

Sebastiano Pilati

CURRICULUM VITAE

ResearcherID: L-4485-2013 URL: <http://www.researcherid.com/rid/L-4485-2013>
Scholar Google: <https://scholar.google.it/citations?user=iegEPQgAAAAJ&hl=it>
ORCID: <http://orcid.org/0000-0002-4845-6299>
Publons: <https://publons.com/a/2596940> SCOPUS Author ID: 23478232500
Scientific qualification: “ASN 02/B2, fisica teorica della materia, fascia II”, valid until 10 May 2023.

CURRENT RESEARCH POSITION

- 12/2017 – ongoing: Temporary Assistant Professor (RTDA), **University of Camerino**
via Madonna delle Carceri 9, I-62032 Camerino (MC), Italy

PREVIOUS RESEARCH POSITIONS:

- 01/2017 – 11/2017: Research fellow (assegnista di ricerca), University of Padova
- 09/2011 – 12/2016: Ludwig Boltzmann Fellow (senior PostDoc)
UNESCO/AIEA Abdus Salam International Centre for Theoretical Physics, Trieste (Italy)
- 09/2009 – 08/2011: Postdoctoral Fellow, ETH – Swiss Federal Institute of Technology, Zurich
- 04/2008 – 08/2009: Postdoctoral Fellow, INO-CNR “BEC Centre” - Trento (Italy)

FURTHER RESEARCH EXPERIENCES:

- 09/2004 – 08/2005: Visiting Graduate Student
Group of Prof. J. Boronat, Polytechnic University of Catalunya, Barcelona (Spain).
- 03/2004 – 09/2004: Post-Lauream Fellowship
INFN - Istituto Nazionale di Fisica della Materia, Unità di Ricerca di Trento

EDUCATION:

- 08/2004 – 02/2008: Ph.D. Degree in Physics at the University of Trento
Title: “*Studies of Ultracold Gases using Quantum Monte Carlo techniques*”
Supervisor: Prof. S. Giorgini Evaluation: excellent.
- 02/2004: Laurea in Physics at the University of Trento (18/02/2004)
Title: “*Quantum Monte Carlo study of the ground-state properties of a two dimensional Bose gas*”
Evaluation: 110/110 cum Laude Average exams grade: 29.7/30

MY RESEARCH PROFILE

I’m a computational physicist with expertise in ultracold atomic gases, in adiabatic quantum computing, and in machine learning methods. My work focuses on the development of novel computer simulation methods for quantum many-body systems based on quantum Monte Carlo algorithms, on machine learning techniques, and on the use of high-performance computers. The long-term goal of my research is to improve the theoretical and computational techniques for quantum many-body systems beyond the state-of-the-art and to guide the engineering of novel phases of coherent quantum matter and of novel quantum technologies. I’m also interested in the development of quantum-enhanced optimization methods for complex optimization problems relevant for industry, and in the use of machine learning methods in diverse fields, including, e.g., protein-ligand binding for drug design, search-engines for booking websites, and protocols for wireless communication networks.

MY RESEARCH ACHIEVEMENTS

In recent years, I have given a relevant contribution to the development of innovative computational methods based on quantum Monte Carlo algorithms. These advancements allowed us to provide quantitative predictions for intriguing many-body phenomena that have been confirmed by cold-atoms experiments, including: the phase separation in

polarized Fermi gases along the BEC-BCS crossover (experimentally observed in Ketterle's and Zwierlein's labs at MIT, as well as in Hulet's lab at Texas A&M), the onset of Stoner ferromagnetism in repulsive Fermi gases (observed in Roati's lab at LENS), the bosonic superfluid-Mott transition (observed in Nagerl's lab in Innsbruck). My research studies lead to a better understanding of the following phenomena: the combined effect of interactions, of disorder, and of optical lattices on the superfluid transition in Bose gases; the breakdown of superfluidity in polarized Fermi gases; the emergence of quantum magnetism in clean and in disordered Fermi gases; the Anderson localization of matter waves in optical speckle fields.

