Giacomo Bighin

Curriculum vitæ

Personal information

Date of birth	19th June, 1987
E-mail	bighin@gmail.com
Nationality	Italian
Website	http://bigh.in

Scientific interests

- Many-body physics and quantum field theory.
- Ultracold gases and Bose-Einstein condensates.
- Computational approaches to many-body physics: Diagrammatic Monte Carlo.
- Statistical mechanics of complex systems.

Professional academic experience

July 2025 **Senior research assistant**, *PMF, University of Zagreb, Croatia*
Since July 2025 I work as a senior research assistant (viši asistent) at PMF (Prirodoslovno-matematički fakultet), Univesity of Zagreb, Division for Theoretical Physics of Condensed Matter.

November 2020– –October 2022 **Postdoctoral researcher**, *Institute for Theoretical Physics (ITP) and STRUCTURES Excellence Cluster, University of Heidelberg, Germany.*
While in Heidelberg, I focused on the statistical mechanics of complex systems, i.e. how collective phenomena and complexity emerge from very simple physical rules. I studied by means of Monte Carlo simulations and machine learning/computer vision tools critical phenomena on lattices and on complex networks.

September 2016– –October 2020 **Postdoctoral researcher**, *IST Austria, Klosterneuburg, Austria*
At ISTA I investigated the quantum properties of a molecule in a solution. How are the molecular energy levels modified by the environment? How will the molecule react to an external perturbation? I developed novel analytical and computational – Markov chain Monte Carlo – approaches to answer these questions, that are essential in understanding how molecules can be used as building blocks for quantum computers.

Education

April 2016 **Ph.D. in Physics**, *University of Padua, Padua, Italy*
Adviser: Prof. Luca Salasnich.
Thesis title: *"Mean field and fluctuations for fermionic systems: from ultracold Fermi gases to cuprates"*.

September 2012 **Master's Degree in Physics**, *University of Padua, Padua, Italy*
Adviser: Prof. Pieralberto Marchetti.
Thesis title: *"A gauge approach to superfluid density in high-T_c cuprates"*, graduation score 110/110 *cum laude* (full marks with honors, the highest score in the Italian system).

Other research experience

April–June 2014 **TQC Group, University of Antwerp**, *Antwerp, Belgium*
Research visit in the group of Prof. Jacques Tempere.

July–September 2011 **U.S. Department of Energy — Fermilab**, *Batavia, IL, U.S.A*
Intern, Particle Physics Division.

Honors, awards and grants

January 2019 Lise Meitner Fellowship of the Austrian Science Fund (FWF), ~170,000€, for the project *"A path-integral approach to composite impurities"*, project nr. M2641-N27.

Summer 2016 FFG (Austria Research Promotion Agency) Career Grant, ~2,000€.

January 2013 Full Ph.D. scholarship from INFN (Istituto Nazionale di Fisica Nucleare), ~40,000€.

Publications

Published in peer-reviewed journals:

28. **G. Bighin**, P.A. Murthy, N. Defenu, T. Enss, *"Resonantly enhanced superconductivity mediated by spinor condensates"*, Phys. Rev. Research **7**, L022070 (2025).
27. A. Cappellaro, **G. Bighin**, I. Cherepanov, and M. Lemeshko, *"Environment-limited transfer of angular momentum in Bose liquids'*, J. Chem. Phys. **162**, 074104 (2025).
26. M. Lanaro, **G. Bighin**, L. Dell'Anna, L. Salasnich, *"Finite-size effects in the two-dimensional BCS-BEC crossover"*, Phys. Rev. B **109**, 104511 (2024).
25. **G. Bighin**, T. Enss, N. Defenu, *"Universal scaling in real dimension"*, Nat. Commun. **15**, 4207 (2024).
24. A. G. Volosniev, **G. Bighin**, L. Santos, L. A Peńa Ardila, *"Non-equilibrium dynamics of dipolar polarons"*, SciPost Phys. **15**, 232 (2023).

