

CURRICULUM VITÆ

LUCA FAUSTO TOCCHIO

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Professional Experience

- 16/11/2019 - present: **Associate professor of Theoretical Condensed Matter Physics**, in the research group of Nanophysics and Quantum System, *Department of Applied Science and Technology (DISAT) at Politecnico di Torino (Italy)*.
- 16/11/2019 - 15/11/2022: **Tenure-track assistant professor (Ricercatore a tempo determinato Legge 240/10 art.24-B) of Theoretical Condensed Matter Physics**, in the research group of Nanophysics and Quantum System, *Department of Applied Science and Technology (DISAT) at Politecnico di Torino (Italy)*.
- 09/01/2017 - 15/11/2019: **Assistant professor with no tenure track (Ricercatore a tempo determinato Legge 240/10 art.24-A) of Theoretical Condensed Matter Physics**, in the research group of Nanophysics and Quantum System, *Department of Applied Science and Technology (DISAT) at Politecnico di Torino (Italy)*.
- 01/11/2013 - 08/01/2017: **PostDoc (Assegnista di Ricerca Legge 240/10 art.22)** in the group of Prof. Sandro Sorella and Dr. Federico Becca, *International School for Advanced Studies (SISSA), Italy*. The period Nov 2013 - Oct 2015 was financed by the research project: “PRIN 2010-2011: Fenomeni quantistici collettivi: dai sistemi fortemente correlati ai simulatori quantistici”.
- 01/07/2011 - 31/10/2013: **PostDoc (Wissenschaftlicher Mitarbeiter)** in the group of Prof. Claudius Gros and Prof. Roser Valentí, *Institute of theoretical physics, University of Frankfurt, Germany*. Financed by the research project: “SFB/TR 49: Condensed Matter Systems with Variable Many-Body Interactions”, second funding period (after positive evaluation of a referral committee).
- 01/12/2008 - 30/06/2011: **PostDoc (Wissenschaftlicher Mitarbeiter)** in the group of Prof. Claudius Gros and Prof. Roser Valentí, *Institute of theoretical physics, University of Frankfurt, Germany*. Financed by the research project: “SFB/TR 49: Condensed Matter Systems with Variable Many-Body Interactions”, first funding period.

Education

- Nov 2004 - Oct 2008: **Ph.D. in Theory and Numerical Simulation of Condensed Matter**
International School for Advanced Studies (SISSA), Trieste (Italy)
Thesis: “*A new variational wave function with backflow correlations for frustrated Hubbard models*”, discussed on the 24th October 2008 (available online at <http://www.sissa.it/cm/phdsection/alumni.php>)
Supervisors: Prof. Sandro Sorella and Dr. Federico Becca
Referee: Prof. Peter Prelovšek (University of Ljubljana)
- Nov 1999 - Jul 2004: **Laurea vecchio ordinamento (Master of Science) in Physics**, University of Genova, (Italy)
Thesis: “*Spin effects in the shot noise of a quantum dot*”, discussed on the 15th July 2004
Supervisors: Prof. Maura Sasseti and Prof. Franco Napoli
Final grade: 110/110 cum laude
- Sept 1994 - Jul 1999: **High School Degree**
Liceo Scientifico “Giordano Bruno”, Albenga (Italy)
Final grade: 100/100

Research interests

- Strongly correlated electron systems in low dimension; Hubbard (also with multiband and bilayer extensions), Heisenberg and Hubbard-Holstein models
- Variational and Green’s Function Monte Carlo; methodological improvements of variational states, i.e., backflow correlations
- Frustrated spin systems in low dimension (i.e., charge-transfer salts), spin liquids and spiral magnetic order; competing charge and magnetic orders in frustrated models with extended interactions
- High-temperature superconductivity (i.e., cuprates), the underdoped region, and the properties of the (underlying) Fermi surface; hidden parity and string orders
- Orbital-selective phases, metal-insulator transitions, magnetism and superconductivity in multiband models (i.e., physics of the iron pnictides)
- Interplay between topological order and correlation

