PD Dr. Konstantin Antonios Leo Merz

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Personal data

Born December 10, 1991 in Munich, Germany
Citizenship: German

Positions

Institut für Partielle Differentialgleichungen, TU Braunschweig
Since 10/2024 — Interim Associate Professor (Vertretungsprofessur W2)

Institut für Analysis und Algebra, TU Braunschweig
04/2024 – 09/2024 — Temporary Academic Councillor (Akademischer Rat, Beamtenverhältnis auf Zeit)
on leave since 10/2024

10/2019 – 03/2024 — Postdoctoral researcher in the group of Prof. Dr. Volker Bach

Department of Mathematics, Osaka University
10/2022 – 09/2023 — Visiting postdoctoral researcher in the group of Prof. Haruya Mizutani

Mathematisches Institut, LMU München
10/2016 – 09/2019 — Research assistant, directed by Prof. Dr. Heinz Siedentop

Education

Technische Universität Braunschweig
11/2024 — Habilitation (venia legendi), Mathematics
- Thesis: *On eigenvalue and functional inequalities for Schrödinger-type operators*

Ludwig-Maximilians-Universität München
10/2016 – 07/2019 — Ph.D., Mathematics
- Dissertation: *Über die Grundzustandsdichte relativistischer Coulomb-Systeme* (Translation: *On the Ground State Density of Relativistic Coulomb Systems*)
- Cumulative grade "magna cum laude" (grade 0.76 where 0.7 is best possible)
- Advisor: Prof. Dr. Heinz Siedentop
- Completion of the graduate training program at the International Max Planck Research School for Quantum Science and Technology

04/2014 – 08/2016 — M.Sc., Physics
- Final grade 1.10
- Specialization in theoretical and mathematical physics
- Thesis: *On the Ground State Energy of Two-Dimensional Coulomb Systems* (grade 1.0)
- Advisor: Prof. Dr. Heinz Siedentop

04/2011 – 04/2014 — B.Sc., Physics
- Final grade 1.29
- Thesis: *Stochastic Quantization in Quantum Mechanics* (grade 1.0)
- Advisor: Prof. Dr. Dieter Lüst

Graf-Rasso-Gymnasium Fürstenfeldbruck
05/2011 — Abitur (university entrance diploma)
- Final grade 1.4

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Research interests

Analysis and Mathematical Physics, in particular

- Schrödinger operators with general kinetic energies (e.g., Laplace, fractional Laplace, Dirac operator, operators occurring in BCS theory), in particular eigenvalue estimates, heat kernel estimates, and spectral multiplier theorems
- PDEs and harmonic analysis, in particular functional inequalities, Fourier restriction theory and applications in mathematical physics
- Many-particle quantum systems

Research stays

02/2025	School of Mathematical and Physical Sciences at Macquarie University, Sydney (two weeks)
11/2023	Faculty of Pure and Applied Mathematics at Wroclaw University of Science and Technology (one week)
08/2023	Department of Mathematical Sciences at Loughborough University (two weeks)
03/2023	Faculty of Pure and Applied Mathematics at Wroclaw University of Science and Technology (one week)
09/2019	Institute for Mathematical Sciences at the National University of Singapore during the program "Density Functionals for Many-Particle Systems: Mathematical Theory and Physical Applications of Effective Equations" (four weeks)
04/2019	Institut Mittag–Leffler (Stockholm) during the program "Spectral Methods in Mathematical Physics" (one week)