In the last few years, we published important results also in the field of adiabatic quantum computing, where we use stochastic algorithms to inspect the potential efficiency of quantum annealers (such as the devices commercialized by D-Wave Systems inc. www.dwavesys.com) in solving complex combinatorial optimization problems relevant for industry, finance, and science. These results have been presented at the AQC2015 (ETH, Zurich) and at AQC2018 (Nasa Ames, CA).

More recently, together with other colleagues at UniCam, we started a collaboration with the company www.6tour.com (involving also fellowships for students financed by 6tour.srl) on problems related to machine learning and big data analysis for booking engines. We use machine learning techniques also to predict properties of quantum many-body systems and protein-molecule complexed relevant for medicinal research.

I have long standing collaborations with worldwide leading theoretical physicists, in particular with Prof. M. Troyer at Microsoft, with N. Prokofev from the University of Massachusetts, with J. Boronat from UPC in Barcelona. At the national level, I often collaborate with scientists at the BEC Center in Trento and at SISSA and ICTP (Trieste).

SUPERVISION OF STUDENTS/POST-DOCTORAL FELLOWS:

- Supervisor of 1 PhD student UniCam, 1 Master student UniCam, 1 Bachelor student UniCam.
- Supervisor of 1 PhD student in SISSA (currently holding the Francis Kofi Allotey fellowship at Perimeter Institute)
- Supervisor of 6 students of the Postgraduate Diploma Program in Condensed Matter Physics at ICTP.
- Co-supervisor of 1 Master Student of the Master in High Performance Computing.
- Advisor of 2 Junior Postdoctoral fellows at ICTP.
- Supervisor of 3 fellowship projects for the UniCam-6trour.com collaboration on machine learning.
- Referee and external jury member of 2 PhD theses in SISSA (Trieste), and 1 PhD thesis at EPFL (Lausanne).
- Supervisor for semester projects and physics pro-seminars at ETHZ (2009-2011).

ORGANIZATION OF ACTIVITIES (Conferences, Workshops, Schools, Seminar Series):

- Conference on "Frontiers in Two-Dimensional Quantum Systems", 13-17 November 2017, Trieste <http://indico.ictp.it/event/8006/>.
- Workshop on "Understanding quantum phenomena with Path Integrals: from Chemical Systems to Quantum Fluid and Solids", 3-7 July 2017 – Trieste <http://indico.ictp.it/event/7975/>.
- Workshop "Theory and Practice of Adiabatic Quantum Computers and Quantum Simulation", 22-26 August 2016 – Trieste <http://indico.ictp.it/event/7607/>.
- Summer School "Computational Condensed Matter Physics: from Atomistic Simulations to Universal Model Hamiltonians", 7-25 September 2015 – Trieste <http://indico.ictp.it/event/a14246/>.
- Workshop "Probing and understanding exotic superconductors and superfluids", 27-31 October 2014 – Trieste <https://exs2014.wordpress.com/>.
- Weekly Seminar Series on "Disorder and Strong Electron Correlations" at ICTP, 2012-2104.
- Bi-weekly Seminar Series on "Condensed Matter and Statistical Physics" at ICTP, since 01/2016.
- Session on "Ultracold Atoms and Photonics" of the XCIX Congress of the Italian Physical Society in 2013, 23 – 27 September, Trieste <https://www.sif.it/attivita/congresso/xcix>
- Co-organizer of the XXIV Congress of the Italian National Institute of Matter Physics, 17-20 September 2006, Levico – Trento.

THIRD PARTY FUNDING:

- PRIN2017 project "CEnTraL" (PI of the UniCam Research Unit) 36 months, unit budget: 123 K€.
- PI of the FAR2018 Unicam project entitled "*Supervised machine learning for quantum matter and computational docking*", 24 months, budget 51 K€.
- PI the IS CRA Class C project entitled "SCALable Neural NETworks for QUantum Systems" (IS70 HP10COYYWP), involving an allocation of 228480cpu/hours.