Full list of Publications

Note: “*” = corresponding author

- (31) V. Marino, A. Scazzola, F. Becca, M. Capone, and L.F. Tocchio*, “*Intertwined superconductivity and orbital selectivity in a three-orbital Hubbard model for the iron pnictides*”, arXiv:2406.13634 (2024).
- (30) A. Lechiara, V. Marino, and L.F. Tocchio*, “*Variational Monte Carlo study of stripes as a function of doping in the $t-t'$ Hubbard model*”, J. Phys.: Condens. Matter **36**, 395602 (2024).
- (29) D. Wu *et al.*, “*Variational Benchmarks for Quantum Many-Body Problems*”, **Science** **386**, 296 (2024).
- (28) V. Marino, F. Becca, and L.F. Tocchio*, “*Stripes in the extended $t-t'$ Hubbard model: A Variational Monte Carlo analysis*”, SciPost Phys. **12**, 180 (2022).
- (27) L.F. Tocchio*, A. Montorsi, and F. Becca, “*Hubbard model on triangular N -leg cylinders: Chiral and nonchiral spin liquids*”, Phys. Rev. Research **3**, 043082 (2021).
- (26) L.F. Tocchio*, A. Montorsi, and F. Becca, “*Magnetic and spin-liquid phases in the frustrated $t-t'$ Hubbard model on the triangular lattice*”, Phys. Rev. B **102**, 115150 (2020).
- (25) L.F. Tocchio*, A. Montorsi, and F. Becca, “*Metallic and insulating stripes and their relation with superconductivity in the doped Hubbard model*”, SciPost Phys. **7**, 021 (2019).
- (24) W.-J. Hu, H. Hu, R. Yu, H.-H. Lai, L.F. Tocchio, F. Becca, and Q. Si, “*Nematic and Antiferromagnetic Quantum Criticality in a Multi-Orbital Hubbard Model for Iron Pnictides*”, arXiv: 1903.12625.
- (23) L.F. Tocchio*, F. Becca, and A. Montorsi, “*Superconductivity in the Hubbard model: a hidden-order diagnostics from the Luther-Emery phase on ladders*”, SciPost Phys. **6**, 018 (2019).
- (22) C. De Franco, L.F. Tocchio*, and F. Becca, “*Metal-insulator transitions, superconductivity, and magnetism in the two-band Hubbard model*”, Phys. Rev. B **98**, 075117 (2018).
- (21) S. Karakuzu, L.F. Tocchio*, S. Sorella, and F. Becca, “*Superconductivity, charge-density waves, and antiferromagnetism in the Hubbard-Holstein model*”, Phys. Rev. B **96**, 205145 (2017).
- (20) R. Kaneko, L.F. Tocchio*, R. Valentí, and F. Becca, “*Charge orders in organic charge-transfer salts*”, New J. Phys. **19**, 103033 (2017).
- (19) L.F. Tocchio*, F. Becca, and S. Sorella, “*Hidden Mott transition and large- U superconductivity in the two-dimensional Hubbard model*”, Phys. Rev. B **94**, 195126 (2016).
- (18) R. Kaneko, L.F. Tocchio, R. Valentí, and C. Gros, “*Emergent lattices with geometrical frustration in doped extended Hubbard models*”, Phys. Rev. B **94**, 195111 (2016).
- (17) R. Kaneko, L.F. Tocchio, R. Valentí, F. Becca, and C. Gros, “*Spontaneous symmetry breaking in correlated wave functions*”, Phys. Rev. B **93**, 125127 (2016).
- (16) L.F. Tocchio*, F. Arrigoni, S. Sorella, and F. Becca, “*Assessing the orbital selective Mott transition with variational wave functions*”, J. Phys.: Condens. Matter **28**, 105602 (2016).
- (15) E. Ghorbani, L.F. Tocchio*, and F. Becca, “*Variational wave functions for the $S = 1/2$ Heisenberg model on the anisotropic triangular lattice: spin liquids and spiral orders*”, Phys. Rev. B **93**, 085111 (2016); **Editors’ Suggestion**.
- (14) J.P.F. LeBlanc *et al.* (Simons Collaboration on the Many-Electron Problem), “*Solutions of the Two Dimensional Hubbard Model: Benchmarks and Results from a Wide Range of Numerical Algorithms*”, Phys. Rev. X **5**, 041041 (2015); **Highly Cited Paper in Web of Science**.
- (13) L.F. Tocchio, C. Gros, X.-F. Zhang, and S. Eggert, “*Phase diagram of the triangular extended Hubbard model*”, Phys. Rev. Lett. **113**, 246405 (2014).
- (12) L.F. Tocchio*, C. Gros, R. Valentí, and F. Becca, “*One-dimensional spin liquid, collinear, and spiral phases from uncoupled chains to the triangular lattice*”, Phys. Rev. B **89**, 235107 (2014).