23. **G. Bighin**, Q.P. Ho, M. Lemeshko, T.V. Tscherbul, *"Diagrammatic Monte Carlo for electronic correlation in molecules: high-order many-body perturbation theory with low scaling"*, Phys. Rev. B **108**, 045115 (2023).
22. L. Salasnich, A. Cappellaro, K. Furutani, A. Tononi, **G. Bighin**, *"First and second sound in two-dimensional bosonic and fermionic superfluids"*, Symmetry **14**, 2182 (2022).
21. **G. Bighin**, A. Cappellaro, L. Salasnich, *"Unitary Fermi superfluid near the critical temperature: thermodynamics and sound modes from elementary excitations"*, Phys. Rev. A **105**, 063329 (2022) (Selected as Editors' Suggestion).
20. I.N. Cherepanov, **G. Bighin**, C.A. Schouder, A.S. Chatterley, H. Stapelfeldt, M. Lemeshko, *"A simple model for high rotational excitations of molecules in a superfluid"*, New J. Phys. **24**, 075004 (2022).
19. **G. Bighin**, A. Burchianti, F. Minardi, T. Macrì, *"An impurity in a heteronuclear two-component Bose mixture"*, Phys. Rev. A. **106**, 023301 (2022).
18. I.N. Cherepanov, **G. Bighin**, C.A. Schouder, A.S. Chatterley, S.H. Albrechtsen, A. Viñas Muñoz, L. Christiansen, H. Stapelfeldt, M. Lemeshko, *"Excited rotational states of molecules in a superfluid"*, Phys. Rev. A **104**, L061303 (2021).
17. A. Tononi*, A. Cappellaro*, **G. Bighin***, L. Salasnich, *"Propagation of first and second sound in a two-dimensional Fermi superfluid"*, Phys. Rev. A **103**, L061303 (2021).
16. W. Rzadkowski, N. Defenu, S. Chiacchiera, A. Trombettoni, **G. Bighin**, *"Detecting hidden and composite orders in layered models via machine learning"*, New. J. Phys. **22**, 093026 (2020).
15. A.S. Chatterley, L. Christiansen, C.A. Schouder, A.V. Jørgensen, B. Shepperson, I.N. Cherepanov, **G. Bighin**, R.E. Zillich, M. Lemeshko, H. Stapelfeldt, *"Rotational coherence spectroscopy of molecules in helium nanodroplets: Reconciling the time and the frequency domains"*, Phys. Rev. Lett. **125**, 013001 (2020).
14. X. Li, E. Yakaboylu, **G. Bighin**, R. Schmidt, M. Lemeshko, A. Deuchert, *"Intermolecular forces and correlations mediated by a phonon bath"*, J. Chem. Phys. **152**, 164302 (2020).
13. **G. Bighin***, N. Defenu*, I. Nándori, L. Salasnich, A. Trombettoni, *"BKT-paired phase in coupled XY models"*, Phys. Rev. Lett. **123**, 100601 (2019).
12. X. Li, **G. Bighin**, E. Yakaboylu and M. Lemeshko, *"Variational approaches to quantum impurities: from the Fröhlich polaron to the angulon"*, Mol. Phys. **117**, 1981-1988 (2019).
11. **G. Bighin**, T. V. Tscherbul and M. Lemeshko, *"Diagrammatic Monte Carlo approach to angular momentum in quantum many-particle systems"*, Phys. Rev. Lett. **121**, 165301 (2018).
10. **G. Bighin** and M. Lemeshko, *"Diagrammatic approach to orbital quantum impurities interacting with a many-particle environment"*, Phys. Rev. B **96**, 085410 (2017) (Selected as Editors' Suggestion).
9. **G. Bighin** and L. Salasnich, *"Vortices and antivortices in two-dimensional ultracold Fermi gases"*, Sci. Rep. **7**, 45702 (2017).

8. P.A. Marchetti and **G. Bighin**, *"Superfluid Density in Cuprates: Hints on Gauge Compositeness of the Holes"*, J. Supercond. Nov. Magn. **30**, 721 (2017).
7. L. Salasnich and **G. Bighin**, *"Quantum Fluctuations and Vortex-Antivortex Unbinding in the 2D BCS-BEC Crossover"*, J. Supercond. Nov. Magn **29**, 3103 (2016).
6. P.A. Marchetti and **G. Bighin**, *"Universality in cuprates: a gauge approach"*, J. Low Temp. Phys. **185**, 87 (2016).
5. **G. Bighin** and L. Salasnich, *"Finite-temperature quantum fluctuations in two-dimensional Fermi superfluids"*, Phys. Rev. B **93**, 014519 (2016)
4. **G. Bighin**, L. Salasnich, P.A. Marchetti and F. Toigo, *"Beliaev damping of the Goldstone mode in atomic Fermi superfluids"*, Phys. Rev. A **92**, 023638 (2015)
3. P.A. Marchetti and **G. Bighin**, *"Gauge approach to superfluid density in underdoped cuprates"*, Europhys. Lett. **110**, 37001 (2015) (Selected as Editor's Choice)
2. L. Salasnich and **G. Bighin**, *"Scattering length of composite bosons in the three-dimensional BCS-BEC crossover"*, Phys. Rev. A **91**, 033610 (2015)
1. **G. Bighin**, L. Salasnich, G. Mazzarella, and L. Dell'Anna, *"Pair condensation of polarized fermions in the BCS-BEC crossover"*, J. Phys. B **47**, 195302 (2014)

∗ denotes equal contribution.