- PI the IS CRA Class C project entitled “*Combining Quantum Monte Carlo Simulations with Machine Learning Techniques*” (IsC63 HP10C59ASO), involving an allocation of 326000cpu/hours, officially corresponding to 2040€.
- PI the IS CRA Class C project entitled “*Simulation of Complex Quantum Systems*” (IsC55 HP10CTITUQ), involving an allocation of 360000cpu/hours, officially corresponding to 2250€.
- With co-organizers, we were awarded the “Junior Block Travel Award”, worth 6000\$, from the international institute ICAM, as contribution for the Workshop “*Probing and understanding exotic superconductors and superfluids*”, 27-31 October 2014.
- With co-organizers, we were awarded the “General Workshop Award”, worth 10000\$, from the international institute ICAM, as contribution for the Workshop “*Theory and Practice of Adiabatic Quantum Computers and Quantum Simulation*”, 22-26 August 2016 – Trieste.
- With co-organizers, we were awarded 7000\$ from the Psi-k network to organize the workshop on “*Understanding quantum phenomena with Path Integrals: from Chemical Systems to Quantum Fluid and Solids*”.

TEACHING:

- Course “Calcolo numerico e Programmazione”, 72h, Laurea Triennale in Fisica, Università di Camerino (a.y. 2017-2019).
- Course “Fisica Statistica”, 8h, Laurea Triennale in Fisica, Università di Camerino (a.y. 2018-2019).
- Member of the Doctoral School Committee for the PhD program in “*Quantum Technologies*” (UniNA, UniCAM, CNR).
- Master in High Performance Computing, module on “Monte Carlo Methods”, 10h, SISSA-ICTP – Trieste, years 2014-2016.
- Course “Numerical Methods I”, 18h, part of the Graduate Diploma Programs in “Condensed Matter Physics” and “Earth System Physics” at ICTP, and for the “International Master in Complex Systems” (Laurea magistrale, SISSA, Politecnico di Torino, Paris 6-7-11 and École Normale Supérieure), years 2012-2016.
- Course “Numerical and Monte Carlo methods”, 18h, Ph.D. Program in Statistical Physics, SISSA (Trieste), years 2011-2016.
- Course “Numerical Methods II”, 18h, in the Graduate Diploma Program in Condensed Matter Physics at ICTP, 2011-2015.
- Tutor during the ICTP Summer School on “Quantum Many-Body Physics of Ultracold Atoms and Molecules”, 2-13 July 2013, Trieste (Italy).
- Lectures (4h) in the course “Computational Quantum Physics” by Prof. M. Troyer at ETHZ in 2009-2011.
- Teaching assistant for the course on electromagnetism, 30h (UniTN, a.y. 2006/2007).

REFEREEING:

- Physical Review Letters, Physical Review B, Physical Review A (published by the American Physical Society).
- The New Journal of Physics, Journal of Physics A: Mathematical and Theoretical, and Journal of Physics B: Atomic, Molecular & Optical Physics (published by the Institute of Physics).
- The European Physical Journal (published by EDP Sciences, Società Italiana di Fisica and Springer).
- Journal of Statistical Mechanics: theory and experiment (published by IOP and SISSA).
- IEEE Access.

INVITED TALKS:

- Machine Learning for Quantum Design, 9-12 July 2019, Waterloo (Canada).
- Quasiperiodicity and Fractality in Quantum Statistical Physics, 20-23 May 2019, New Brunswick (USA).
- SuperFluctuations 2018, Fluctuations and Highly Non-Linear Phenomena in Superfluids and Superconductors, 5-7 September (2018), San Benedetto del Tronto (Italy).
- Superfluctuations 2017, 6-8 September 2017, San Benedetto del Tronto (Italy).
- IX Brazilian Meeting on Simulational Physics (BMSP), 21-25 August 2017, Natal (Brazil).
- Many-body Physics in Synthetic Quantum Systems, 4-8 April 2016, Stellenbosch, South Africa.

