

# Konstantin Antonios Leo Merz

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**PERSONAL DATA** Born December 10, 1991 in Munich, Germany  
Citizenship: German

## **EDUCATION** 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 Fürstentfeldbruck**

05/2011 Abitur (university entrance diploma)

- Final grade 1.4

## **POSITIONS**

Since 04/2024

### **Institut für Analysis und Algebra, TU Braunschweig**

Temporary Academic Councillor (Akademischer Rat (A13) - Beamtenverhältnis auf Zeit)

10/2019 – 03/2024

Postdoctoral researcher in the group of Prof. Dr. Volker Bach

10/2022 – 09/2023

### **Department of Mathematics, Osaka University**

Visiting postdoctoral researcher in the group of Prof. Haruya Mizutani

10/2016 – 09/2019

### **Mathematisches Institut, LMU München**

Research assistant, directed by Prof. Dr. Heinz Siedentop

## **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

- 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**
- 04/2024 – 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

- 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 Integral Equations and Applications*, *Journal of Mathematical Physics*, *Letters in Mathematical Physics*, *Nonlinear Differential Equations and Applications*, *Nonlinearity*, *Probability and Mathematical Statistics* (17 reports since 12/2019)
- Reviewer for *Mathematical Reviews* and *zbMATH* (36 reviews since 07/2019)
- Since 11/2020 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)
- 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**
- [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, preprint. arXiv 2308.15026. Submitted.
- [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, 26 pages. To appear in *Anal. PDE*. (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/vol15/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

*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*, Wrocław University of Science and Technology (03/2023)

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

*Relativistic Coulomb systems and Hardy operators*, Wrocław 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)