

Bibliography

- [ACC05] G. Arena, A. O. Caruso, and A. Causa. Taylor formula for Carnot groups and applications. *Matematiche (Catania)*, 60(2):375–383 (2006), 2005.
- [ADBR09] F. Astengo, B. Di Blasio, and F. Ricci. Gelfand pairs on the Heisenberg group and Schwartz functions. *J. Funct. Anal.*, 256(5):1565–1587, 2009.
- [ADBR13] F. Astengo, B. Di Blasio, and F. Ricci. Fourier transform of Schwartz functions on the Heisenberg group. *Studia Math.*, 214(3):201–222, 2013.
- [Ale94] G. Alexopoulos. Spectral multipliers on Lie groups of polynomial growth. *Proc. Amer. Math. Soc.*, 120(3):973–979, 1994.
- [AR15] R. Akylzhanov and M. Ruzhansky. Hausdorff-Young-Paley inequalities and L^p - L^q Fourier multipliers on locally compact groups. *arXiv:1510.06321*, 2015.
- [Arv76] W. Arveson. *An invitation to C^* -algebras*. Springer-Verlag, New York-Heidelberg, 1976. Graduate Texts in Mathematics, No. 39.
- [AtER94] P. Auscher, A. F. M. ter Elst, and D. W. Robinson. On positive Rockland operators. *Colloq. Math.*, 67(2):197–216, 1994.
- [Bea77a] R. Beals. Characterization of pseudodifferential operators and applications. *Duke Math. J.*, 44(1):45–57, 1977.
- [Bea77b] R. Beals. Opérateurs invariants hypoelliptiques sur un groupe de Lie nilpotent. In *Séminaire Goulaouic-Schwartz 1976/1977: Équations aux dérivées partielles et analyse fonctionnelle, Exp. No. 19*, page 8. Centre Math., École Polytech., Palaiseau, 1977.
- [BFKG12a] H. Bahouri, C. Fermanian-Kammerer, and I. Gallagher. Phase-space analysis and pseudodifferential calculus on the Heisenberg group. *Astérisque*, (342):vi+127, 2012.

- [BFKG12b] H. Bahouri, C. Fermanian-Kammerer, and I. Gallagher. Refined inequalities on graded Lie groups. *C. R. Math. Acad. Sci. Paris*, 350(7–8):393–397, 2012.
- [BG88] R. Beals and P. Greiner. *Calculus on Heisenberg manifolds*, volume 119 of *Annals of Mathematics Studies*. Princeton University Press, Princeton, NJ, 1988.
- [BGGV86] R. W. Beals, B. Gaveau, P. C. Greiner, and J. Vauthier. The Laguerre calculus on the Heisenberg group. II. *Bull. Sci. Math. (2)*, 110(3):225–288, 1986.
- [BGJR89] O. Bratteli, F. Goodman, P. Jorgensen, and D. W. Robinson. Unitary representations of Lie groups and Gårding’s inequality. *Proc. Amer. Math. Soc.*, 107(3):627–632, 1989.
- [BGX00] H. Bahouri, P. Gérard, and C.-J. Xu. Espaces de Besov et estimations de Strichartz généralisées sur le groupe de Heisenberg. *J. Anal. Math.*, 82:93–118, 2000.
- [BJR98] C. Benson, J. Jenkins, and G. Ratcliff. The spherical transform of a Schwartz function on the Heisenberg group. *J. Funct. Anal.*, 154(2):379–423, 1998.
- [BL76] J. Bergh and J. Löfström. *Interpolation spaces. An introduction*. Springer-Verlag, Berlin, 1976. Grundlehren der Mathematischen Wissenschaften, No. 223.
- [Bla06] B. Blackadar. *Operator algebras*, volume 122 of *Encyclopaedia of Mathematical Sciences*. Springer-Verlag, Berlin, 2006. Theory of C^* -algebras and von Neumann algebras, Operator Algebras and Non-commutative Geometry, III.
- [BLU07] A. Bonfiglioli, E. Lanconelli, and F. Uguzzoni. *Stratified Lie groups and potential theory for their sub-Laplacians*. Springer Monographs in Mathematics. Springer, Berlin, 2007.
- [BM95] D. R. Bell and S. E. A. Mohammed. An extension of Hörmander’s theorem for infinitely degenerate second-order operators. *Duke Math. J.*, 78(3):453–475, 1995.
- [Bon09] A. Bonfiglioli. Taylor formula for homogeneous groups and applications. *Math. Z.*, 262(2):255–279, 2009.
- [Bou98] N. Bourbaki. *Lie groups and Lie algebras. Chapters 1–3*. Elements of Mathematics (Berlin). Springer-Verlag, Berlin, 1998. Translated from the French, Reprint of the 1989 English translation.
- [BP08] E. Binz and S. Pods. *The geometry of Heisenberg groups*, volume 151 of *Mathematical Surveys and Monographs*. American Mathematical

- Society, Providence, RI, 2008. With applications in signal theory, optics, quantization, and field quantization, With an appendix by Serge Preston.
- [Bru68] F. Bruhat. *Lectures on Lie groups and representations of locally compact groups*. Tata Institute of Fundamental Research, Bombay, 1968. Notes by S. Ramanan, Tata Institute of Fundamental Research Lectures on Mathematics, No. 14.
 - [BV08] I. Birindelli and E. Valdinoci. The Ginzburg-Landau equation in the Heisenberg group. *Commun. Contemp. Math.*, 10(5):671–719, 2008.
 - [Cap99] L. Capogna. Regularity for quasilinear equations and 1-quasiconformal maps in Carnot groups. *Math. Ann.*, 313(2):263–295, 1999.
 - [CCG07] O. Calin, D.-C. Chang, and P. Greiner. *Geometric analysis on the Heisenberg group and its generalizations*, volume 40 of *AMS/IP Studies in Advanced Mathematics*. American Mathematical Society, Providence, RI, 2007.
 - [CdG71] R. R. Coifman and M. de Guzmán. Singular integrals and multipliers on homogeneous spaces. *Rev. Un. Mat. Argentina*, 25:137–143, 1970/71. Collection of articles dedicated to Alberto González Domínguez on his sixty-fifth birthday.
 - [CDPT07] L. Capogna, D. Danielli, S. D. Pauls, and J. T. Tyson. *An introduction to the Heisenberg group and the sub-Riemannian isoperimetric problem*, volume 259 of *Progress in Mathematics*. Birkhäuser Verlag, Basel, 2007.
 - [CG84] M. Christ and D. Geller. Singular integral characterizations of Hardy spaces on homogeneous groups. *Duke Math. J.*, 51(3):547–598, 1984.
 - [CG90] L. J. Corwin and F. P. Greenleaf. *Representations of nilpotent Lie groups and their applications. Part I*, volume 18 of *Cambridge Studies in Advanced Mathematics*. Cambridge University Press, Cambridge, 1990. Basic theory and examples.
 - [CGGP92] M. Christ, D. Geller, P. Głowacki, and L. Polin. Pseudodifferential operators on groups with dilations. *Duke Math. J.*, 68(1):31–65, 1992.
 - [Che99] C. Chevalley. *Theory of Lie groups. I*, volume 8 of *Princeton Mathematical Series*. Princeton University Press, Princeton, NJ, 1999. Fifteenth printing, Princeton Landmarks in Mathematics.
 - [Chr84] M. Christ. Characterization of H^1 by singular integrals: necessary conditions. *Duke Math. J.*, 51(3):599–609, 1984.
 - [Cow83] M. G. Cowling. Harmonic analysis on semigroups. *Ann. of Math. (2)*, 117(2):267–283, 1983.