Teaching

Institut für Analysis und Algebra, TU Braunschweig

04/2025 – 07/2025	Instructor, Discrete Mathematics, Bachelor course, one lecture and one exercise class weekly
04/2025 – 07/2025	Instructor, Fourier Restriction and Applications, Master course, one lecture and one exercise class weekly
04/2025 – 07/2025	Organizer, Seminar on dispersive partial differential equations
10/2024 – 02/2025	Instructor, Advanced Analysis for Electrical Engineers, Bachelor course, two lectures and one exercise class weekly
10/2024 – 02/2025	Instructor, Ordinary Differential Equations, Bachelor course, two lectures and one exercise class weekly
10/2024 – 02/2025	Instructor, Mathematics using Mathematica, one lecture and one exercise class weekly
10/2024 – 02/2025	Organizer, Seminar on Distribution Theory
04/2024 – 07/2024	Instructor, Discrete Mathematics, Bachelor course, one lecture and one exercise class weekly
04/2024	Instructor, Analysis part of a ramp up course for freshmen of the Master's program Data Science, four lectures and two exercise classes
10/2023 – 02/2024	Instructor, Harmonic Analysis, Master course, two lectures and one exercise class weekly
11/2023	Instructor, Analysis part of a ramp up course for freshmen of the Master's program Data Science, four lectures and two exercise classes
04/2022 – 07/2022	Assistant, Linear Algebra 2, Bachelor course, one large and one small exercise class weekly
04/2022 – 07/2022	Organizer, Seminar on Topics in Many-Body Quantum Mechanics
10/2021 – 02/2022	Assistant, Linear Algebra 1, Bachelor course, one large and one small exercise class weekly
04/2021 – 07/2021	Instructor, Fourier Restriction and Applications, Master course, one lecture and one exercise class weekly

04/2021 – 07/2021	Organizer, Seminar on High-Dimensional Probability Theory
10/2020 – 02/2021	Instructor, Topics in Partial Differential Equations, Master course, one lecture and one exercise class weekly
10/2020 – 02/2021	Organizer, Seminar on Scattering Theory
04/2020 – 07/2020	Instructor, Harmonic Analysis, Master course, two lectures and one exercise class weekly
10/2019 – 02/2020	Assistant, Partial Differential Equations 2, Master course, one large exercise class weekly
10/2019 – 02/2020	Organizer, Seminar on Trace Ideals and Matrix Inequalities
	Mathematisches Institut, LMU München
10/2016 – 02/2017	Assistant, Analysis of Several Variables, Measure and Integration Theory, Bachelor course, one large and one small exercise class weekly
	Mathematisches Institut and Fakultät für Physik, LMU München
11/2013 – 07/2016	Student teaching assistant for courses on Mathematical Quantum Mechanics, Statistical Physics, Theoretical Mechanics, and Mathematical Methods for Theoretical Physics

(Co)-advised students

04/2025 – 07/2025	Julian Rausch, B.Sc. student, TU Braunschweig
01/2020 – 09/2022	Robert Rauch, Ph.D. student, TU Braunschweig, co-advised with Prof. Dr. Volker Bach being the principal advisor

Mathematical activity

	Referee for Advances in Nonlinear Analysis, Annales Henri Poincaré, Communications in Mathematical Physics, Complex Analysis and Operator Theory, Documenta Mathematica, EMS Press, Journal of Applied and Engineering Mathematics, Journal of Integral Equations and Applications, Journal of Mathematical Physics, Journal of Physics A, Journal of the London Mathematical Society, Letters in Mathematical Physics, Nonlinear Differential Equations and Applications, Nonlinearity, Probability and Mathematical Statistics (22 reports since 12/2019)
	Reviewer for Mathematical Reviews and zbMATH (38 reviews since 07/2019)
01/2025	Organization of the *Gauss Mini Workshop* on Analysis, PDE, and Mathematical Physics
11/2020 – 02/2024	Organization of the online *GAuS seminar* on topics in analysis, PDE, and mathematical physics jointly with Christoph Kehle and Simone Rademacher
09/2022	Organization of the mini-symposium *Mathematical Analysis of Complex Quantum Systems* at the DMV annual meeting in Berlin jointly with Heinz Siedentop

Grants

10/2022 – 03/2024	DAAD (German Academic Exchange Service) Postdoctoral Researchers International Mobility Experience (PRIME) grant for an 18-month postdoc at Osaka University (12 months) and Technische Universität Braunschweig (six months)

