinity-norm, 3
 $L(X, Y)$, Bounded linear operators, 3
 $\|\cdot\|_{\text{Op}, X, Y}$, Operator norm, 3
 $C(U, Y)$, 3
 $\text{Lip}(U, Y)$, 3
 ψ_ξ , Spectral measure, 6
 $A^{1/2}$, Square root of A , 9
 $-\Delta$, Negative Laplace operator, 10
 J_0 , Bessel function of order 0, 11
 J_1 , Bessel function of order 1, 11
 K_0 , Macdonald function of order 0, 11
 K_1 , Macdonald function of order 1, 11
 $\|\cdot\|_{X \times Y}$, 13
 $\langle \cdot | \cdot \rangle_{X \times Y}$, 13
 $D(A)$, Domain of A , 14
 $G(A)$, Graph of A , 14
 $A \subset B$, B is a linear extension of A , 14
 $B \supset A$, B is a linear extension of A , 14
 \bar{A} , Closure of A , 14
 $\|\cdot\|_A$, 15

- A^* , Adjoint of A , 17
- $s\text{--lim}$, Strong limit, 22
- $\rho(A)$, Resolvent set of A , 24
- R_A , Resolvent of A , 24
- $\exp(A)$, Exponential of A , 36
- \nmid , Contradiction, 38
- $W_{\mathbb{C}}^n(I)$, Sobolev space of order n , 78
- D_I^k , k -th weak ordinary derivative, 78
- ∂^α , α -th weak partial derivative, 97
- $W_{\mathbb{C}}^n(\mathbb{R}^n)$, Sobolev space of order n , 98
- \langle, \rangle_k , 98
- $*$, Convolution product, 98
- $w\text{--lim}$, Weak limit, 108
- $\| \cdot \|_k$, Sobolev norm of order k , 133
- $C_*(K, L(X, Y))$, 138
- $PC_*(I, L(X, Y))$, 138
- $\| \cdot \|_\infty$, Infinity norm, 138
- $\Delta(I)$, 138
- $[UBV]$, 138
- $\text{volt}(U, B)$, 138
- $\ln(A)$, Natural logarithm of A , 181
- F_2 , Fourier transformation, 199
- $K_{(n/2)-1}$, Macdonald function, 205
- F_1 , Fourier transformation, 236

Index of Terminology

- Boundary condition
 - Engquist-Majda, 78, 127
 - Sommerfeld, 78, 124
- Chains, 146
 - finitely generated, 148
 - juxtapositions, 147
- Commutator estimates, 186, 199, 246
- Commutator function, 9
- Conventions, 1
- Couette flow, 74
- Difference method, 78
- Equation
 - abstract evolution
 - linear, 171
 - quasilinear, 221
 - Burgers, 235
 - Dirac, 103
 - Klein-Gordon
 - in Minkowski space, 11
 - on the real line, 10
 - Maxwell's equations, 132
 - wave, 8, 84
- Evolution operator, 149
 - associated differential equations, 150
 - finitely generated, 151
 - for the linear evolution equation, 165
 - uniqueness, 150
- Exponential function, 35
- Group
 - strongly continuous, 63
 - associated differential equation, 63
 - infinitesimal generator, 63, 65
- Inequalities
 - Elementary, 235
 - Peetre's, 265
 - Sobolev, 236
 - Sobolev's, 265
- Infinitesimal generators, 42
 - bounded, 42
 - bounded perturbations, 61
 - characterization, 51
 - exponential formula, 155
 - fractional powers, 180
 - homogeneous IVP, 42

- inhomogeneous IVP, 66, 67
- logarithm, 180
- maximality, 42
- resolvent estimates, 42
- resolvent representation, 42
- spectrum property, 42
- uniqueness, 42
- Integration
 - Bochner, 30
 - Pettis, 26
 - weak, 26
 - existence, 26, 27
 - Fubini's theorem, 30
 - properties, 27
 - substitution rule, 34
- Intertwining relation, 112
 - equivalent conditions, 114
 - sufficient conditions, 115
- Kernels, 137
 - Convolution, 137
 - Volterra, 137
 - approximation, 145
 - distance, 143
 - Volterra equation, 137
- Kreiss condition, 78
- Linear operators, 14
 - 1st resolvent formula, 24
 - 2nd resolvent formula, 24
 - accretive, 54
 - characterization, 55
 - closability, 56
 - adjoint, 17
 - closable, 14
 - closed, 14
 - core, 14
 - densely-defined, 14
 - essentially self-adjoint, 17
 - extension, 14
 - weak vs strong, 100
 - graph, 14
 - mollifiers, 98
 - non-closable, 16
 - quasi-accretive, 54
 - closability, 56
 - resolvent, 24
 - resolvent set, 24
 - self-adjoint, 17
 - maximality, 17
 - spectrum, 24
 - symmetric, 17
 - unbounded, 16
- Nonexpansive homomorphisms
 - properties, 117
- Numerics of PDEs, 78
- Quantum system
 - conservation of probability, 7
 - example, 7
 - Hamilton operator, 6
 - measurement, 5
 - probabilities, 5
 - observables, 5
 - expectation value, 6
 - spectral measure, 6
 - spectrum, 5