- [CR81] L. Corwin and L. P. Rothschild. Necessary conditions for local solvability of homogeneous left invariant differential operators on nilpotent Lie groups. *Acta Math.*, 147(3-4):265–288, 1981.
- [CS01] M. Cowling and A. Sikora. A spectral multiplier theorem for a sublaplacian on $SU(2)$. *Math. Z.*, 238(1):1–36, 2001.
- [CW71a] R. R. Coifman and G. Weiss. *Analyse harmonique non-commutative sur certains espaces homogènes*. Lecture Notes in Mathematics, Vol. 242. Springer-Verlag, Berlin, 1971. Étude de certaines intégrales singulières.
- [CW71b] R. R. Coifman and G. Weiss. Multiplier transformations of functions on $SU(2)$ and \sum_2 . *Rev. Un. Mat. Argentina*, 25:145–166, 1971. Collection of articles dedicated to Alberto González Domínguez on his sixty-fifth birthday.
- [CW74] R. R. Coifman and G. Weiss. Central multiplier theorems for compact Lie groups. *Bull. Amer. Math. Soc.*, 80:124–126, 1974.
- [Cyg81] J. Cygan. Subadditivity of homogeneous norms on certain nilpotent Lie groups. *Proc. Amer. Math. Soc.*, 83(1):69–70, 1981.
- [Dav80] E. B. Davies. *One-parameter semigroups*, volume 15 of *London Mathematical Society Monographs*. Academic Press Inc. [Harcourt Brace Jovanovich Publishers], London, 1980.
- [DHZ94] J. Dziubański, W. Hebisch, and J. Zienkiewicz. Note on semigroups generated by positive Rockland operators on graded homogeneous groups. *Studia Math.*, 110(2):115–126, 1994.
- [DiB02] E. DiBenedetto. *Real analysis*. Birkhäuser Advanced Texts: Basler Lehrbücher. [Birkhäuser Advanced Texts: Basel Textbooks]. Birkhäuser Boston, Inc., Boston, MA, 2002.
- [Dix53] J. Dixmier. Formes linéaires sur un anneau d’opérateurs. *Bull. Soc. Math. France*, 81:9–39, 1953.
- [Dix77] J. Dixmier. *C^* -algebras*. North-Holland Publishing Co., Amsterdam, 1977. Translated from the French by Francis Jellett, North-Holland Mathematical Library, Vol. 15.
- [Dix81] J. Dixmier. *von Neumann algebras*, volume 27 of *North-Holland Mathematical Library*. North-Holland Publishing Co., Amsterdam, 1981. With a preface by E. C. Lance, Translated from the second French edition by F. Jellett.
- [Dix96] J. Dixmier. *Les algèbres d’opérateurs dans l’espace hilbertien (algèbres de von Neumann)*. Les Grands Classiques Gauthier-Villars. [Gauthier-Villars Great Classics]. Éditions Jacques Gabay, Paris, 1996. Reprint of the second (1969) edition.

- [DM78] J. Dixmier and P. Malliavin. Factorisations de fonctions et de vecteurs indéfiniment différentiables. *Bull. Sci. Math. (2)*, 102(4):307–330, 1978.
- [DR14a] A. Dasgupta and M. Ruzhansky. Gevrey functions and ultradistributions on compact Lie groups and homogeneous spaces. *Bull. Sci. Math.*, 138(6):756–782, 2014.
- [DR14b] J. Delgado and M. Ruzhansky. L^p -nuclearity, traces, and Grothendieck-Lidskii formula on compact Lie groups. *J. Math. Pures Appl. (9)*, 102(1):153–172, 2014.
- [DR16] A. Dasgupta and M. Ruzhansky. Eigenfunction expansions of ultra-differentiable functions and ultradistributions. *arXiv:1410.2637. To appear in Trans. Amer. Math. Soc.*, 2016.
- [DtER03] N. Dungey, A. F. M. ter Elst, and D. W. Robinson. *Analysis on Lie groups with polynomial growth*, volume 214 of *Progress in Mathematics*. Birkhäuser Boston Inc., Boston, MA, 2003.
- [Dye70] J. L. Dyer. A nilpotent Lie algebra with nilpotent automorphism group. *Bull. Amer. Math. Soc.*, 76:52–56, 1970.
- [Dyn76] A. S. Dynin. An algebra of pseudodifferential operators on the Heisenberg groups. Symbolic calculus. *Dokl. Akad. Nauk SSSR*, 227(4):792–795, 1976.
- [Dyn78] A. Dynin. Pseudodifferential operators on Heisenberg groups. In *Pseudodifferential operator with applications (Bressanone, 1977)*, pages 5–18. Liguori, Naples, 1978.
- [Dzi93] J. Dziubański. On semigroups generated by subelliptic operators on homogeneous groups. *Colloq. Math.*, 64(2):215–231, 1993.
- [Edw72] R. E. Edwards. *Integration and harmonic analysis on compact groups*. Cambridge Univ. Press, London, 1972. London Mathematical Society Lecture Note Series, No. 8.
- [Eym72] P. Eymard. *Moyennes invariantes et représentations unitaires*. Lecture Notes in Mathematics, Vol. 300. Springer-Verlag, Berlin-New York, 1972.
- [Feg91] H. D. Fegan. *Introduction to compact Lie groups*, volume 13 of *Series in Pure Mathematics*. World Scientific Publishing Co. Inc., River Edge, NJ, 1991.
- [Fis15] V. Fischer. Intrinsic pseudo-differential calculi on any compact Lie group. *J. Funct. Anal.*, 268(11):3404–3477, 2015.
- [FMV07] G. Furioli, C. Melzi, and A. Veneruso. Strichartz inequalities for the wave equation with the full Laplacian on the Heisenberg group. *Canad. J. Math.*, 59(6):1301–1322, 2007.