- (11) R. Rürger, L.F. Tocchio*, R. Valentí, and C. Gros, “*Phase diagram of the square lattice bilayer Hubbard model: A variational Monte Carlo study*”, New. J. Phys. **16** 033010 (2014).
- (10) A.C. Jacko, L.F. Tocchio, H.O. Jeschke, and R. Valentí, “*Importance of anisotropy in the spin-liquid candidate $Me_3EtSb[Pd(dmit)_2]_2$* ”, Phys. Rev. B **88**, 155139 (2013).
- (9) L.F. Tocchio*, H. Feldner, F. Becca, R. Valentí and C. Gros, “*Spin-liquid versus spiral-order phases in the anisotropic triangular lattice*”, Phys. Rev. B **87**, 035143 (2013).
- (8) L.F. Tocchio*, H. Lee, H.O. Jeschke, R. Valentí and C. Gros, “*Mott correlated states in the underdoped two-dimensional Hubbard model: variational Monte Carlo versus a dynamical cluster approximation*”, Phys. Rev. B **87**, 045111 (2013).
- (7) L.F. Tocchio*, F. Becca and C. Gros, “*Strong renormalization of the Fermi-surface topology close to the Mott transition*”, Phys. Rev. B **86**, 035102 (2012).
- (6) L.F. Tocchio, F. Becca and C. Gros, “*Backflow correlations in the Hubbard model: An efficient tool for the study of the metal-insulator transition and the large- U limit*”, Phys. Rev. B **83**, 195138 (2011).
- (5) A. Di Ciolo, L.F. Tocchio and C. Gros, “*Tunneling matrix elements with antiferromagnetic Gutzwiller wave functions*”, Phys. Rev. B **83**, 165116 (2011).
- (4) L.F. Tocchio, F. Becca and C. Gros, “*Interaction-induced Fermi-surface renormalization in the $t_1 - t_2$ Hubbard model close to the Mott-Hubbard transition*”, Phys. Rev. B **81**, 205109 (2010).
- (3) L.F. Tocchio, A. Parola, C. Gros and F. Becca, “*Spin-liquid and magnetic phases in the anisotropic triangular lattice: The case of $\kappa - (ET)_2X$* ”, Phys. Rev. B **80**, 064419 (2009).
- (2) F. Becca, L.F. Tocchio and S. Sorella, “*Metal-insulator transition and strong-coupling spin liquid in the $t - t'$ Hubbard model*”, J. Phys.: Conf. Ser. **145**, 012016 (2009).
- (1) L.F. Tocchio, F. Becca, A. Parola and S. Sorella, “*Role of backflow correlations for the non-magnetic phase of the $t - t'$ Hubbard model*”, Phys. Rev. B **78**, 041101(R) (2008).

Bibliometric data

Total number of citations: 1161, h-index: 16, Source: Web of Science

Total number of citations: 1679, h-index: 19, Source: Google Scholar

Prizes, Grants, and Qualifications

- **Europhysics Letters (EPL) Award** for the best contributed talk at the conference: “Correlations, integrability, and criticality in quantum systems”, 24-28 October, 2016 - Évora (Portugal). Talk title: “Hidden Mott transition and large- U superconductivity in the two-dimensional Hubbard model”. The prize is assigned to the best presentations by young researchers attending selected conferences, workshops, and summer schools.
- Starting Grant for Assistant Professors, provided by Politecnico di Torino for the period 2017-2019 (15 k€) and for the period 2020-2022 (15 k€); grant number: 54_RSG17TL01 - Starting grant RTDA/RTDB
- Funding for basic research activities, provided by Politecnico di Torino for the year 2023 (8 k€); grant number: 54_RBA23TL01 - Finanziamento diffuso 2023
- Funding for basic research activities (FFABR), provided by the Ministry of Education, University and Research for the year 2018 (3 k€); grant number: 54_RID17TL01 - MIUR Ricerca di Base

- French qualification for the position of Maître de Conférence in the section 28 “Condensed Matter Physics”, obtained in 2013
- Italian qualification for the position of Associate Professor in Theoretical Condensed Matter Physics (settore concorsuale 02/B2), obtained on 08/08/2018
- Italian qualification for the position of Full Professor in Theoretical Condensed Matter Physics (settore concorsuale 02/B2), obtained on 01/12/2023

Participation into research projects

- Nov 2013 - Jan 2016; Italian research project: “PRIN 2010-2011: Fenomeni quantistici collettivi: dai sistemi fortemente correlati ai simulatori quantistici”
- Dec 2008 - Oct 2013: German research project: “SFB/TR 49: Condensed Matter Systems with Variable Many-Body Interactions”
- 2008: Italian research project: “PRIN 2007: Ruolo della forte correlazione elettronica nei superconduttori non convenzionali, in sistemi bidimensionali di elettroni in dispositivi e in sistemi a molti corpi di recente interesse fisico e chimico”.