 - quantization of a classical system, 5
 - representation space, 5
 - Schrödinger equation, 7
 - states, 5
 - superposition principle, 6
 - time evolution
 - unitary, 6
- Regularity, 105
- Scalar field
 - in black hole background, 178
 - in Minkowski space, 11
 - on the real line, 10, 78, 123, 127
- Semigroup
 - strongly continuous, 42
 - approximation, 54
 - associated differential equation, 42
 - contraction, 56
 - infinitesimal generator, 42
 - integral representation, 59
 - quasi-contraction, 56
 - uniformly continuous, 42

Spaces
 admissible, 109
 sufficient condition , 112
 Banach
 direct sum, 13
 Hilbert
 direct sum, 13
 Sobolev, 98
 Stable families of generators,
 155
 bounded perturbations, 162
 criterion, 160
 equivalent conditions, 158
 Systems
 Hermitian hyperbolic
 linear autonomous, 103

linear non-autonomous, 199
 quasi-linear, 246
 Tangent functionals
 normalized, 54
 Theorem
 Banach fixed point, 215
 variation, 216
 Closed graph, 14
 application, 17
 E. Noether, 113
 Hellinger-Toeplitz, 17
 Hille-Yosida-Phillips, 51
 Inverse mapping, 14
 Lumer-Phillips, 56
 Mazur, 108

Lecture Notes in Mathematics

For information about earlier volumes
please contact your bookseller or Springer
LNM Online archive: springerlink.com

- Vol. 1711: W. Ricker, Operator Algebras Generated by Commuting Projections: A Vector Measure Approach (1999)
- Vol. 1712: N. Schwartz, J. J. Madden, Semi-algebraic Function Rings and Reflectors of Partially Ordered Rings (1999)
- Vol. 1713: F. Bethuel, G. Huisken, S. Müller, K. Steffen, Calculus of Variations and Geometric Evolution Problems, Cetraro, 1996. Editors: S. Hildebrandt, M. Struwe (1999)
- Vol. 1714: O. Diekmann, R. Durrett, K. P. Hadeler, P. K. Maini, H. L. Smith, Mathematics Inspired by Biology, Martina Franca, 1997. Editors: V. Capasso, O. Diekmann (1999)
- Vol. 1715: N. V. Krylov, M. Röckner, J. Zabczyk, Stochastic PDE's and Kolmogorov Equations in Infinite Dimensions, Cetraro, 1998. Editor: G. Da Prato (1999)
- Vol. 1716: J. Coates, R. Greenberg, K. A. Ribet, K. Rubin, Arithmetic Theory of Elliptic Curves, Cetraro, 1997. Editor: C. Viola (1999)
- Vol. 1717: J. Bertoin, F. Martinelli, Y. Peres, Lectures on Probability Theory and Statistics, Saint-Flour, 1997. Editor: P. Bernard (1999)
- Vol. 1718: A. Eberle, Uniqueness and Non-Uniqueness of Semigroups Generated by Singular Diffusion Operators (1999)
- Vol. 1719: K. R. Meyer, Periodic Solutions of the N-Body Problem (1999)
- Vol. 1720: D. Elworthy, Y. Le Jan, X-M. Li, On the Geometry of Diffusion Operators and Stochastic Flows (1999)
- Vol. 1721: A. Iarrobino, V. Kanev, Power Sums, Gorenstein Algebras, and Determinantal Loci (1999)
- Vol. 1722: R. McCutcheon, Elementary Methods in Ergodic Ramsey Theory (1999)
- Vol. 1723: J. P. Croisille, C. Lebeau, Diffraction by an Immersed Elastic Wedge (1999)
- Vol. 1724: V. N. Kolokoltsov, Semiclassical Analysis for Diffusions and Stochastic Processes (2000)
- Vol. 1725: D. A. Wolf-Gladrow, Lattice-Gas Cellular Automata and Lattice Boltzmann Models (2000)
- Vol. 1726: V. Marić, Regular Variation and Differential Equations (2000)
- Vol. 1727: P. Kravanja M. Van Barel, Computing the Zeros of Analytic Functions (2000)
- Vol. 1728: K. Gatermann Computer Algebra Methods for Equivariant Dynamical Systems (2000)
- Vol. 1729: J. Azéma, M. Émery, M. Ledoux, M. Yor (Eds.) Séminaire de Probabilités XXXIV (2000)
- Vol. 1730: S. Graf, H. Luschgy, Foundations of Quantization for Probability Distributions (2000)
- Vol. 1731: T. Hsu, Quilts: Central Extensions, Braid Actions, and Finite Groups (2000)
- Vol. 1732: K. Keller, Invariant Factors, Julia Equivalences and the (Abstract) Mandelbrot Set (2000)
- Vol. 1733: K. Ritter, Average-Case Analysis of Numerical Problems (2000)
- Vol. 1734: M. Espedal, A. Fasano, A. Mikelić, Filtration in Porous Media and Industrial Applications, Cetraro 1998. Editor: A. Fasano. 2000.