- [Fol75] G. B. Folland. Subelliptic estimates and function spaces on nilpotent Lie groups. *Ark. Mat.*, 13(2):161–207, 1975.
- [Fol77a] G. B. Folland. Applications of analysis on nilpotent groups to partial differential equations. *Bull. Amer. Math. Soc.*, 83(5):912–930, 1977.
- [Fol77b] G. B. Folland. On the Rothschild-Stein lifting theorem. *Comm. Partial Differential Equations*, 2(2):165–191, 1977.
- [Fol89] G. B. Folland. *Harmonic analysis in phase space*, volume 122 of *Annals of Mathematics Studies*. Princeton University Press, Princeton, NJ, 1989.
- [Fol94] G. B. Folland. Meta-heisenberg groups. In *Fourier analysis (Orono, ME, 1992)*, volume 157 of *Lecture Notes in Pure and Appl. Math.*, pages 121–147. Dekker, New York, 1994.
- [Fol95] G. B. Folland. *A course in abstract harmonic analysis*. Studies in Advanced Mathematics. CRC Press, Boca Raton, FL, 1995.
- [Fol99] G. B. Folland. *Real analysis*. Pure and Applied Mathematics (New York). John Wiley & Sons Inc., New York, second edition, 1999. Modern techniques and their applications, A Wiley-Interscience Publication.
- [FP78] C. Fefferman and D. H. Phong. On positivity of pseudo-differential operators. *Proc. Nat. Acad. Sci. U.S.A.*, 75(10):4673–4674, 1978.
- [FR66] E. B. Fabes and N. M. Rivière. Singular integrals with mixed homogeneity. *Studia Math.*, 27:19–38, 1966.
- [FR13] V. Fischer and M. Ruzhansky. Lower bounds for operators on graded Lie groups. *C. R. Math. Acad. Sci. Paris*, 351(1-2):13–18, 2013.
- [FR14a] V. Fischer and M. Ruzhansky. A pseudo-differential calculus on graded nilpotent Lie groups. In *Fourier analysis*, Trends Math., pages 107–132. Birkhäuser/Springer, Cham, 2014.
- [FR14b] V. Fischer and M. Ruzhansky. A pseudo-differential calculus on the Heisenberg group. *C. R. Math. Acad. Sci. Paris*, 352(3):197–204, 2014.
- [Fri70] K. O. Friedrichs. *Pseudo-differential operators. An introduction*. Notes prepared with the assistance of R. Vaillancourt. Revised edition. Courant Institute of Mathematical Sciences New York University, New York, 1970.
- [FS74] G. B. Folland and E. M. Stein. Estimates for the $\bar{\partial}_b$ complex and analysis on the Heisenberg group. *Comm. Pure Appl. Math.*, 27:429–522, 1974.

- [FS82] G. B. Folland and E. M. Stein. *Hardy spaces on homogeneous groups*, volume 28 of *Mathematical Notes*. Princeton University Press, Princeton, N.J., 1982.
- [Går53] L. Gårding. Dirichlet's problem for linear elliptic partial differential equations. *Math. Scand.*, 1:55–72, 1953.
- [Gel80] D. Geller. Fourier analysis on the Heisenberg group. I. Schwartz space. *J. Funct. Anal.*, 36(2):205–254, 1980.
- [Gel83] D. Geller. Liouville's theorem for homogeneous groups. *Comm. Partial Differential Equations*, 8(15):1665–1677, 1983.
- [Gel90] D. Geller. *Analytic pseudodifferential operators for the Heisenberg group and local solvability*, volume 37 of *Mathematical Notes*. Princeton University Press, Princeton, NJ, 1990.
- [GGV86] B. Gaveau, P. Greiner, and J. Vauthier. Intégrales de Fourier quadratiques et calcul symbolique exact sur le groupe d'Heisenberg. *J. Funct. Anal.*, 68(2):248–272, 1986.
- [GKS75] P. C. Greiner, J. J. Kohn, and E. M. Stein. Necessary and sufficient conditions for solvability of the Lewy equation. *Proc. Nat. Acad. Sci. U.S.A.*, 72(9):3287–3289, 1975.
- [Gło89] P. Głowacki. The Rockland condition for nondifferential convolution operators. *Duke Math. J.*, 58(2):371–395, 1989.
- [Gło91] P. Głowacki. The Rockland condition for nondifferential convolution operators. II. *Studia Math.*, 98(2):99–114, 1991.
- [Gło04] P. Głowacki. A symbolic calculus and L^2 -boundedness on nilpotent Lie groups. *J. Funct. Anal.*, 206(1):233–251, 2004.
- [Gło07] P. Głowacki. The Melin calculus for general homogeneous groups. *Ark. Mat.*, 45(1):31–48, 2007.
- [Gło12] P. Głowacki. Invertibility of convolution operators on homogeneous groups. *Rev. Mat. Iberoam.*, 28(1):141–156, 2012.
- [Goo76] R. W. Goodman. *Nilpotent Lie groups: structure and applications to analysis*. Lecture Notes in Mathematics, Vol. 562. Springer-Verlag, Berlin, 1976.
- [Goo80] R. Goodman. Singular integral operators on nilpotent Lie groups. *Ark. Mat.*, 18(1):1–11, 1980.
- [Gro96] M. Gromov. Carnot-Carathéodory spaces seen from within. In *Sub-Riemannian geometry*, volume 144 of *Progr. Math.*, pages 79–323. Birkhäuser, Basel, 1996.