Memberships

	American Mathematical Society (AMS), Deutsche Mathematiker-Vereinigung (DMV), Deutsche Physikalische Gesellschaft (DPG), International Association of Mathematical Physics (IAMP)

Academic self-governance

Technische Universität Braunschweig

Since 04/2025 — Member of the curriculum and admissions committees for the study program Data Science

Languages

German (native), English (fluent), French (basic knowledge, five years in school), Japanese (basic knowledge, one-semester course, levels A1.1 & A1.2)

Publications and preprints

[18] T. A. Bui, X. T. Duong, and K. Merz. Equivalence of Sobolev norms for Kolmogorov operators with scaling-critical drift, 45 pages, preprint. arXiv 2410.00191. Submitted.

[17] K. Bogdan, T. Jakubowski and K. Merz. Hardy perturbations of subordinated Bessel heat kernels, 59 pages, preprint. arXiv 2409.02853. Submitted.

[16] T. A. Bui and K. Merz. Equivalence of Sobolev norms in Lebesgue spaces for Hardy operators in a half-space, 42 pages, preprint. arXiv 2309.02928. Submitted.

[15] K. Bogdan and K. Merz. Subordinated Bessel heat kernels, 18 pages. To appear in *Theory Probab. Math. Statist.* (arXiv 2308.15026).

[14] J.-C. Cuenin and K. Merz. Lieb–Thirring-type inequalities for random Schrödinger operators with complex potentials, 14 pages. To appear in *RIMS Kôkyûroku Bessatsu.* (arXiv 2308.08889).

[13] K. Bogdan and K. Merz. Ground state representation for the fractional Laplacian with Hardy potential in angular momentum channels. *J. Math. Pures Appl. (9).* **186** (2024), 176–204. doi: 10.1016/j.matpur.2024.04.003 (arXiv 2305.00881).

[12] R. L. Frank and K. Merz. On Sobolev norms involving Hardy operators in a half-space. *J. Funct. Anal.* **285** (2023), no. 10, 54 pages. doi: 10.1016/j.jfa.2023.110104 (arXiv 2303.05348).

[11] R. L. Frank, K. Merz, and H. Siedentop. The Scott conjecture for large Coulomb systems: a review. *Lett. Math. Phys.* **113** (2023), no. 1, paper number 11, 79 pages. doi: 10.1007/s11005-023-01631-9 (arXiv 2204.10081).

[10] J.-C. Cuenin and K. Merz. On the number and sums of eigenvalues of Schrödinger-type operators with degenerate kinetic energy. Book chapter in: From Complex Analysis to Operator Theory: A Panorama: In Memory of Sergey Naboko, M. Brown, F. Gesztesy, P. Kurasov, A. Laptev, B. Simon, G. Stolz, and I. Wood, *Operator Theory: Advances and Applications* **291**, 313–340, Birkhäuser, Cham, 2023. doi: 10.1007/978-3-031-31139-0_13 (arXiv 2202.05212).

[9] J.-C. Cuenin and K. Merz. Random Schrödinger operators with complex decaying potentials. *Anal. PDE.* **18** (2025), no. 2, 279–306. doi: 10.2140/apde.2025.18.279 (arXiv 2201.04466).

[8] K. Merz. On complex-time heat kernels of fractional Schrödinger operators via Phragmén–Lindelöf principle. *J. Evol. Equ.* **22** (2022), no. 3, paper number 62, 30 pages. doi: 10.1007/s00028-022-00819-1 (arXiv 2107.10228).

[7] R. L. Frank, K. Merz, and H. Siedentop. Relativistic Strong Scott Conjecture: A Short Proof. Book chapter in: Density Functionals for Many-Particle Systems. Mathematical Theory and Physical Applications of Effective Equations, B.-G. Englert, H. Siedentop, and M.-I. Trappe (eds.), *Lect. Notes Ser. Inst. Math. Sci. Natl. Univ. Singap.* **41**, 69–79, World Scientific, Singapore, 2023. doi: 10.1142/9789811272158_0003 (arXiv 2009.02474).