- Vol. 1735: D. Yafaev, Scattering Theory: Some Old and New Problems (2000)
- Vol. 1736: B. O. Turesson, Nonlinear Potential Theory and Weighted Sobolev Spaces (2000)
- Vol. 1737: S. Wakabayashi, Classical Microlocal Analysis in the Space of Hyperfunctions (2000)
- Vol. 1738: M. Émery, A. Nemirovski, D. Voiculescu, Lectures on Probability Theory and Statistics (2000)
- Vol. 1739: R. Burkard, P. Deufhard, A. Jameson, J.-L. Lions, G. Strang, Computational Mathematics Driven by Industrial Problems, Martina Franca, 1999. Editors: V. Capasso, H. Engl, J. Periaux (2000)
- Vol. 1740: B. Kawohl, O. Pironneau, L. Tartar, J.-P. Zolesio, Optimal Shape Design, Tróia, Portugal 1999, Editors: A. Cellina, A. Ornelas (2000)
- Vol. 1741: E. Lombardi, Oscillatory Integrals and Phenomena Beyond all Algebraic Orders (2000)
- Vol. 1742: A. Unterberger, Quantization and Non-holomorphic Modular Forms (2000)
- Vol. 1743: L. Habermann, Riemannian Metrics of Constant Mass and Moduli Spaces of Conformal Structures (2000)
- Vol. 1744: M. Kunze, Non-Smooth Dynamical Systems (2000)
- Vol. 1745: V. D. Milman, G. Schechtman (Eds.), Geometric Aspects of Functional Analysis. Israel Seminar 1999-2000 (2000)
- Vol. 1746: A. Degtyarev, I. Itenberg, V. Kharlamov, Real Enriques Surfaces (2000)
- Vol. 1747: L. W. Christensen, Gorenstein Dimensions (2000)
- Vol. 1748: M. Ruzicka, Electrorheological Fluids: Modeling and Mathematical Theory (2001)
- Vol. 1749: M. Fuchs, G. Seregin, Variational Methods for Problems from Plasticity Theory and for Generalized Newtonian Fluids (2001)
- Vol. 1750: B. Conrad, Grothendieck Duality and Base Change (2001)
- Vol. 1751: N. J. Cutland, Loeb Measures in Practice: Recent Advances (2001)
- Vol. 1752: Y. V. Nesterenko, P. Philippon, Introduction to Algebraic Independence Theory (2001)
- Vol. 1753: A. I. Bobenko, U. Eitner, Painlevé Equations in the Differential Geometry of Surfaces (2001)
- Vol. 1754: W. Bertram, The Geometry of Jordan and Lie Structures (2001)
- Vol. 1755: J. Azéma, M. Émery, M. Ledoux, M. Yor (Eds.), Séminaire de Probabilités XXXV (2001)
- Vol. 1756: P. E. Zhidkov, Korteweg de Vries and Nonlinear Schrödinger Equations: Qualitative Theory (2001)

- Vol. 1757: R. R. Phelps, Lectures on Choquet's Theorem (2001)
- Vol. 1758: N. Monod, Continuous Bounded Cohomology of Locally Compact Groups (2001)
- Vol. 1759: Y. Abe, K. Kopfermann, Toroidal Groups (2001)
- Vol. 1760: D. Filipović, Consistency Problems for Heath-Jarrow-Morton Interest Rate Models (2001)
- Vol. 1761: C. Adelmann, The Decomposition of Primes in Torsion Point Fields (2001)
- Vol. 1762: S. Cerrai, Second Order PDE's in Finite and Infinite Dimension (2001)
- Vol. 1763: J.-L. Loday, A. Frabetti, F. Chapoton, F. Goichot, Dialgebras and Related Operads (2001)
- Vol. 1764: A. Cannas da Silva, Lectures on Symplectic Geometry (2001)
- Vol. 1765: T. Kerler, V. V. Lyubashenko, Non-Semisimple Topological Quantum Field Theories for 3-Manifolds with Corners (2001)
- Vol. 1766: H. Hennion, L. Hervé, Limit Theorems for Markov Chains and Stochastic Properties of Dynamical Systems by Quasi-Compactness (2001)
- Vol. 1767: J. Xiao, Holomorphic Q Classes (2001)
- Vol. 1768: M. J. Pflaum, Analytic and Geometric Study of Stratified Spaces (2001)
- Vol. 1769: M. Alberich-Carramiñana, Geometry of the Plane Cremona Maps (2002)