- [GS85] A. Grigis and J. Sjöstrand. Front d'onde analytique et sommes de carrés de champs de vecteurs. *Duke Math. J.*, 52(1):35–51, 1985.
- [Hel82] B. Helffer. Conditions nécessaires d'hypoanalyticité pour des opérateurs invariants à gauche homogènes sur un groupe nilpotent gradué. *J. Differential Equations*, 44(3):460–481, 1982.
- [Hel84a] B. Helffer. *Théorie spectrale pour des opérateurs globalement elliptiques*, volume 112 of *Astérisque*. Société Mathématique de France, Paris, 1984. With an English summary.
- [Hel84b] S. Helgason. *Groups and geometric analysis*, volume 113 of *Pure and Applied Mathematics*. Academic Press Inc., Orlando, FL, 1984. Integral geometry, invariant differential operators, and spherical functions.
- [Hel01] S. Helgason. *Differential geometry, Lie groups, and symmetric spaces*, volume 34 of *Graduate Studies in Mathematics*. American Mathematical Society, Providence, RI, 2001. Corrected reprint of the 1978 original.
- [HJL85] A. Hulanicki, J. W. Jenkins, and J. Ludwig. Minimum eigenvalues for positive, Rockland operators. *Proc. Amer. Math. Soc.*, 94(4):718–720, 1985.
- [HN79] B. Helffer and J. Nourrigat. Caractérisation des opérateurs hypoelliptiques homogènes invariants à gauche sur un groupe de Lie nilpotent gradué. *Comm. Partial Differential Equations*, 4(8):899–958, 1979.
- [HN05] B. Helffer and F. Nier. *Hypoelliptic estimates and spectral theory for Fokker-Planck operators and Witten Laplacians*, volume 1862 of *Lecture Notes in Mathematics*. Springer-Verlag, Berlin, 2005.
- [Hör60] L. Hörmander. Estimates for translation invariant operators in L^p spaces. *Acta Math.*, 104:93–140, 1960.
- [Hör66] L. Hörmander. Pseudo-differential operators and non-elliptic boundary problems. *Ann. of Math. (2)*, 83:129–209, 1966.
- [Hör67a] L. Hörmander. Hypoelliptic second order differential equations. *Acta Math.*, 119:147–171, 1967.
- [Hör67b] L. Hörmander. Pseudo-differential operators and hypoelliptic equations. In *Singular integrals (Proc. Sympos. Pure Math., Vol. X, Chicago, Ill., 1966)*, pages 138–183. Amer. Math. Soc., Providence, R.I., 1967.
- [Hör77] L. Hörmander. The Cauchy problem for differential equations with double characteristics. *J. Analyse Math.*, 32:118–196, 1977.

- [Hör03] L. Hörmander. *The analysis of linear partial differential operators. I.* Classics in Mathematics. Springer-Verlag, Berlin, 2003. Distribution theory and Fourier analysis, Reprint of the second (1990) edition [Springer, Berlin; MR1065993 (91m:35001a)].
- [How80] R. Howe. On the role of the Heisenberg group in harmonic analysis. *Bull. Amer. Math. Soc. (N.S.)*, 3(2):821–843, 1980.
- [How84] R. Howe. A symbolic calculus for nilpotent groups. In *Operator algebras and group representations, Vol. I (Neptun, 1980)*, volume 17 of *Monogr. Stud. Math.*, pages 254–277. Pitman, Boston, MA, 1984.
- [HP57] E. Hille and R. S. Phillips. *Functional analysis and semi-groups*. American Mathematical Society Colloquium Publications, vol. 31. American Mathematical Society, Providence, R. I., 1957. rev. ed.
- [HR70] E. Hewitt and K. A. Ross. *Abstract harmonic analysis. Vol. II: Structure and analysis for compact groups. Analysis on locally compact Abelian groups*. Die Grundlehren der mathematischen Wissenschaften, Band 152. Springer-Verlag, New York, 1970.
- [HS90] W. Hebisch and A. Sikora. A smooth subadditive homogeneous norm on a homogeneous group. *Studia Math.*, 96(3):231–236, 1990.
- [Hul84] A. Hulanicki. A functional calculus for Rockland operators on nilpotent Lie groups. *Studia Math.*, 78(3):253–266, 1984.
- [Hun56] G. A. Hunt. Semi-groups of measures on Lie groups. *Trans. Amer. Math. Soc.*, 81:264–293, 1956.
- [Kec95] A. S. Kechris. *Classical descriptive set theory*, volume 156 of *Graduate Texts in Mathematics*. Springer-Verlag, New York, 1995.
- [Kg81] H. Kumano-go. *Pseudodifferential operators*. MIT Press, Cambridge, Mass., 1981. Translated from the Japanese by the author, Rémi Vailancourt and Michihiro Nagase.
- [Kir04] A. A. Kirillov. *Lectures on the orbit method*, volume 64 of *Graduate Studies in Mathematics*. American Mathematical Society, Providence, RI, 2004.
- [Kna01] A. W. Knapp. *Representation theory of semisimple groups*. Princeton Landmarks in Mathematics. Princeton University Press, Princeton, NJ, 2001. An overview based on examples, Reprint of the 1986 original.
- [Koh73] J. J. Kohn. Pseudo-differential operators and hypoellipticity. In *Partial differential equations (Proc. Sympos. Pure Math., Vol. XXIII, Univ. California, Berkeley, Calif., 1971)*, pages 61–69. Amer. Math. Soc., Providence, R.I., 1973.

- [Kol34] A. Kolmogoroff. Zufällige Bewegungen (zur Theorie der Brownschen Bewegung). *Ann. of Math. (2)*, 35(1):116–117, 1934.
- [Kor72] A. Koranyi. Harmonic functions on symmetric spaces. In *Symmetric spaces (Short Courses, Washington Univ., St. Louis, Mo., 1969–1970)*, pages 379–412. Pure and Appl. Math., Vol. 8. Dekker, New York, 1972.
- [Kra09] S. G. Krantz. *Explorations in harmonic analysis*. Applied and Numerical Harmonic Analysis. Birkhäuser Boston Inc., Boston, MA, 2009. With applications to complex function theory and the Heisenberg group, With the assistance of Lina Lee.
- [KS69] A. W. Knapp and E. M. Stein. Singular integrals and the principal series. I, II. *Proc. Nat. Acad. Sci. U.S.A.* 63 (1969), 281–284; *ibid.*, 66:13–17, 1969.
- [Kun58] R. A. Kunze. L_p Fourier transforms on locally compact unimodular groups. *Trans. Amer. Math. Soc.*, 89:519–540, 1958.
- [KV71] A. Korányi and S. Vági. Singular integrals on homogeneous spaces and some problems of classical analysis. *Ann. Scuola Norm. Sup. Pisa (3)*, 25:575–648 (1972), 1971.
- [Lan60] R. P. Langlands. Some holomorphic semi-groups. *Proc. Nat. Acad. Sci. U.S.A.*, 46:361–363, 1960.
- [Ler10] N. Lerner. *Metrics on the phase space and non-selfadjoint pseudo-differential operators*, volume 3 of *Pseudo-Differential Operators. Theory and Applications*. Birkhäuser Verlag, Basel, 2010.
- [Liz75] P. I. Lizorkin. Interpolation of weighted L_p spaces. *Dokl. Akad. Nauk SSSR*, 222(1):32–35, 1975.
- [LN66] P. D. Lax and L. Nirenberg. On stability for difference schemes: A sharp form of Gårding’s inequality. *Comm. Pure Appl. Math.*, 19:473–492, 1966.
- [LP61] G. Lumer and R. S. Phillips. Dissipative operators in a Banach space. *Pacific J. Math.*, 11:679–698, 1961.
- [LP94] E. Lanconelli and S. Polidoro. On a class of hypoelliptic evolution operators. *Rend. Sem. Mat. Univ. Politec. Torino*, 52(1):29–63, 1994. Partial differential equations, II (Turin, 1993).
- [Man91] D. Manchon. Formule de Weyl pour les groupes de Lie nilpotents. *J. Reine Angew. Math.*, 418:77–129, 1991.
- [MCSA01] C. Martínez Carracedo and M. Sanz Alix. *The theory of fractional powers of operators*, volume 187 of *North-Holland Mathematics Studies*. North-Holland Publishing Co., Amsterdam, 2001.