Proceedings:

— L. Salasnich and **G. Bighin**, *"Renormalization of the superfluid density in the two-dimensional BCS-BEC crossover"*, in the proceedings of the International Conference "Electron correlation in superconductors and nanostructures", 17-20 August 2017, Odessa (Ukraine). International Journal of Modern Physics B **32**, 1840022 (2018).

— **G. Bighin** and L. Salasnich, *"Gaussian fluctuations in the two-dimensional BCS-BEC crossover: finite temperature properties"*, in the proceedings of the 24th Annual International Laser Physics Workshop, J. Phys.: Conf. Ser. **691**, 012018 (2016).

Invited and contributed talks

April 15th, 2025 *"Quantum impurities and angular momentum in a many-body system: analytical and numerical approaches"*
Invited talk at PMF (Prirodoslovno-matematički fakultet), University of Zagreb, Zagreb, Croatia.

March 6th, 2025 *"Quantum impurities and angular momentum in a many-body system: analytical and numerical approaches"*
Invited talk at the Institut za Fiziku, Zagreb, Croatia.

December 7th, 2022 *"An impurity in a heteronuclear two-component Bose-Bose mixture"*
Invited talk at the Institute for Science and Technology Austria, Klosterneuburg, Austria.

May 13th, 2022 *"Detecting composite orders in layered models via machine learning"*
Contributed talk the Quantum Magnetism and Statistical Mechanics of Lattice Models conference, Yerevan, Armenia.

March 3rd, 2022 *"An impurity in a heteronuclear two-component Bose-Bose mixture"*
Invited talk at University of Padua, Italy.

June 23rd, 2020 *"Rotational coherence spectroscopy and far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets"*
Invited talk at the SuperFluctuations 2020 conference, Padova, Italy. Delivered online due to the COVID-19 crisis.

June 4th, 2020 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at the 'Spring Workshop on Ultracold Quantum Matter', University of Padova, Italy. Delivered online due to the COVID-19 crisis.

April 16th, 2020 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at Universidade Federal do Rio Grande do Norte – Natal, Brazil. Delivered online due to the COVID-19 crisis.

March 17th, 2020 Invited talk at Leibniz Universität Hannover, Germany. Canceled due to the COVID-19 crisis.

February 17th, 2020 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at Max Planck Institute of Quantum Optics, Garching, Germany.

December 19th, 2019 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Contributed talk at the 1st Workshop on Molecular Quantum Technology (MQT2019), Puerto Natales, Chile.

December 10th, 2019 *"Diagrammatic Monte Carlo approach to angular momentum in quantum many-body systems"*
Contributed talk at the "Polarons in the 21st Century" workshop, Erwin Schrödinger Institute, Vienna.

September 2019 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at Universitat Politècnica de Catalunya, Barcelona, Spain.

September 3rd, 2019 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at the SuperFluctuations 2019 conference, Padova, Italy.

May 23th, 2019 *"Far-from-equilibrium dynamics of molecules in ^{4}He nanodroplets: a quasiparticle perspective"*
Invited talk at Universität Heidelberg, Germany.

March 15th, 2019 *"Diagrammatic Monte Carlo approach to angular momentum in quantum many-body systems."*
Contributed talk at the DPG Frühjahrstagung, Rostock, Germany.

March 5th, 2019 *"Diagrammatic Monte Carlo approach to angular momentum in quantum many-body systems"*
Contributed talk at the APS March Meeting, Boston, USA.

October 31st, 2018 *"Composite, rotating impurities interacting with a many-body environment: analytical and numerical approaches"*
Physics Colloquium, University of Nevada, Reno, U.S.A.

September 6th, 2018 *"Molecular impurities interacting with a many-body environment: dynamics in Helium nanodroplets"*
Invited talk at the SuperFluctuations 2018 conference, San Benedetto del Tronto, Italy.