- XVIII International Conference on Recent Progress in Many-Body Theories, 16-21 August 2015, Buffalo (USA).
- Multisuper 2014. International Conference on “Multicondensate Superconductivity and Superfluidity in Solids and Ultracold Gases”, 24-27 June 2014, Camerino (Italy).
- Workshop “Correlation in Ultracold Atomic Gases”, 26-27 September 2013, Padova (Italy).
- Conference “Quantum Technologies IV”, 15-20 September 2013, Warsaw (Poland).
- INT Program “Advances in QMC techniques”, 24 June -2 August 2013, Seattle (USA).
- CECAM Workshop on “Modeling Materials with Cold Gases Through Simulations”, 9-11 November 2011, Zurich (Switzerland).
- Workshop “Correlations in Quantum Gases”, 30 September-2 October 2010, Menorca (Spain).
- International Workshop: “Theory of Quantum Gases and Quantum Coherence” 2-4 June 2010, Nice (France).
- Workshop on Quantum Monte Carlo techniques, 29 November 2008, Sardinia (Italy).

TALKS GIVEN AT REVIEW MEETINGS:

- DARPA Review meeting, Optical Lattice Emulator project, 20-24 June 2011, Vail (Colorado-USA).
- DARPA Review meeting, Optical Lattice Emulator project, 23-25 May 2010 Houston (Texas-USA).
- QSIT Meeting, 27-29 January 2010, Arosa (Switzerland).
- Joint Trento-Innsbruck Meeting, 30 November 2007, Innsbruck (Austria).

COMPUTER/PROGRAMMING SKILLS:

- Programming in Python, C/C++, Fortran90, Bash scripts.
- Machine learning: deep and convolutional neural networks, Boltzmann machines, clustering algorithms (k-means, SOM), PCA. Machine learning libraries: scikit-learn, Keras.
- Parallel Programming (OPENMP).
- Use of modern libraries of Linear Algebra Computations (PLASMA, MKL, Lapack).
- Microsoft Office (Word, Excel, PowerPoint), OpenOffice, Xmgrace, Gnuplot.
- Versioning and revision control systems (Github, SVN, Vistrails).

LANGUAGE SKILLS: fluent in Italian, English and Spanish, basic knowledge of German (level A2.1 of CEFR).

BIBLIOGRAPHIC DATA

Published Articles: 30

1 in Nature Physics (2017 WOS Impact Factor 22.727), 8 in Physical Review Letters (8.839), 1 in Scientific Reports (4.122), 4 in Physical Review B (3.813), 2 in New Journal of Physics (3.579), 10 in Physical Review A (2.909), 1 in Journal of Statistical Mechanics: Theory and Experiment (2.404), 1 in Physical Review E (2.284), 1 in The European Physical Journal B (1.536), 1 in Condensed Matter Theories [Proceedings Paper].

Citations according to ISI - Web of Science (Thomson Reuters)

Sum of the Times Cited: 620

h-index (Web of Science): 13

August 22nd, 2019.