- [Mel71] A. Melin. Lower bounds for pseudo-differential operators. *Ark. Mat.*, 9:117–140, 1971.
- [Mel81] A. Melin. Parametrix constructions for some classes of right-invariant differential operators on the Heisenberg group. *Comm. Partial Differential Equations*, 6(12):1363–1405, 1981.
- [Mel83] A. Melin. Parametrix constructions for right invariant differential operators on nilpotent groups. *Ann. Global Anal. Geom.*, 1(1):79–130, 1983.
- [Mét80] G. Métivier. Hypoellipticité analytique sur des groupes nilpotents de rang 2. *Duke Math. J.*, 47(1):195–221, 1980.
- [Mih56] S. G. Mihlin. On the theory of multidimensional singular integral equations. *Vestnik Leningrad. Univ.*, 11(1):3–24, 1956.
- [Mih57] S. G. Mihlin. Singular integrals in L_p spaces. *Dokl. Akad. Nauk SSSR (N.S.)*, 117:28–31, 1957.
- [Mil80] K. G. Miller. Parametrices for hypoelliptic operators on step two nilpotent Lie groups. *Comm. Partial Differential Equations*, 5(11):1153–1184, 1980.
- [MPP07] M. Mughetti, C. Parenti, and A. Parmeggiani. Lower bound estimates without transversal ellipticity. *Comm. Partial Differential Equations*, 32(7-9):1399–1438, 2007.
- [MPR99] D. Müller, M. M. Peloso, and F. Ricci. On local solvability for complex coefficient differential operators on the Heisenberg group. *J. Reine Angew. Math.*, 513:181–234, 1999.
- [MR15] M. Măntoiu and M. Ruzhansky. Pseudo-differential operators, Wigner transform and Weyl systems on type I locally compact groups. *arXiv:1506.05854*, 2015.
- [MS87] G. A. Meladze and M. A. Shubin. A functional calculus of pseudodifferential operators on unimodular Lie groups. *Trudy Sem. Petrovsk.*, (12):164–200, 245, 1987.
- [MS99] D. Müller and E. M. Stein. L^p -estimates for the wave equation on the Heisenberg group. *Rev. Mat. Iberoamericana*, 15(2):297–334, 1999.
- [MS11] P. McKeag and Y. Safarov. Pseudodifferential operators on manifolds: a coordinate-free approach. In *Partial differential equations and spectral theory*, volume 211 of *Oper. Theory Adv. Appl.*, pages 321–341. Birkhäuser Basel AG, Basel, 2011.
- [Nac82] A. I. Nachman. The wave equation on the Heisenberg group. *Comm. Partial Differential Equations*, 7(6):675–714, 1982.

- [Nag77] M. Nagase. A new proof of sharp Gårding inequality. *Funkcial. Ekvac.*, 20(3):259–271, 1977.
- [Nik77] S. M. Nikolskii. *Priblizhenie funktsii mnogikh peremennykh i teoremy vložheniya (Russian) [Approximation of functions of several variables and imbedding theorems]*. “Nauka”, Moscow, 1977. Second edition, revised and supplemented.
- [Nom56] K. Nomizu. *Lie groups and differential geometry*. The Mathematical Society of Japan, 1956.
- [NS59] E. Nelson and W. F. Stinespring. Representation of elliptic operators in an enveloping algebra. *Amer. J. Math.*, 81:547–560, 1959.
- [NSW85] A. Nagel, E. M. Stein, and S. Wainger. Balls and metrics defined by vector fields. I. Basic properties. *Acta Math.*, 155(1-2):103–147, 1985.
- [OR73] O. A. Olešnik and E. V. Radkevič. *Second order equations with non-negative characteristic form*. Plenum Press, New York, 1973. Translated from the Russian by Paul C. Fife.
- [Pan89] P. Pansu. Métriques de Carnot-Carathéodory et quasiisométries des espaces symétriques de rang un. *Ann. of Math. (2)*, 129(1):1–60, 1989.
- [Paz83] A. Pazy. *Semigroups of linear operators and applications to partial differential equations*, volume 44 of *Applied Mathematical Sciences*. Springer-Verlag, New York, 1983.
- [Pon66] L. S. Pontryagin. *Topological groups*. Translated from the second Russian edition by Arlen Brown. Gordon and Breach Science Publishers, Inc., New York, 1966.
- [Pon08] R. S. Ponge. Heisenberg calculus and spectral theory of hypoelliptic operators on Heisenberg manifolds. *Mem. Amer. Math. Soc.*, 194(906):viii+ 134, 2008.
- [Puk67] L. Pukánszky. *Leçons sur les représentations des groupes*. Monographies de la Société Mathématique de France, No. 2. Dunod, Paris, 1967.
- [PW27] F. Peter and H. Weyl. Die Vollständigkeit der primitiven Darstellungen einer geschlossenen kontinuierlichen Gruppe. *Math. Ann.*, 97(1):737–755, 1927.
- [Ric] F. Ricci. Sub-Laplacians on nilpotent Lie groups. Unpublished lecture notes accessible on webpage <http://homepage.sns.it/fricci/corsi.html>.
- [Roc78] C. Rockland. Hypoellipticity on the Heisenberg group-representation-theoretic criteria. *Trans. Amer. Math. Soc.*, 240:1–52, 1978.