July 19th, 2018 *"Composite, rotating impurities interacting with a many-body environment: analytical and numerical approaches"*,
CQD Special Seminar, Universität Heidelberg, July 19th, 2018

March 5th, 2018 *"A Diagrammatic Monte Carlo study of a composite, rotating impurity."*
Contributed talk at the DPG Frühjahrstagung, Erlangen, Germany.

September 7th, 2017 *"A diagrammatic approach to composite, rotating impurities"*
Invited talk at the SuperFluctuations 2017 conference, San Benedetto del Tronto, Italy.

June 27th, 2017 Contributed talk at the CECAM Workshop *"Dopant dynamics in superfluid Helium-4 nanodroplets: from statics to time-dependent He-DFT"*, Toulouse, France.

July 4th, 2017 *"A diagrammatic approach to composite, rotating impurities"*
Contributed talk at the Workshop on Understanding Quantum Phenomena with Path Integrals: From Chemical Systems to Quantum fluids and Solids, ICTP, Trieste, Italy.

June 14th, 2017 *"A diagrammatic approach to composite, rotating impurities."*
Invited talk at University of Padua, Italy.

March 7th, 2017 *"A diagrammatic approach to composite, rotating impurities."*,
Contributed talk at the 2017 DPG Frühjahrstagung, Mainz, Germany.

April 6th, 2016 *"Gaussian fluctuations in the two-dimensional BCS-BEC crossover"*
Invited talk at IST Austria, Klosterneuburg, Austria.

January 11th, 2016 *"Gaussian fluctuations in the two-dimensional BCS-BEC crossover"*
Invited talk at the Winter Workshop on Ultracold Quantum Matter, University of Padua, Italy

August 25th, 2015 *"Gaussian fluctuations in the two-dimensional BCS-BEC crossover: finite temperature properties"*, Contributed talk at the 24th International Laser Physics Workshop, Shanghai, PR China

June 5th, 2014 *"Condensate fraction for a polarized Fermi gas"*
Invited talk at University of Antwerp, Belgium

Refereeing

Referee for Physical Review Letters, Physical Review X, Physical Review A, Physical Review B, Physical Review Research, New Journal of Physics, Journal of Physics B: Atomic, Molecular and Optical Physics, Journal of Superconductivity and Novel Magnetism, MDPI Condensed Matter, MDPI Symmetry, and MDPI Applied Sciences.

Teaching experience

Winter semester 2021-2022	Teaching assistantship for the course *"Condensed Matter Theory"* by professor M. Haverkort, University of Heidelberg.
Summer semester 2021	Teaching assistantship for the seminar course *"Statistical Physics"* by professor A. Mielke, University of Heidelberg.
March 2017 and March 2018	Three guest lectures on the path integral formalism, as a part of Prof. Mikhail Lemeshko's course *"Modern Atomic, Molecular, and Optical Physics"* at IST Austria.
Spring 2016	Teaching assistantship (didattica di supporto), Physics Laboratory course, Biology Department, University of Padova.
Fall 2015	Teaching assistantship (didattica di supporto) for the Electromagnetism course for 3rd year students, B.D. in Mathematics, University of Padova.

Outreach and other activities

July 2019 and July 2022	I taught at a 'Maths Camp', designed to expose high-school students of developing countries to new mathematical ideas, inspiring them outside the classroom. The activity is run by NGO 'Supporting African Maths Initiatives' (SAMI) and hosted by the African Institute for Mathematical Sciences, Kigali, Rwanda.
April 2017–April 2018	President, PostDoc Association, IST Austria, Klosterneuburg, Austria.
October 2014–April 2016	Ph.D. students' representative, Department of Physics and Astronomy, University of Padua.

Languages

Italian	Native.
English	Full professional proficiency. In 2011, I have taken the TOEFL® IBT standardized test, achieving a total score of 102/120.
Croatian	Basic knowledge.
German	Basic knowledge.
Ancient Greek	Fair reading comprehension.
Latin	Fair reading comprehension.

Computer skills

Advanced experience:	Excellent knowledge of the C, C++, and Python programming languages, which I used extensively in academic and industry projects. Very good knowledge of parallel computing interfaces (OpenMP and MPI), of workload managers for high-performance clusters (SLURM) and of standard scientific computing/machine learning libraries (PyTorch, TensorFlow). Very high familiarity with UNIX-like operating systems, especially Linux and macOS.
Intermediate experience:	LaTeX, bash. Haskell.