

PERSONAL INFORMATION

Family name: Salasnich. First name: Luca.
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Education

1995 PhD with honors in Physics, University of Florence.
1991 MSc with honors in Physics, University of Padua.

Current Position

Full Professor of Condensed Matter Theory, University of Padua.

Previous Positions

2011-2020 Associate Professor of Condensed Matter Theory, University of Padua.
2003-2011 Researcher (with tenure), Consiglio Nazionale delle Ricerche (CNR, Milan and then Padua).
1997-2003 Postdoc, Department of Physics, University of Milan.
1996-1997 Postdoc, Department of Pure and Applied Mathematics, University of Padua.
1996 Postdoc, CAMTP, University of Maribor (Slovenia).
1994-1995 Visiting Scholar, Department of Physics, “Complutense” University of Madrid (Spain).

Main Fellowships and Awards

2017 Individual research grant (FFABR) of MIUR for the best Associate Professors of Italy.
2009 “Best CNR researchers”. Award received from Consiglio Nazionale delle Ricerche.
2003-2004 Researcher INFM Fellowship “Giovani Valenti”.
2000-2001 Postdoc INFM Fellowship “Giovani Valenti - Giovanni Paladin”.
1997 “Premio Operosità Scientifica – Giovani Laureati”. Award received from Italian Physical Society.
1996 Scholarship of Rectors' Conference of Alps-Adria Regions.
1994 “Prize Prof. Italo Filosofo”, from Venetian Institute for Sciences, Humanities, and Arts.

Supervision of Graduate Students and Postdoctoral Fellows

30 Master Students in Physics; 15 Master Students in Physics Education; 6 PhD Students in Physics;
10 Postdoctoral Fellows in Physics.

TEACHING ACTIVITIES

2011-2023 Structure of Matter and Advanced Quantum Physics, MSc and PhD in Physics,
University of Padua.
2015-2019 Theoretical Physics, BSc in Philosophy, University of Padua.
2016-2019 General Physics, Free University of Bozen.
2008-2010 Epistemology of Physics, “Ca' Foscari” University of Venice.
2001-2003 Epistemology of Physics and Mathematics, Free University of Bozen.
1997-2010 General Physics, Applied Physics, and General Mathematics, University of Padua.

ORGANIZATION OF SCIENTIFIC MEETINGS

Until now, I was the co-organizer of more than 20 Scientific International Conferences, Workshops and Colloquia. Among them:

- “Quantum gases as analogues of condensed matter systems”, MiniColloquium, 30th General Conference Condensed Matter Division of European Physical Society, Milan, 2023.
- “Superstripes 2023”, Ischia, 2023.
- “SuperFluctuations 2022”, Padua, 2022.
- “Quantum and Atom Optics 2018”, Patna (India), 2018.
- Focus Workshop on “Long-Range Interacting Systems”, Natal (Brazil), 2016.

INSTITUTIONAL RESPONSIBILITIES

2013-2021 Program Director, BSc in Optics and Optometrics, University of Padua.
2002-2020 Member, Scientific Funding Committee “Physical Sciences”, University of Padua.
2018-2022 Member, Board of Directors, PhD School of Physics, University of Padua.
2016-2021 Member, Board of Directors, School of Sciences, University of Padua.
2017-2021 Program Director, Advanced Training Course in Contactology, University of Padua.

REVIEWING ACTIVITIES**Editorial Boards and Scientific Institutions**

From 2022 Scientific Chair, Experts Panel W&T2 “Physics”, FWO (Funding Agency of Flanders).

From 2020 College Editorial Fellow of “SciPost Physics”.

From 2022 Member of the Editorial Board of “Scientific Reports”

From 2019 Member of the Editorial Board of “Symmetry-Basel”.

2018-2021 Member of the Editorial Board of “New Journal of Physics”.

2019-2021 Member of the Experts Panel W&T2 “Physics”, FWO (Funding Agency of Flanders).

In addition, I was the external/board member reviewer of more than 30 PhD thesis.

Scientific Journals and Funding Agencies

Referee of many scientific journals, among them Nature, Phys. Rev. Lett., Phys. Rev. A, Phys. Rev. B, Phys. Rev. E, and New J. Phys. Referee of many funding agencies, among them National Science Foundation, European Research Council, and US-Israel Binational Science Foundation.

RESEARCH ACTIVITIES

Throughout my scientific career, I worked mainly on i) trapped ultracold atoms: Bose-Einstein condensation (BEC) and BCS-BEC crossover; ii) statistics of energy levels and quantum chaos; iii) nonlinear dynamics in quantum and statistical field theory; iv) many-body theory at finite temperature.

Bibliometrics

Until now, I published more than 240 scientific papers in peer-reviewed indexed journals (51 of these papers are single-authored). Among them: 1 in Nature Rev. Phys., 1 in Phys. Rep, 8 in Phys. Rev. Lett., 98 in Phys. Rev. A, 4 in Phys. Rev. B, 3 in Phys. Rev. C, 1 in Phys. Rev. D, 6 in Phys. Rev. E. The average number of authors per paper is 2.4. According to Elsevier Scopus (ES), my papers got more than 5500 citations with a Hirsch h-index of 39, while for Google Scholar (GS) the citations are more than 7300 and the h-index is 48.