- Vol. 1770: H. Gluesing-Luerssen, Linear Delay-Differential Systems with Commensurate Delays: An Algebraic Approach (2002)
- Vol. 1771: M. Émery, M. Yor (Eds.), Séminaire de Probabilités 1967-1980. A Selection in Martingale Theory (2002)
- Vol. 1772: F. Burstall, D. Ferus, K. Leschke, F. Pedit, U. Pinkall, Conformal Geometry of Surfaces in S^4 (2002)
- Vol. 1773: Z. Arad, M. Muzychuk, Standard Integral Table Algebras Generated by a Non-real Element of Small Degree (2002)
- Vol. 1774: V. Runde, Lectures on Amenability (2002)
- Vol. 1775: W. H. Meeks, A. Ros, H. Rosenberg, The Global Theory of Minimal Surfaces in Flat Spaces. Martina Franca 1999. Editor: G. P. Pirola (2002)
- Vol. 1776: K. Behrend, C. Gomez, V. Tarasov, G. Tian, Quantum Cohomology. Cetraro 1997. Editors: P. de Bartolomeis, B. Dubrovin, C. Reina (2002)
- Vol. 1777: E. García-Río, D. N. Kupeli, R. Vázquez-Lorenzo, Osserman Manifolds in Semi-Riemannian Geometry (2002)
- Vol. 1778: H. Kiechle, Theory of K-Loops (2002)
- Vol. 1779: I. Chueshov, Monotone Random Systems (2002)
- Vol. 1780: J. H. Bruinier, Borcherds Products on $O(2,1)$ and Chern Classes of Heegner Divisors (2002)
- Vol. 1781: E. Bolthausen, E. Perkins, A. van der Vaart, Lectures on Probability Theory and Statistics. Ecole d'Été de Probabilités de Saint-Flour XXIX-1999. Editor: P. Bernard (2002)
- Vol. 1782: C.-H. Chu, A. T.-M. Lau, Harmonic Functions on Groups and Fourier Algebras (2002)
- Vol. 1783: L. Grüne, Asymptotic Behavior of Dynamical and Control Systems under Perturbation and Discretization (2002)
- Vol. 1784: L. H. Eliasson, S. B. Kuksin, S. Marmi, J.-C. Yoccoz, Dynamical Systems and Small Divisors. Cetraro, Italy 1998. Editors: S. Marmi, J.-C. Yoccoz (2002)
- Vol. 1785: J. Arias de Reyna, Pointwise Convergence of Fourier Series (2002)
- Vol. 1786: S. D. Cutkosky, Monomialization of Morphisms from 3-Folds to Surfaces (2002)
- Vol. 1787: S. Caenepeel, G. Militaru, S. Zhu, Frobenius and Separable Functors for Generalized Module Categories and Nonlinear Equations (2002)
- Vol. 1788: A. Vasil'ev, Moduli of Families of Curves for Conformal and Quasiconformal Mappings (2002)
- Vol. 1789: Y. Sommerhäuser, Yetter-Drinfel'd Hopf algebras over groups of prime order (2002)
- Vol. 1790: X. Zhan, Matrix Inequalities (2002)
- Vol. 1791: M. Knebusch, D. Zhang, Manis Valuations and Prüfer Extensions I: A new Chapter in Commutative Algebra (2002)
- Vol. 1792: D. D. Ang, R. Gorenflo, V. K. Le, D. D. Trong, Moment Theory and Some Inverse Problems in Potential Theory and Heat Conduction (2002)
- Vol. 1793: J. Cortés Monforte, Geometric, Control and Numerical Aspects of Nonholonomic Systems (2002)
- Vol. 1794: N. Pytheas Fogg, Substitution in Dynamics, Arithmetics and Combinatorics. Editors: V. Berthé, S. Ferenczi, C. Mauduit, A. Siegel (2002)
- Vol. 1795: H. Li, Filtered-Graded Transfer in Using Non-commutative Gröbner Bases (2002)
- Vol. 1796: J.M. Melenk, hp-Finite Element Methods for Singular Perturbations (2002)
- Vol. 1797: B. Schmidt, Characters and Cyclotomic Fields in Finite Geometry (2002)
- Vol. 1798: W.M. Oliva, Geometric Mechanics (2002)
- Vol. 1799: H. Pajot, Analytic Capacity, Rectifiability, Menger Curvature and the Cauchy Integral (2002)
- Vol. 1800: O. Gabber, L. Ramero, Almost Ring Theory (2003)
- Vol. 1801: J. Azéma, M. Émery, M. Ledoux, M. Yor (Eds.), Séminaire de Probabilités XXXVI (2003)