Teaching Experience and Supervision of Students

@University of Frankfurt

- Tutor and responsible of exercise preparation for the course “Introduction to Solid State Physics”, Master degree in Physics (WS 2011/12 and WS 2010/11)
- Tutor and responsible of exercise preparation for the course “Advanced Solid State Physics”, Master degree in Physics (SS 2011 and SS 2009)
- Tutor for the course “Quantum Mechanics I”, Bachelor degree in Physics (SS 2013)
- Tutor for the course “Quantum Mechanics II”, Bachelor degree in Physics (SS 2010)
- Tutor for the course “Electromagnetism”, Bachelor degree in Physics (WS 2009/2010)
- Co-advisor (with Roser Valentí) of three Bachelor theses:
 - Robert Rürger: “Monte-Carlo methods in Statistical Physics and their Application to the Simulation of Spin systems”, 2011
 - Steffi Hartmann: “Superconductivity, from the perspective of a bachelor student”, 2011
 - Wiebke Ritter: “The Monte Carlo method and its application to the Ising model”, 2012
- Co-advisor (with Roser Valentí) of a Master thesis:
 - Robert Rürger: “Implementation of the Variational Monte Carlo method for the Hubbard model”, 2013

@SISSA, Trieste

- Tutor for the week on Monte Carlo methods in the “Summer School on Atomistic Simulation Techniques for Material Science, Nanotechnology, and Biophysics”; 30 June - 4 July 2014, 6 - 10 July 2015, 11 - 15 July 2016.

- **Supervisor** (together with Prof. Federico Becca) **of the Ph.D. thesis of Caterina De Franco**. Title: “Magnetism and Superconductivity in the Two-Band Hubbard Model: A Variational Monte Carlo Perspective”. Date of defense: 26/10/2018

@Politecnico di Torino

- Attendance of a training course on university teaching: “Apprendere ad Insegnare nell’Higher Education - Percorso Formativo Junior Faculty Learning”, February-June 2017
- Teacher for the guidance project to STEM academic disciplines: “Progetto orientamento formativo - Lezioni di Matematica e Fisica”, provided by Politecnico di Torino for high-school students (17 November 2018, 16 November 2019, 28 November 2020, 26 November 2022, 18 November 2023)
- Teaching assistant (Recitations and laboratory tutoring) in the course “Classical Physics I: Mechanics and thermodynamics” for Bachelor degrees in Engineering (2nd semester a.y. 2016/2017); Laboratory tutoring in the 2nd semester a.y. 2022/2023
- Teaching assistant (Recitations) and member of the examination committee in the course “Classical Physics II: Electromagnetism” for the Bachelor degree in Mechanical Engineering (1st semester a.y.’s 2017/2018, 2018/2019, 2019/2020, and 2020/2021) and for the Bachelor degree in Computer engineering (1st semester a.y. 2017/2018)
- Main teacher (**Docente titolare**) in the course “**Classical Physics I: Mechanics and thermodynamics**” for **Bachelor degrees in Engineering** (2nd semester a.y.’s 2023/2024 and 2024/2025)
- Teaching assistant and member of the examination committee in the course “Condensed Matter Theory” for the Master degree in “Physics of Complex Systems” (Module on Quantum Monte Carlo in the 2nd semester a.y. 2018/2019; Recitations on lattices, band theory and phonons, as well as a module on Quantum Monte Carlo in the 2nd semester a.y.’s 2019/2020 and 2020/2021; Recitations on lattices, band theory and phonons in the 2nd semester a.y.’s 2023/2024 and 2024/2025)
- Main teacher (**Docente titolare**) in the course “**Condensed Matter Theory**” for the **Master degree in “Physics of Complex Systems”** (2nd semester a.y.’s 2021/2022 and 2022/2023)
- Lecturer (together with Prof. Federico Becca) for the Ph.D. course “Quantum Monte Carlo methods for strongly correlated systems” (March 2018)
- Supervision of Master theses:
 - Vito Marino, Title: “Competition and interplay between stripe order and superconductivity in cuprate superconductors”. Date of graduation: 14/04/2021
 - Antonio Lechiara, Title: “Effects of Doping on Stripe Order and Superconductivity in Cuprates: A Variational Monte Carlo approach”, Date of graduation: 13/04/2023
 - Gabriele Gatti, Title: “Variational Monte Carlo study of a two-orbital Hubbard model for iron-based superconductors”, Date of graduation 13/12/2024
 - Lorenzo Soncin, Title: “Photon thermalization in disordered scattering media”, in collaboration with Institut Langevin, Paris, Date of graduation 13/12/2024
 - Alberto Rosso, Title: “Towards quantum devices: a study on the fabrication and measurement of WS2 field effect transistors”, in collaboration with the Agency for Science, Technology and Research, Singapore, Date of graduation 31/10/2024
 - Rebecca Semeria: Title: “A game-theoretic approach to spin models”, co-supervised with