- [Rot83] L. P. Rothschild. A remark on hypoellipticity of homogeneous invariant differential operators on nilpotent Lie groups. *Comm. Partial Differential Equations*, 8(15):1679–1682, 1983.
- [RS75] M. Reed and B. Simon. *Methods of modern mathematical physics. II. Fourier analysis, self-adjointness*. Academic Press [Harcourt Brace Jovanovich Publishers], New York, 1975.
- [RS76] L. P. Rothschild and E. M. Stein. Hypoelliptic differential operators and nilpotent groups. *Acta Math.*, 137(3-4):247–320, 1976.
- [RS80] M. Reed and B. Simon. *Methods of modern mathematical physics. I.* Academic Press Inc. [Harcourt Brace Jovanovich Publishers], New York, second edition, 1980. Functional analysis.
- [RT10a] M. Ruzhansky and V. Turunen. *Pseudo-differential operators and symmetries. Background analysis and advanced topics*, volume 2 of *Pseudo-Differential Operators. Theory and Applications*. Birkhäuser Verlag, Basel, 2010.
- [RT10b] M. Ruzhansky and V. Turunen. Quantization of pseudo-differential operators on the torus. *J. Fourier Anal. Appl.*, 16(6):943–982, 2010.
- [RT11] M. Ruzhansky and V. Turunen. Sharp Gårding inequality on compact Lie groups. *J. Funct. Anal.*, 260(10):2881–2901, 2011.
- [RT13] M. Ruzhansky and V. Turunen. Global quantization of pseudo-differential operators on compact Lie groups, $SU(2)$, 3-sphere, and homogeneous spaces. *Int. Math. Res. Not. IMRN*, (11):2439–2496, 2013.
- [RTW14] M. Ruzhansky, V. Turunen, and J. Wirth. Hörmander class of pseudo-differential operators on compact Lie groups and global hypoellipticity. *J. Fourier Anal. Appl.*, 20(3):476–499, 2014.
- [Rud87] W. Rudin. *Real and complex analysis*. McGraw-Hill Book Co., New York, third edition, 1987.
- [Rud91] W. Rudin. *Functional analysis*. International Series in Pure and Applied Mathematics. McGraw-Hill Inc., New York, second edition, 1991.
- [RW13] M. Ruzhansky and J. Wirth. On multipliers on compact Lie groups. *Funct. Anal. Appl.*, 47(1):87–91, 2013.
- [RW14] M. Ruzhansky and J. Wirth. Global functional calculus for operators on compact Lie groups. *J. Funct. Anal.*, 267(1):144–172, 2014.
- [RW15] M. Ruzhansky and J. Wirth. L^p Fourier multipliers on compact Lie groups. *Math. Z.*, 280(3-4):621–642, 2015.

- [Saf97] Y. Safarov. Pseudodifferential operators and linear connections. *Proc. London Math. Soc. (3)*, 74(2):379–416, 1997.
- [Sak79] K. Saka. Besov spaces and Sobolev spaces on a nilpotent Lie group. *Tôhoku Math. J. (2)*, 31(4):383–437, 1979.
- [Sak98] S. Sakai. *C^* -algebras and W^* -algebras*. Classics in Mathematics. Springer-Verlag, Berlin, 1998. Reprint of the 1971 edition.
- [See69] R. T. Seeley. Eigenfunction expansions of analytic functions. *Proc. Amer. Math. Soc.*, 21:734–738, 1969.
- [Seg50] I. E. Segal. An extension of Plancherel’s formula to separable unimodular groups. *Ann. of Math. (2)*, 52:272–292, 1950.
- [Seg53] I. E. Segal. A non-commutative extension of abstract integration. *Ann. of Math. (2)*, 57:401–457, 1953.
- [Sem03] S. Semmes. An introduction to Heisenberg groups in analysis and geometry. *Notices Amer. Math. Soc.*, 50(6):640–646, 2003.
- [Sha05] V. A. Sharafutdinov. Geometric symbol calculus for pseudodifferential operators. I [Translation of Mat. Tr. 7 (2004), no. 2, 159–206]. *Siberian Adv. Math.*, 15(3):81–125, 2005.
- [Shu87] M. A. Shubin. *Pseudodifferential operators and spectral theory*. Springer Series in Soviet Mathematics. Springer-Verlag, Berlin, 1987. Translated from the Russian by Stig I. Andersson.
- [Sjö82] J. Sjöstrand. Singularités analytiques microlocales. In *Astérisque*, 95, volume 95 of *Astérisque*, pages 1–166. Soc. Math. France, Paris, 1982.
- [Ste70a] E. M. Stein. *Singular integrals and differentiability properties of functions*. Princeton Mathematical Series, No. 30. Princeton University Press, Princeton, N.J., 1970.
- [Ste70b] E. M. Stein. *Topics in harmonic analysis related to the Littlewood-Paley theory*. Annals of Mathematics Studies, No. 63. Princeton University Press, Princeton, N.J., 1970.
- [Ste93] E. M. Stein. *Harmonic analysis: real-variable methods, orthogonality, and oscillatory integrals*, volume 43 of *Princeton Mathematical Series*. Princeton University Press, Princeton, NJ, 1993. With the assistance of Timothy S. Murphy, Monographs in Harmonic Analysis, III.
- [Str72] R. S. Strichartz. Invariant pseudo-differential operators on a Lie group. *Ann. Scuola Norm. Sup. Pisa (3)*, 26:587–611, 1972.
- [SW71] E. M. Stein and G. Weiss. *Introduction to Fourier analysis on Euclidean spaces*. Princeton University Press, Princeton, N.J., 1971. Princeton Mathematical Series, No. 32.

- [SZ02] A. Sikora and J. Zienkiewicz. A note on the heat kernel on the Heisenberg group. *Bull. Austral. Math. Soc.*, 65(1):115–120, 2002.
- [Tar78] D. S. Tartakoff. Local analytic hypoellipticity for \square_b on nondegenerate Cauchy-Riemann manifolds. *Proc. Nat. Acad. Sci. U.S.A.*, 75(7):3027–3028, 1978.
- [Tar80] D. S. Tartakoff. The local real analyticity of solutions to \square_b and the $\bar{\partial}$ -Neumann problem. *Acta Math.*, 145(3-4):177–204, 1980.
- [Tay81] M. E. Taylor. *Pseudodifferential operators*, volume 34 of *Princeton Mathematical Series*. Princeton University Press, Princeton, N.J., 1981.
- [Tay84] M. E. Taylor. Noncommutative microlocal analysis. I. *Mem. Amer. Math. Soc.*, 52(313):iv+182, (Revised version accessible at <http://math.unc.edu/Faculty/met/ncmlms.pdf>) 1984.
- [Tay86] M. E. Taylor. *Noncommutative harmonic analysis*, volume 22 of *Mathematical Surveys and Monographs*. American Mathematical Society, Providence, RI, 1986.
- [tER97] A. F. M. ter Elst and D. W. Robinson. Spectral estimates for positive Rockland operators. In *Algebraic groups and Lie groups*, volume 9 of *Austral. Math. Soc. Lect. Ser.*, pages 195–213. Cambridge Univ. Press, Cambridge, 1997.
- [Tha98] S. Thangavelu. *Harmonic analysis on the Heisenberg group*, volume 159 of *Progress in Mathematics*. Birkhäuser Boston Inc., Boston, MA, 1998.
- [Tre67] F. Treves. *Topological vector spaces, distributions and kernels*. Academic Press, New York, 1967.
- [Trè78] F. Trèves. Analytic hypo-ellipticity of a class of pseudodifferential operators with double characteristics and applications to the $\bar{\partial}$ -Neumann problem. *Comm. Partial Differential Equations*, 3(6-7):475–642, 1978.
- [Vai70] R. Vaillancourt. A simple proof of Lax-Nirenberg theorems. *Comm. Pure Appl. Math.*, 23:151–163, 1970.
- [vE10a] E. van Erp. The Atiyah-Singer index formula for subelliptic operators on contact manifolds. Part I. *Ann. of Math. (2)*, 171(3):1647–1681, 2010.
- [vE10b] E. van Erp. The Atiyah-Singer index formula for subelliptic operators on contact manifolds. Part II. *Ann. of Math. (2)*, 171(3):1683–1706, 2010.