- Vol. 1802: V. Capasso, E. Merzbach, B. G. Ivanoff, M. Dozzi, R. Dalang, T. Mountford, Topics in Spatial Stochastic Processes. Martina Franca, Italy 2001. Editor: E. Merzbach (2003)
- Vol. 1803: G. Dolzmann, Variational Methods for Crystalline Microstructure – Analysis and Computation (2003)
- Vol. 1804: I. Cherednik, Ya. Markov, R. Howe, G. Lusztig, Iwahori-Hecke Algebras and their Representation Theory. Martina Franca, Italy 1999. Editors: V. Baldoni, D. Barbasch (2003)
- Vol. 1805: F. Cao, Geometric Curve Evolution and Image Processing (2003)
- Vol. 1806: H. Broer, I. Hoveijn, G. Lunther, G. Vegter, Bifurcations in Hamiltonian Systems. Computing Singularities by Gröbner Bases (2003)
- Vol. 1807: V. D. Milman, G. Schechtman (Eds.), Geometric Aspects of Functional Analysis. Israel Seminar 2000-2002 (2003)
- Vol. 1808: W. Schindler, Measures with Symmetry Properties (2003)
- Vol. 1809: O. Steinbach, Stability Estimates for Hybrid Coupled Domain Decomposition Methods (2003)
- Vol. 1810: J. Wengenroth, Derived Functors in Functional Analysis (2003)
- Vol. 1811: J. Stevens, Deformations of Singularities (2003)
- Vol. 1812: L. Ambrosio, K. Deckelnick, G. Dziuk, M. Mimura, V. A. Solonnikov, H. M. Sonner, Mathematical Aspects of Evolving Interfaces. Madeira, Funchal, Portugal 2000. Editors: P. Colli, J. F. Rodrigues (2003)
- Vol. 1813: L. Ambrosio, L. A. Caffarelli, Y. Brenier, G. Buttazzo, C. Villani, Optimal Transportation and its

- Applications. Martina Franca, Italy 2001. Editors: L. A. Caffarelli, S. Salsa (2003)
- Vol. 1814: P. Bank, F. Baudoin, H. Föllmer, L.C.G. Rogers, M. Soner, N. Touzi, Paris-Princeton Lectures on Mathematical Finance 2002 (2003)
- Vol. 1815: A. M. Vershik (Ed.), Asymptotic Combinatorics with Applications to Mathematical Physics. St. Petersburg, Russia 2001 (2003)
- Vol. 1816: S. Albeverio, W. Schachermayer, M. Tala-grand, Lectures on Probability Theory and Statistics. Ecole d'Été de Probabilités de Saint-Flour XXX-2000. Editor: P. Bernard (2003)
- Vol. 1817: E. Koelink, W. Van Assche (Eds.), Orthogonal Polynomials and Special Functions. Leuven 2002 (2003)
- Vol. 1818: M. Bildhauer, Convex Variational Problems with Linear, nearly Linear and/or Anisotropic Growth Conditions (2003)
- Vol. 1819: D. Masser, Yu. V. Nesterenko, H. P. Schlickeweï, W. M. Schmidt, M. Waldschmidt, Diophantine Approximation. Cetraro, Italy 2000. Editors: F. Amoroso, U. Zannier (2003)
- Vol. 1820: F. Hiai, H. Kosaki, Means of Hilbert Space Operators (2003)
- Vol. 1821: S. Teufel, Adiabatic Perturbation Theory in Quantum Dynamics (2003)
- Vol. 1822: S.-N. Chow, R. Conti, R. Johnson, J. Mallet-Paret, R. Nussbaum, Dynamical Systems. Cetraro, Italy 2000. Editors: J. W. Macki, P. Zecca (2003)
- Vol. 1823: A. M. Anile, W. Allegretto, C. Ringhofer, Mathematical Problems in Semiconductor Physics. Cetraro, Italy 1998. Editor: A. M. Anile (2003)
- Vol. 1824: J. A. Navarro González, J. B. Sancho de Salas, \mathcal{C}^∞ -Differentiable Spaces (2003)
- Vol. 1825: J. H. Bramble, A. Cohen, W. Dahmen, Multiscale Problems and Methods in Numerical Simulations, Martina Franca, Italy 2001. Editor: C. Canuto (2003)
- Vol. 1826: K. Dohmen, Improved Bonferroni Inequalities via Abstract Tubes. Inequalities and Identities of Inclusion-Exclusion Type. VIII, 113 p. 2003.