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COMPLETE PUBLICATION LIST

30. P. Mujal, A. Polls, S. Pilati, B. Juliá-Díaz, "Few-boson localization in a continuum with speckle disorder"
Physical Review A **100**, 013603 (2019)
DOI: 10.1103/PhysRevA.100.013603 WOS:000473534300004 2-s2.0-85069875424
29. S. Pilati, P. Pieri, "Supervised machine learning of ultracold atoms with speckle disorder",
Scientific Reports **9**, 5613 (2019)
DOI: 10.1038/s41598-019-42125-w WOS:000463313600007 2-s2.0-85064006185
28. E. M. Inack, G. Santoro, L. Dell'Anna, S. Pilati, "Projective quantum Monte Carlo simulations guided by unrestricted neural network states"
Physical Review B **98**, 235145 (2018)
DOI: 10.1103/PhysRevB.98.235145 WOS:000454160800003 2-s2.0-85058936079
27. E. M. Inack, G. Giudici, T. Parolini, G. Santoro, S. Pilati, "Understanding Quantum Tunneling using Diffusion Monte Carlo Simulations"
Physical Review A **97**, 032307 (2018)
DOI: 10.1103/PhysRevA.97.032307 WOS:000426900500005 2-s2.0-85043999521
26. F. Ancilotto, D. Rossini, S. Pilati, "Out-of-equilibrium dynamics of repulsive Fermi gases in quasi-periodic potentials: a Density Functional Theory study"
Physical Review B **97**, 155107 (2018)
DOI: 10.1103/PhysRevB.97.155107 WOS:000429209200001 2-s2.0-85045241346
25. S. Pilati, I. Zintchenko, M. Troyer, F. Ancilotto, "Density functional theory versus quantum Monte Carlo simulations of Fermi gases in the optical-lattice arena"
The European Physical Journal B **91** (4), 70 (2018)
DOI: 10.1140/epjb/e2018-90021-1 WOS:000431352800001 2-s2.0-85046487276
24. S. Pilati, L. Barbiero, R. Fazio, L. Dell'Anna, "One-dimensional Repulsive Fermi Gas in a Tunable Periodic Potential"
Physical Review A **96**, 021601(R) (2017)
DOI: 10.1103/PhysRevA.96.021601 WOS:000407923500001 2-s2.0-85028683006
23. S. Pilati, V. Kerala Varma, "Localization of interacting Fermi gases in quasiperiodic potentials"
Physical Review A **95**, 013613 (2017)
DOI: 10.1103/PhysRevA.95.013613 WOS:000392070100013 2-s2.0-85010015296
22. G. Mossi, T. Parolini, S. Pilati, A. Scardicchio, "On the quantum spin glass transition on the Bethe lattice"
Journal of Statistical Mechanics: Theory and Experiment, (2017) 013102
DOI: 10.1088/1742-5468/aa5286 WOS:000395433200001 2-s2.0-85012249163
21. V. Kerala Varma, S. Pilati, V. E. Kravtsov, "Conduction in quasi-periodic and quasi-random lattices: Fibonacci, Riemann, and Anderson models"
Physical Review B **94**, 214204 (2016)
DOI: 10.1103/PhysRevB.94.214204 WOS:000390247100001 2-s2.0-85006289263
20. S. Pilati, E. Fratini, "Ferromagnetism in a repulsive atomic Fermi gas with correlated disorder"
Physical Review A **93**, 051604(R) (2016)
DOI: 10.1103/PhysRevA.93.051604 WOS:000376902600002 2-s2.0-84973375498
19. E. Fratini, S. Pilati, "Anderson localization in optical lattices with correlated disorder"
Physical Review A **92**, 063621 (2015)
DOI: 10.1103/PhysRevA.91.061601 WOS:000366490300012 2-s2.0-84950151756