[6] K. Merz and H. Siedentop. Proof of the Strong Scott Conjecture for Heavy Atoms: the Furry Picture. *Ann. H. Lebesgue* **5** (2022), 611–642. doi: 10.5802/ahl.131 (arXiv 2007.03895).

[5] J.-C. Cuenin and K. Merz. Weak coupling limit for Schrödinger-type operators with degenerate kinetic energy for a large class of potentials. *Lett. Math. Phys.* **111** (2021), no. 2, paper number 46, 29 pages. doi: 10.1007/s11005-021-01385-2 (arXiv 2006.07110).

[4] R. L. Frank, K. Merz, H. Siedentop, and B. Simon. Proof of the strong Scott conjecture for Chandrasekhar atoms. *Pure Appl. Funct. Anal.* **5** (2020), no. 6, 1319–1356.
URL: `http://www.yokohamapublishers.jp/online2/oppafa/vol5/p1319.html` (arXiv 1907.04894).

[3] K. Merz. On scales of Sobolev spaces associated to generalized Hardy operators. *Math. Z.* **299** (2021), no. 1, 101–121. doi: 10.1007/s00209-020-02651-0 (arXiv 1904.07614).

[2] K. Merz and H. Siedentop. The atomic density on the Thomas-Fermi length scale for the Chandrasekhar Hamiltonian. *Rep. Math. Phys.* **83** (2019), no. 3, 387–391. doi: 10.1016/S0034-4877(19)30057-6 (arXiv 1810.00632).

[1] R. L. Frank, K. Merz, and H. Siedentop. Equivalence of Sobolev norms involving generalized Hardy operators. *Int. Math. Res. Not.* **2021** (2021), no. 3, 2284–2303. doi:10.1093/imrn/rnz135 (arXiv 1807.09027).

Invited conference, workshop talks

Random Schrödinger operators with complex decaying potentials, "VIASM-IAMP Summer School in Mathematical Physics" in Quy Nhon (08/2023)

Random Schrödinger operators with complex decaying potentials, symposium "Harmonic Analysis and Nonlinear Partial Differential Equations" at RIMS in Kyoto (07/2023)

Hardy operators in angular momentum channels, conference "Nonlocal Operators and Markov Processes III" in Bedlewo (03/2023)

Random Schrödinger operators with complex decaying potentials, "Himeji Conference on Partial Differential Equations" in Himeji (03/2023)

On some functional inequalities for generalized Hardy operators, conference "The analysis of relativistic quantum systems", Centre International De Rencontres Mathématiques in Luminy (01/2023)

The Scott conjectures for large Coulomb systems, conference "Mathematical Results of Many-Body Quantum Systems" in Herrsching (06/2022)

Weak coupling limit for Schrödinger-type operators with degenerate kinetic energy for a large class of potentials, online DMV–ÖMG annual meeting in Passau (09/2021)

Weak coupling limit for Schrödinger operators with degenerate kinetic energy for a large class of potentials, online workshop "Harmonic Analysis and Partial Differential Operators" (07/2021)

On the strong Scott conjecture for Chandrasekhar atoms, workshop "The Analysis of Complex Quantum Systems: Large Coulomb Systems and Related Matters", Centre International De Rencontres Mathématiques in Luminy (10/2019)

On the strong Scott conjecture for Chandrasekhar atoms, program "Density Functionals for Many-Particle Systems: Mathematical Theory and Physical Applications of Effective Equations", Institute for Mathematical Sciences in Singapore (09/2019)

On the strong Scott conjecture for the Chandrasekhar model, workshop "Analysis of Effective One-Particle Equations and their Derivation", LMU Munich (06/2018)

On the atomic density on the semiclassical length scale in relativistic quantum mechanics, Joint DMV and GDM annual meeting, Paderborn (03/2018)

On the atomic density on the semiclassical length scale in relativistic quantum mechanics, workshop "Effective equations for many particle Coulomb systems", Universität Mannheim (12/2017)