- Vol. 1827: K. M. Pilgrim, Combinations of Complex Dynamical Systems. IX, 118 p. 2003.
- Vol. 1828: D. J. Green, Gröbner Bases and the Computation of Group Cohomology. XII, 138 p. 2003.
- Vol. 1829: E. Altman, B. Gaujal, A. Hordijk, Discrete-Event Control of Stochastic Networks: Multimodularity and Regularity. XIV, 313 p. 2003.
- Vol. 1830: M. I. Gil', Operator Functions and Localization of Spectra. XIV, 256 p. 2003.
- Vol. 1831: A. Connes, J. Cuntz, E. Guentner, N. Higson, J. E. Kaminker, Noncommutative Geometry, Martina Franca, Italy 2002. Editors: S. Doplicher, L. Longo (2004)
- Vol. 1832: J. Azéma, M. Émery, M. Ledoux, M. Yor (Eds.), Séminaire de Probabilités XXXVII (2003)
- Vol. 1833: D.-Q. Jiang, M. Qian, M.-P. Qian, Mathematical Theory of Nonequilibrium Steady States. On the Frontier of Probability and Dynamical Systems. IX, 280 p. 2004.
- Vol. 1834: Yo. Yomdin, G. Comte, Tame Geometry with Application in Smooth Analysis. VIII, 186 p. 2004.
- Vol. 1835: O.T. Izhboldin, B. Kahn, N.A. Karpenko, A. Vishik, Geometric Methods in the Algebraic Theory of Quadratic Forms. Summer School, Lens, 2000. Editor: J.-P. Tignol (2004)
- Vol. 1836: C. Năstăsescu, F. Van Oystaeyen, Methods of Graded Rings. XIII, 304 p. 2004.
- Vol. 1837: S. Tavaré, O. Zeitouni, Lectures on Probability Theory and Statistics. Ecole d'Été de Probabilités de Saint-Flour XXXI-2001. Editor: J. Picard (2004)
- Vol. 1838: A.J. Ganesh, N.W. O'Connell, D.J. Wischik, Big Queues. XII, 254 p. 2004.
- Vol. 1839: R. Gohm, Noncommutative Stationary Processes. VIII, 170 p. 2004.
- Vol. 1840: B. Tsirelson, W. Werner, Lectures on Probability Theory and Statistics. Ecole d'Été de Probabilités de Saint-Flour XXXII-2002. Editor: J. Picard (2004)
- Vol. 1841: W. Reichel, Uniqueness Theorems for Variational Problems by the Method of Transformation Groups (2004)
- Vol. 1842: T. Johnsen, A. L. Knutsen, K_3 Projective Models in Scrolls (2004)
- Vol. 1843: B. Jefferies, Spectral Properties of Noncommuting Operators (2004)
- Vol. 1844: K.F. Siburg, The Principle of Least Action in Geometry and Dynamics (2004)
- Vol. 1845: Min Ho Lee, Mixed Automorphic Forms, Torus Bundles, and Jacobi Forms (2004)
- Vol. 1846: H. Ammari, H. Kang, Reconstruction of Small Inhomogeneities from Boundary Measurements (2004)
- Vol. 1847: T.R. Bielecki, T. Björk, M. Jeanblanc, M. Rutkowski, J.A. Scheinkman, W. Xiong, Paris-Princeton Lectures on Mathematical Finance 2003 (2004)
- Vol. 1848: M. Abate, J. E. Fornæss, X. Huang, J. P. Rosay, A. Tumanov, Real Methods in Complex and CR Geometry, Martina Franca, Italy 2002. Editors: D. Zaitsev, G. Zampieri (2004)
- Vol. 1849: Martin L. Brown, Heegner Modules and Elliptic Curves (2004)
- Vol. 1850: V. D. Milman, G. Schechtman (Eds.), Geometric Aspects of Functional Analysis. Israel Seminar 2002-2003 (2004)
- Vol. 1851: O. Catoni, Statistical Learning Theory and Stochastic Optimization (2004)
- Vol. 1852: A.S. Kechris, B.D. Miller, Topics in Orbit Equivalence (2004)
- Vol. 1853: Ch. Favre, M. Jonsson, The Valuation Tree (2004)
- Vol. 1854: O. Saeki, Topology of Singular Fibers of Differential Maps (2004)
- Vol. 1855: G. Da Prato, P.C. Kunstmann, I. Lasiecka, A. Lunardi, R. Schnaubelt, L. Weis, Functional Analytic Methods for Evolution Equations. Editors: M. Iannelli, R. Nagel, S. Piazzera (2004)