Prof. Marco Morandotti at Politecnico di Torino, Date of graduation 31/10/2024

- **Supervisor of the Ph.D. thesis of Vito Marino.** Project title: “Superconductivity and Orbital Selectivity in a three-orbital Hubbard model for the iron-based superconductors: Variational Monte Carlo analysis”. Starting date: 01/11/2021

Service for the scientific community

- Referee for “Physical Review Letters”, “Physical Review X”, “Physical Review A”, “Physical Review B”, “Physical Review E”, “Physical Review Research”, “SciPost Physics”, “Quantum”, “New Journal of Physics”, “Nature Communications”, “npj Quantum Materials”, “Physics Letters A”, “Annalen der Physik”, “Condensed Matter”, and “Crystals”
- Scientific Evaluator for the Italian SuperComputing Resource Allocation (ISCRA) of CINECA (March 2021 and November 2024)
- Scientific Evaluator for the Swiss National Science Foundation (29/11/2021)
- Member of the evaluation committee for the funding of public and private projects that are presented within the “bandi a cascata finanziati dal PNRR - Centro Nazionale di Ricerca in High Performance Computing, Big Data e Quantum Computing ICSC SPOKE 7” (July 2024).
- External member for the entrance exam to the Ph.D. program in “Theory and Numerical Simulation of Condensed Matter” at the International School for Advanced Studies (SISSA), Trieste (Italy), in the exam session of 25-27 March 2020, valid for the academic year 2020/21
- Member of the examining board for the Ph.D. defense of Alberto Scazzola at SISSA (Trieste). Date of defense: 28/10/2022. Thesis title: “Interplay between electron-phonon interaction and electron-electron repulsion in multiorbital Hubbard models”
- President of the examining board for the Ph.D. defense of Lorenzo Rossi at Politecnico di Torino. Date of defense: 3/05/2023. Thesis title: “Topological signatures and quenches in one dimensional fermionic systems”
- Member of the examining board for the Ph.D. defense of Gabriele Bellomia at SISSA (Trieste). Date of defense: 10/04/2024. Thesis title: “Quantum information insights into strongly correlated electrons”
- Member of the examining board for the admission to the international curriculum of the Master program in “Physics of complex systems” (Trieste/Turin/Paris) for the a.y. 2023/2024
- Member of the “Timetable committee” within the School of Electronic, Physical and Telecommunication Engineering at Politecnico di Torino, starting from Spring 2025

Professional memberships

- Deutsche Physikalische Gesellschaft (DPG)

Computer and Numerical skills

- **Numerical techniques:** Variational Quantum Monte Carlo, Green's Function Monte Carlo and the Fixed Node approximation, classical Monte Carlo, minimization techniques (steepest descent, stochastic reconfiguration)
- **Programming tools** (excellent knowledge): Fortran 77/90
- **Programming tools** (good knowledge): MPI libraries, batch systems, bash shell scripting
- **Programming tools** (basic knowledge): C, Java
- **Packages:** Office, L^AT_EX, gnuplot, Mathematica
- **Operating systems:** Good knowledge of Linux, standard knowledge of Windows.

Language skills

- **Italian:** mother-tongue
- **English:** excellent knowledge
- **German:** good knowledge (B1 certificate)
- **French:** intermediate knowledge

Torino, 03/02/2025

Luca Fausto Tocchio