Radial coherent states and the Scott correction, workshop "Mean Fields for Fermions", LMU Munich (01/2017)

The atomic density on the length scale $Z^{-1/3}$, workshop "Effective one-particle equations for fermionic many-particle Coulomb systems: derivation and properties", Universität Mannheim (10/2016)

Invited seminar talks

Electron distribution of relativistic atoms and heat kernel bounds, Kyushu University (03/2025)

From weak coupling limits for degenerate Schrödinger operators to Schrödinger operators with complex potentials, Universität Oldenburg (06/2024)

Eigenvalue estimates for Schrödinger operators using Fourier analysis, ETH Zürich (06/2024)

Random Schrödinger operators with complex decaying potentials, Hokkaido University (07/2023)

On some functional inequalities for generalized Hardy operators, Kansai University (07/2023)

On some functional inequalities for generalized Hardy operators, Kyoto University (06/2023)

Relativistic Coulomb systems and Hardy operators 2, Wroclaw University of Science and Technology (03/2023)

The Scott conjectures for relativistic atoms, University of Warsaw (01/2023)

Relativistic Coulomb systems and Hardy operators, Wroclaw University of Science and Technology (01/2023)

Some applications of the Hardy–Kato–Herbst inequality, Osaka University (10/2022)

Random Schrödinger operators with complex decaying potentials, online "Mathematical Physics and Harmonic Analysis Seminar", Texas A&M University (09/2022)

Random Schrödinger operators with complex decaying potentials, online Munich–Aarhus–Santiago Seminar in Mathematical Physics (12/2021)

Eigenvalue estimates for Schrödinger operators using Fourier analysis, Friedrich-Alexander-Universität Erlangen–Nürnberg (11/2021)

Weak coupling limit for Schrödinger-type operators with degenerate kinetic energy for a large class of potentials, online seminar "Analysis Of Complex Physical Systems", The University of Texas at Austin (11/2021)

Eigenvalue estimates for Schrödinger operators using Fourier analysis, Jacobs University Bremen (09/2021)

Weak coupling limit for Schrödinger operators with degenerate kinetic energy for a large class of potentials, online seminar "KIT Mathematical Physics Seminar" (07/2021)

Equivalence of Sobolev norms involving generalized Hardy operators, online seminar "Theory of Markov Semigroups and Schrödinger Operators" (05/2021)

On the ground state density of relativistically described atoms, LMU Munich (07/2019)

On the strong Scott conjecture for Chandrasekhar atoms, TU Braunschweig (04/2019)

Contributed talks, posters

Random Schrödinger operators with complex decaying potentials, XXI International Congress on Mathematical Physics in Strasbourg (07/2024)

Random Schrödinger operators with complex decaying potentials, workshop of the GAMM Activity Group "Applied Operator Theory" in Hamburg (05/2024)

Random Schrödinger operators with complex decaying potentials, school and workshop "Mathematical Challenges in Quantum Mechanics" in Como (06/2022)

Weak coupling limit for Schrödinger-type operators with degenerate kinetic energy for a large class of potentials (poster), XX International Congress on Mathematical Physics in Geneva (08/2021)

Weakly coupled bound states of $|p^2 - 1| - \lambda V$ (poster), online summer school "Applications of Bogoliubov theory" (06/2020)

Equivalence of Sobolev norms involving generalized Hardy operators, workshop of the GAMM Activity Group "Applied Operator Theory" in Kaiserslautern (05/2019)

On the strong Scott conjecture for Chandrasekhar atoms, Young Researchers Symposium preceding the XIX International Congress on Mathematical Physics in Montréal (07/2018)

On the ground state density of relativistic models of atoms on the semiclassical length scale (poster), Joint CoQuS & IMPRS-QST Vienna Summer School on Complex Quantum Systems (09/2017)

On the ground state energy of the statistical model of the two-dimensional atom using phase space localization techniques (poster), Vienna Central European Seminar on Particle Physics and Quantum Field Theory (11/2015)