- Vol. 1856: K. Back, T.R. Bielecki, C. Hipp, S. Peng, W. Schachermayer, Stochastic Methods in Finance, Bressanone/Brixen, Italy, 2003. Editors: M. Frittelli, W. Runggaldier (2004)
- Vol. 1857: M. Émery, M. Ledoux, M. Yor (Eds.), Séminaire de Probabilités XXXVIII (2005)
- Vol. 1858: A.S. Cherny, H.-J. Engelbert, Singular Stochastic Differential Equations (2005)
- Vol. 1859: E. Letellier, Fourier Transforms of Invariant Functions on Finite Reductive Lie Algebras (2005)
- Vol. 1860: A. Borisyuk, G.B. Ermentrout, A. Friedman, D. Terman, Tutorials in Mathematical Biosciences I. Mathematical Neurosciences (2005)
- Vol. 1861: G. Benettin, J. Henrard, S. Kuksin, Hamiltonian Dynamics – Theory and Applications, Cetraro, Italy, 1999. Editor: A. Giorgilli (2005)
- Vol. 1862: B. Helffer, F. Nier, Hypocoelliptic Estimates and Spectral Theory for Fokker-Planck Operators and Witten Laplacians (2005)

- Vol. 1863: H. Führ, Abstract Harmonic Analysis of Continuous Wavelet Transforms (2005)
- Vol. 1864: K. Efsthathiou, Metamorphoses of Hamiltonian Systems with Symmetries (2005)
- Vol. 1865: D. Applebaum, B.V. R. Bhat, J. Kustermans, J. M. Lindsay, Quantum Independent Increment Processes I. From Classical Probability to Quantum Stochastic Calculus. Editors: M. Schürmann, U. Franz (2005)
- Vol. 1866: O.E. Barndorff-Nielsen, U. Franz, R. Gohm, B. Kümmerer, S. Thorbjørnsen, Quantum Independent Increment Processes II. Structure of Quantum Lévy Processes, Classical Probability, and Physics. Editors: M. Schürmann, U. Franz, (2005)
- Vol. 1867: J. Sneyd (Ed.), Tutorials in Mathematical Biosciences II. Mathematical Modeling of Calcium Dynamics and Signal Transduction. (2005)
- Vol. 1868: J. Jorgenson, S. Lang, $\text{Pos}_n(\mathbb{R})$ and Eisenstein Series. (2005)
- Vol. 1869: A. Dembo, T. Funaki, Lectures on Probability Theory and Statistics. Ecole d'Été de Probabilités de Saint-Flour XXXIII-2003. Editor: J. Picard (2005)
- Vol. 1870: V.I. Gurariy, W. Lusky, Geometry of Müntz Spaces and Related Questions. (2005)
- Vol. 1871: P. Constantin, G. Gallavotti, A.V. Kazhikhov, Y. Meyer, S. Ukai, Mathematical Foundation of Turbulent Viscous Flows, Martina Franca, Italy, 2003. Editors: M. Cannone, T. Miyakawa (2006)
- Vol. 1872: A. Friedman (Ed.), Tutorials in Mathematical Biosciences III. Cell Cycle, Proliferation, and Cancer (2006)
- Vol. 1873: R. Mansuy, M. Yor, Random Times and Enlargements of Filtrations in a Brownian Setting (2006)
- Vol. 1874: M. Yor, M. Émery (Eds.), In Memoriam Paul-André Meyer - Séminaire de probabilités XXXIX (2006)
- Vol. 1875: J. Pitman, Combinatorial Stochastic Processes. Ecole d'Été de Probabilités de Saint-Flour XXXII-2002. Editor: J. Picard (2006)
- Vol. 1876: H. Herrlich, Axiom of Choice (2006)
- Vol. 1877: J. Steuding, Value Distributions of L -Functions (2007)
- Vol. 1878: R. Cerf, The Wulff Crystal in Ising and Percolation Models, Ecole d'Été de Probabilités de Saint-Flour XXXIV-2004. Editor: Jean Picard (2006)
- Vol. 1879: G. Slade, The Lace Expansion and its Applications, Ecole d'Été de Probabilités de Saint-Flour XXXIV-2004. Editor: Jean Picard (2006)