- [Vil68] N. J. Vilenkin. *Special functions and the theory of group representations*. Translated from the Russian by V. N. Singh. Translations of Mathematical Monographs, Vol. 22. American Mathematical Society, Providence, R. I., 1968.
- [VK91] N. J. Vilenkin and A. U. Klimyk. *Representation of Lie groups and special functions. Vol. 1*, volume 72 of *Mathematics and its Applications (Soviet Series)*. Kluwer Academic Publishers Group, Dordrecht, 1991. Simplest Lie groups, special functions and integral transforms, Translated from the Russian by V. A. Groza and A. A. Groza.
- [VK93] N. J. Vilenkin and A. U. Klimyk. *Representation of Lie groups and special functions. Vol. 2*, volume 74 of *Mathematics and its Applications (Soviet Series)*. Kluwer Academic Publishers Group, Dordrecht, 1993. Class I representations, special functions, and integral transforms, Translated from the Russian by V. A. Groza and A. A. Groza.
- [VSCC92] N. T. Varopoulos, L. Saloff-Coste, and T. Coulhon. *Analysis and geometry on groups*, volume 100 of *Cambridge Tracts in Mathematics*. Cambridge University Press, Cambridge, 1992.
- [Wal73] N. R. Wallach. *Harmonic analysis on homogeneous spaces*. Marcel Dekker Inc., New York, 1973. Pure and Applied Mathematics, No. 19.
- [Wal92] N. R. Wallach. *Real reductive groups. II*, volume 132 of *Pure and Applied Mathematics*. Academic Press Inc., Boston, MA, 1992.
- [Wei72] N. J. Weiss. L^p estimates for bi-invariant operators on compact Lie groups. *Amer. J. Math.*, 94:103–118, 1972.
- [Wid80] H. Widom. A complete symbolic calculus for pseudodifferential operators. *Bull. Sci. Math. (2)*, 104(1):19–63, 1980.
- [Žel73] D. P. Želobenko. *Compact Lie groups and their representations*. American Mathematical Society, Providence, R.I., 1973. Translated from the Russian by Israel Program for Scientific Translations, Translations of Mathematical Monographs, Vol. 40.
- [Zie04] J. Zienkiewicz. Schrödinger equation on the Heisenberg group. *Studia Math.*, 161(2):99–111, 2004.
- [Zui93] C. Zuily. Existence globale de solutions régulières pour l'équation des ondes non linéaire amortie sur le groupe de Heisenberg. *Indiana Univ. Math. J.*, 42(2):323–360, 1993.

Open Access. This chapter is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, duplication, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, a link is provided to the Creative Commons license and any changes made are indicated.

The images or other third party material in this chapter are included in the work's Creative Commons license, unless indicated otherwise in the credit line; if such material is not included in the work's Creative Commons license and the respective action is not permitted by statutory regulation, users will need to obtain permission from the license holder to duplicate, adapt or reproduce the material.

Index

- C^* -algebra, 520
dual, spectrum, 521
reduced, 523
representation, 520
- adjoint representations Ad and ad, 27
- Ado-Iwasawa theorem, 25
- algebra, 517
 C^* , 520
Banach, 518
involutive, $*$ -, 518
von Neumann, 525
- amplitude, 374
class $AS_{\rho,\delta}^m$, 379
matrix-valued, 79
operator, 79
- asymptotic, 78, 351
adjoint, 80, 370
composition, 78, 362
- Baker-Campbell-Hausdorff formula, 28
- Bessel potential, 211
- $\mathcal{K}_{a,b}$ norm, 285
 $\mathcal{K}_{a,b}$ space, 285
- Calderón-Vaillancourt theorem, 385
- Calderón-Zygmund
kernel, 141, 345, 502
operator, 142, 503
- Cartan's maximal torus theorem, 60
- Casimir element Ω , 28
- character, 59
- Clebsch-Gordan coefficient, 60
- co-adjoint representation co-Ad, 44
- commutant, 517
- commutator, 22
bracket, 23
- convolution, 30, 33
kernel, 133, 137, 179
- Cotlar-Stein lemma, 505
crude version, 505
- difference operator, 75, 300
 Δ^α , 75, 302
 \mathbb{D}^α , 82
 \mathbb{A} , 85
admissible collection of, 75
Heisenberg group, 443
- dilations, 94, 96
in \mathcal{K} , 285
of spectral multipliers, 179
on \widehat{G} , 404
weights, 95
- direct integral
of Hilbert spaces, 511
- direct product, 510
- distribution, 29, 64
convolution, 33, 127, 155, 287
principal value *p.v.*, 149
support, 30
tempered $\mathcal{S}'(\mathbb{R}^n)$, 29
tempered $\mathcal{S}'(G)$, 37, 125
- Dixmier-Malliavin theorem, 42
- doubling condition, 501
- dual \widehat{G} , 18
- ellipticity, 78, 410
order, 410
- exponential mapping \exp_G , 23, 35