18. E. M. Inack, S. Pilati, "*Simulated quantum annealing of double-well and multi-well potentials*"
Physical Review E **92**, 053304 (2015)
DOI: 10.1103/PhysRevE.92.053304 WOS:000365001400009 2-s2.0-84949255555
17. V. K. Varma, S. Pilati, "*Kohn's localization in disordered fermionic systems with and without interactions*"
Physical Review B **92**, 134207 (2015)
DOI: 10.1103/PhysRevB.92.134207 WOS:000362895100002 2-s2.0-84944789770
16. E. Fratini, S. Pilati, "*Anderson localization of matter waves in quantum-chaos theory*"
Physical Review A **91**, 061601(R) (2015) **Editors' Suggestion**
DOI: 10.1103/PhysRevA.91.061601 WOS:000355824800002 2-s2.0-84937458468
15. E. Fratini, S. Pilati, "*Zero-temperature equation of state and phase diagram of repulsive fermionic mixtures*"
Physical Review A **90**, 023605 (2014)
DOI: 10.1103/PhysRevA.90.023605 WOS:000341251000006 2-s2.0-84905671247
14. T. T. Nguyen, A. J. Herrmann, M. Troyer, S. Pilati, "*Critical Temperature of Interacting Bose Gases in Periodic Potentials*"
Physical Review Letters **112**, 170402 (2014)
DOI: 10.1103/PhysRevLett.112.170402 WOS:000338647900001 2-s2.0-84899767442
13. S. Pilati, I. Zintchenko, M. Troyer, "*Ferromagnetism of a Repulsive Atomic Fermi gas in an Optical Lattice: a Quantum Monte Carlo study*"
Physical Review Letters **112**, 015301 (2014)
DOI: 10.1103/PhysRevLett.112.015301 WOS:000331937900014 2-s2.0-77954769193
12. P. N. Ma, S. Pilati, M. Troyer, X. Dai, "*Density functional theory for atomic Fermi gases*"
Nature Physics **8**, 601-605 (2012)
DOI: 10.1038/NPHYS2348 WOS:000307223900011 2-s2.0-84864969316
11. S. Pilati, M. Troyer, "*Bosonic superfluid-insulator transition in continuous space*",
Physical Review Letters **108**, 155301 (2012)
DOI: 10.1103/PhysRevLett.108.155301 WOS:000302635600009 2-s2.0-84859620702
10. S. Nascimbène, N. Navon, S. Pilati, F. Chevy, S. Giorgini, A. Georges, C. Salomon, "*Fermi-Liquid Behavior of the Normal Phase of a Strongly Interacting Gas of Cold Atoms*"
Physical Review Letters **106**, 215303 (2011)
DOI: 10.1103/PhysRevLett.106.215303 WOS:000291018000006 2-s2.0-79960651373
9. S. Pilati, G. Bertaina, S. Giorgini, M. Troyer, "*Itinerant ferromagnetism of a repulsive atomic Fermi gas: a quantum Monte Carlo study*"
Physical Review Letters **105**, 030405 (2010)
DOI: 10.1103/PhysRevLett.105.030405 WOS:000280008900001 2-s2.0-77954769193
8. S. Pilati, S. Giorgini, M. Modugno, N. Prokof'ev, "*Dilute Bose gas with correlated disorder: a path integral Monte Carlo study*"
New Journal of Physics **12**, 073003 (2010)
DOI: 10.1088/1367-2630/12/7/073003 WOS:000279880100003 2-s2.0-77955313155
7. B. Capogrosso-Sansone, S. Giorgini, S. Pilati, L. Pollet, N. V. Prokof'ev, B. V. Svistunov, and M. Troyer, "*Beliaev technique for a weakly interacting Bose gas*"
New Journal of Physics **12**, 043010 (2010)
DOI: 10.1088/1367-2630/12/4/043010 WOS:000276349800010 2-s2.0-77951958029
6. S. Pilati, S. Giorgini, N. Prokof'ev, "*Superfluid Transition in a Bose Gas with Correlated Disorder*"
Physical Review Letters **102**, 150402 (2009)

- DOI: 10.1103/PhysRevLett.102.150402 WOS:000265285700002 2-s2.0-65549167933
5. S. Pilati, S. Giorgini, N. Prokof'ev, "Critical Temperature of Interacting Bose Gases in Two and Three Dimensions" Physical Review Letters **100**, 140405 (2008)
DOI: 10.1103/PhysRevLett.100.140405 WOS:000254940900005 2-s2.0-42149154773
 4. S. Pilati, S. Giorgini, "Phase separation in a polarized Fermi gas at zero temperature" Physical Review Letters **100**, 030401 (2008)
DOI: 10.1103/PhysRevLett.100.030401 WOS:000252698100003 2-s2.0-38549131501
 3. S. Pilati, K. Sakkos, J. Boronat, J. Casulleras and S. Giorgini, "Equation of State of an interacting Bose gas: A path-integral Monte Carlo study" Physical Review A **74**, 043621 (2006)
DOI: 10.1103/PhysRevA.74.043621 WOS:000241723100155 2-s2.0-33750458017
 2. J. Boronat, G. E. Astrakharchik, J. Casulleras, S. Giorgini, S. Pilati, "Quantum Monte Carlo in the Study of Dilute Bosonic and Fermionic Gases" CONDENSED MATTER THEORIES **20**, 395 (2006)
WOS:000246300900031
 1. S. Pilati, J. Boronat, J. Casulleras and S. Giorgini, "Quantum Monte Carlo simulation of a two-dimensional Bose gas" Physical Review A **71**, 023605 (2005)
DOI: 10.1103/PhysRevA.71.023605 WOS:000227483900091 2-s2.0-33344467801

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