- Vol. 1880: S. Attal, A. Joye, C.-A. Pillet, Open Quantum Systems I, The Hamiltonian Approach (2006)
- Vol. 1881: S. Attal, A. Joye, C.-A. Pillet, Open Quantum Systems II, The Markovian Approach (2006)
- Vol. 1882: S. Attal, A. Joye, C.-A. Pillet, Open Quantum Systems III, Recent Developments (2006)
- Vol. 1883: W. Van Assche, F. Marcellán (Eds.), Orthogonal Polynomials and Special Functions, Computation and Application (2006)
- Vol. 1884: N. Hayashi, E.I. Kaikina, P.I. Naumkin, I.A. Shishmarev, Asymptotics for Dissipative Nonlinear Equations (2006)
- Vol. 1885: A. Telcs, The Art of Random Walks (2006)
- Vol. 1886: S. Takamura, Splitting Deformations of Degenerations of Complex Curves (2006)
- Vol. 1887: K. Habermann, L. Habermann, Introduction to Symplectic Dirac Operators (2006)
- Vol. 1888: J. van der Hoeven, Transseries and Real Differential Algebra (2006)
- Vol. 1889: G. Osipenko, Dynamical Systems, Graphs, and Algorithms (2006)
- Vol. 1890: M. Bunge, J. Funk, Singular Coverings of Toposes (2006)
- Vol. 1891: J.B. Friedlander, D.R. Heath-Brown, H. Iwaniec, J. Kaczorowski, Analytic Number Theory, Cetraro, Italy, 2002. Editors: A. Perelli, C. Viola (2006)
- Vol. 1892: A. Baddeley, I. Bárány, R. Schneider, W. Weil, Stochastic Geometry, Martina Franca, Italy, 2004. Editor: W. Weil (2007)
- Vol. 1893: H. Hanßmann, Local and Semi-Local Bifurcations in Hamiltonian Dynamical Systems, Results and Examples (2007)
- Vol. 1894: C.W. Groetsch, Stable Approximate Evaluation of Unbounded Operators (2007)
- Vol. 1895: L. Molnár, Selected Preserver Problems on Algebraic Structures of Linear Operators and on Function Spaces (2007)
- Vol. 1896: P. Massart, Concentration Inequalities and Model Selection, Ecole d'Été de Probabilités de Saint-Flour XXXIII-2003. Editor: J. Picard (2007)
- Vol. 1897: R. Doney, Fluctuation Theory for Lévy Processes, Ecole d'Été de Probabilités de Saint-Flour-2005. Editor: J. Picard (2007)
- Vol. 1898: H.R. Beyer, Beyond Partial Differential Equations, On Linear and Quasi-Linear Abstract Hyperbolic Evolution Equations (2007)
- Vol. 1899: Séminaire de Probabilités XL. Editors: C. Donati-Martin, M. Émery, A. Rouault, C. Stricker (2007)
- Vol. 1900: E. Bolthausen, A. Bovier (Eds.), Spin Glasses (2007)
- Vol. 1901: O. Wittenberg, Intersections de deux quadriques et pinceaux de courbes de genre 1, Intersections of Two Quadrics and Pencils of Curves of Genus 1 (2007)
- Vol. 1902: A. Isaev, Lectures on the Automorphism Groups of Kobayashi-Hyperbolic Manifolds (2007)
- Vol. 1903: G. Kresin, V. Maz'ya, Sharp Real-Part Theorems (2007)

Recent Reprints and New Editions

- Vol. 1618: G. Pisier, Similarity Problems and Completely Bounded Maps. 1995 – 2nd exp. edition (2001)
- Vol. 1629: J.D. Moore, Lectures on Seiberg-Witten Invariants. 1997 – 2nd edition (2001)
- Vol. 1638: P. Vanhaecke, Integrable Systems in the realm of Algebraic Geometry. 1996 – 2nd edition (2001)
- Vol. 1702: J. Ma, J. Yong, Forward-Backward Stochastic Differential Equations and their Applications. 1999 – Corr. 3rd printing (2005)
- Vol. 830: J.A. Green, Polynomial Representations of GL_n , with an Appendix on Schensted Correspondence and Littelmann Paths by K. Erdmann, J.A. Green and M. Schocker 1980 – 2nd corr. and augmented edition (2007)