- Fell topology, 523
- field of operators, 47, 49, 52, 288
 - acting on smooth vectors, 53
 - defined on \mathcal{H}_π^a , 277
 - defined on smooth vectors, 53, 278
 - measurable, 53, 278, 515
 - with range on \mathcal{H}_π^a , 278
- Fourier
 - coefficient, 20
 - inversion formula, 45, 282
 - transform, 20, 43, 51, 64, 66, 280, 290
- fractional powers of operators, 198, 495
- functional calculus
 - compact Lie groups, 81
 - Rockland operators, 178
- fundamental solution, 158, 177
- Gårding subspace, 42
- Gagliardo-Nirenberg inequality, 247
- Gamma function $\Gamma(\alpha)$, 498
- group
 - C^* -algebra, 522
 - algebra, 519
 - amenable, 523
 - Lie, 15
 - locally compact, 16
 - topological, 16
 - unimodular, 19, 519
 - von Neumann algebra, 526
- Gårding inequality, 90
 - sharp, 88
- Haar measure, 19
- harmonic oscillator, 460
- Hausdorff-Young inequality, 67
- heat kernel and heat semi-group, 185
- Heisenberg group
 - \mathbb{H}_n , 428
 - \mathbb{H}_{n_o} , 34, 92, 96
 - polarised \mathbb{H}_n , 428
- Hellfer-Nourrigat theorem, 177
- homogeneous
 - degree, 101, 102, 104
 - dimension Q , 100
 - function, 101
 - Lie group, 94
 - operator, 101
 - quasi-norm, 109
- Hulanicki theorem, 252
- hypoellipticity, 78, 160, 177, 423, 491
- infinitesimal representation, 39
- integral kernel, 29, 142
- integral of representations, 516
- interpolation
 - analytic, 506
 - between Sobolev spaces, 225
 - complex, 462
 - Marcinkiewicz theorem, 32
- intertwining operator, 17
- Jacobi identity, 22
- kernel
 - associated with symbol, 296
 - of an amplitude, 375
 - of an operator, 71, 330
 - of type ν , 139, 154
- Killing form B , 27
- Laplace Beltrami operator \mathcal{L}_G , 61
- Lebesgue space $L^p(G)$, 19
- Leibniz formula, 83, 305
- Lie algebra, 22
 - graded, 92
 - nilpotent, 34
 - of a Lie group, 23
 - stratified, 93
- Lie group, 15
 - compact, 16
 - graded, 92
 - homogeneous, 94
 - linear, 27
 - nilpotent, 34
 - semi-simple, 28

- stratified, 93
- Liouville theorem, 167
- Mackey structure, 521, 523
- mean value theorem, 119
- modular function, 519
- multiplier, 82, 179, 251, 319
- nilpotent, 34
- operator
 - adjoint, 26
 - class Ψ^m , 77, 309
 - class $\Psi_{\rho,\delta}^m$, 309
 - invariant (left or right), 20
 - of type ν , 139
 - transpose, 26
- orbit method, 44
- Peter-Weyl theorem, 61
- Plancherel
 - formula, 46, 47, 62, 63
 - measure, 529
 - measure μ , 45, 47, 51, 441
 - measure, Heisenberg group, 441
 - theorem, 43, 51, 527
- Poincaré-Birkhoff-Witt theorem, 25
- polar coordinates, 116
- Pontryagin duality, 18, 524
- potential
 - Bessel, 211
 - Riesz, 211
- quantization
 - on compact Lie groups, 57, 72
 - on nilpotent Lie group, 272, 296
 - on the Heisenberg group, 476
 - toroidal, on the torus, 73
 - Weyl, 435
- quasi-ball, 109, 387
- quasi-distance, 500
- quasi-norm (homogeneous), 109
- rank, 60
- representation, 16
- Rep G , 43
- continuous, 17
- unitary, 16
- adjoint Ad, 27
- adjoint ad, 27
- co-adjoint co-Ad, 44
- dilated $\pi^{(r)}$, 404
- dimension/degree, 17
- equivalent, 17
- finite dimensional, 17
- infinite dimensional, 17
- infinitesimal, 39
- irreducible, 16
- regular, 20, 523
- Schrödinger π_λ , 432
- strongly continuous, 18
- tensor product, 59
- trivial, 17
- Riesz potential, 211
- Rockland
 - condition, 172
 - operator, 172
 - operator, functional calculus, 178
- Schur's lemma, 18
- Schwartz kernel theorem, 29, 132
- Schwartz space
 - $\mathcal{S}(G)$, 37, 125
 - $\mathcal{S}(\mathbb{R}^n)$, 29
- semi-group, 493
- sharp Gårding inequality, 88
- Shubin classes
 - $\Sigma_\rho^m(\mathbb{R}^n)$, 459
 - $\Sigma_{\rho,\lambda}^m(\mathbb{R}^n)$, 470
 - λ -uniform, 471
 - commutator characterisation, 474
- singular integral, 499
 - theorem, 141, 501
- smooth vector, 38
- Sobolev embeddings, 241
 - local, 240
- Sobolev space
 - $H(M, g)$, Weyl-Hörmander, 458
 - $L_a^2(\widehat{G})$, 280

- $L_s^p(G)$, on the group, 219
 $L_{s,\text{loc}}^p(G)$, local, 240
 \mathcal{H}_π^a , 276
 $\mathcal{Q}_s(\mathbb{R}^n)$, Shubin-Sobolev, 461
 $\tilde{L}_a^2(\widehat{G})$, 281
- solvability, 159
standard
 Borel space, 514
 measure, 515
Sterling formula, 499
sub-Laplacian, 84, 174, 431
symbol, 294
 λ -symbol a_λ , 445
 λ -symbol, Heisenberg group, 476
 asymptotic for adjoint, 370
 asymptotic for composition, 362
 asymptotic sums, 78–80, 351, 362,
 370
 class $S(M, g)$, 457
 class $S_{\rho, \delta}^m$, 77, 306
 class $S^{-\infty}$, 309
 continuous, smooth, 294
 of an operator, 71, 72, 297
Weyl, 435
- tangent
 bundle, 22
 vector, 22
Taylor polynomial $P_{x,M}^{(f)}$, 122
tensor product
 algebraic, 511
 of Hilbert spaces, 512
topological space
 separable, 509
trigonometric polynomials, 61
- ultradifferentiable function
 Gevrey-Beurling, 66
 Gevrey-Roumieu, 66
ultradistribution, 66
unimodular, 19
unit element, 16, 36, 100
universal enveloping algebra $\mathfrak{U}(\mathfrak{g})$, 24
- vector field, 22
 in Hilbert spaces, 510
left or right invariant, 23, 105
square integrable, 511
von Neumann algebra, 48, 525
 $L^\infty(\widehat{G})$, 49
 $\mathcal{K}(G)$, 50
 $\mathcal{L}_L(L^2(G))$, 48
 of the group, 526
von Neumann bi-commutant theorem, 524
- weak type
 (p, p) , 32
 $w - L^p(G)$, 32
Weyl quantization, 435
Weyl-Hörmander calculus, 455
- Young's inequality, 32

Open Access. This chapter is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, duplication, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, a link is provided to the Creative Commons license and any changes made are indicated.

The images or other third party material in this chapter are included in the work's Creative Commons license, unless indicated otherwise in the credit line; if such material is not included in the work's Creative Commons license and the respective action is not permitted by statutory regulation, users will need to obtain permission from the license holder to duplicate, adapt or reproduce the material.