Three key scientific achievements

[1] In a groundbreaking paper [L. Salasnich, A. Parola, and L. Reatto, Effective wave equations for the dynamics of cigar-shaped and disk-shaped Bose condensates, Phys. Rev. A **65**, 043614 (2002)] (522 ES citations; 730 GS citations) I derived 1D and 2D nonpolynomial Schrodinger equations, obtained from the familiar 3D Gross-Pitaevskii equation performing a dimensional reduction which, however, takes into account the integrated degrees of freedom. These equations are routinely used by several experimental and theoretical groups to investigate BECs under strong confinement. [2] In a highly-relevant paper [L. Salasnich, A. Parola, and L. Reatto, Modulational Instability and Complex Dynamics of Confined Matter-Wave Solitons, Phys. Rev. Lett. **91**, 080405 (2003)] (178 ES citations; 256 GS citations) I explained the physical mechanism of modulational instability which gives rise to a train of bright solitons in BECs observed in two seminal experiments. [3] In a third groundbreaking paper [N. Manini and L. Salasnich, Bulk and collective properties of dilute Fermi gas in the BCS-BEC crossover, Phys. Rev. A **71**, 033625 (2005)] (152 ES citations; 182 GS citations), by using a density functional approach, I predicted the collective modes of oscillations of a trapped Fermi gas in the 3D BCS-BEC crossover, confirmed by subsequent experiments.

Main international collaborators

BEC with ultracold atoms: Boris Malomed (Tel Aviv University, 24 joint papers); Sadhan Adhikari (Sao Paulo State University, 11 joint papers); Wesley B. Cardoso (Univ. Federal Goias; 3 joint papers); Luis Ever Young Silva (Univ. Cartagena, 1 joint paper); Gergely Szirmai (Wigner Research Center, 3 joint papers); Artur Polls and Bruno Julia-Diaz (University of Barcelona, 1 joint paper). Quantum chaos and spectral statistics: Marko Robnik (University of Maribor, 4 joint papers); Jose Maria Gomez Gomez (Univ. of Madrid, 5 joint papers), Armando Relano (Univ. of Madrid, 1 joint paper), Kamales Kar (Saha Institute of Nuclear Physics, 1 joint paper). Many-body theory: Barnali Chakrabarti (Presidency University, 4 joint papers). Tapan Das (Calcutta University, 3 joint papers). Edmond Orignac (CNRS Lyon, 2 joint papers). Statistical field theory: Istvan Nandori (University of Debrecen, 1 joint paper).

Invited talks at International Conferences/Schools

Until now, I gave 54 invited talks at International Conferences/Worskshops and 48 invited talks at Universities, Research Institutes, and Winter/Summer Schools.

MEMBERSHIP OF ACADEMIES AND SCIENTIFIC INSTITUTIONS

- Elected member, European Academy of Sciences (Salzbug, Austria), from 2023.
- Istituto Nazionale di Ottica (INO), Consiglio Nazionale delle Ricerche (CNR), from 2012.
- Istituto Nazionale di Fisica Nucleare (INFN), from 1990 to 1997; and now from 2020.
- Americal Physical Society, from 1991 to 1998; and now from 2020.
- Italian Physical Society, from 1992.

On-going grants

<i>Project Title</i>	<i>Funding source</i>	<i>Amount (Euros)</i>	<i>Period</i>	<i>Role of the PI</i>
Struttura della Materia	University of Padua	135.000,00	2023	Investigator
Ultracold atoms in curved geometries	University of Padua	60.000,00	2022-2023	Principal Investigator
Iniziativa Specifica Quantum	Istituto Nazionale di Fisica Nucleare (INFN)	80.000,00	2023	Investigator
Spoke Quantum	Centro Nazionale di Ricerca in High Performance Computing, Big Data e Quantum Computing	4.500.000,00	2022-2026	Investigator
Frontiere Quantistiche	MUR - Dipartimenti di Eccellenza	9.000.000,00	2023-2027	Investigator (one of the seven members who wrote the project)
Quantum Atomic Mixtures: Droplets, Topological Structures, and Vortices	MUR - PRIN 2022	240.000,00	2023-2025	Principal Investigator

Past grants

<i>Project Title</i>	<i>Funding source</i>	<i>Amount (Euros)</i>	<i>Period</i>	<i>Role of the PI</i>
Static and dynamical properties of quantum gases	University of Padua	48.000,00	2019-2020	Principal Investigator
Spin-orbit coupling in ultracold fermionic gases	University of Padua	48.000,00	2015-2016	Principal Investigator
Macroscopic quantum properties of ultracold atoms	Cariparo Foundation	75.000,00	2012-2013	Principal Investigator
Quantum information with ultracold atoms in optical lattices	University of Padua	62.000,00	2012-2014	Principal Investigator

10-Year-Track-Record

In the last 10 years (2014-2023) I obtained innovative results on the beyond-mean-field effects in bosonic and fermionic ultracold atomic gases and two-band superconductors. I was one of the first theoretical physicists who studied and understood the effects of spin-orbit and Rabi couplings on bright and dark solitons. My theoretical contribution was crucial in the first experimental study of quantum droplets in heteronuclear Bose-Bose mixtures. My predictions about Bose-Einstein condensates in spherical and elliptical configurations are nowadays a recognized benchmark for the ongoing experiments. In this period I published more than 90 papers (12 single-authored). According to Google Scholar (GS), these papers received more than 1500 citations. The top 10 publications of this period (in reverse chronological order) are:

[LS-1] A. Tononi, F. Cinti, and L. Salasnich,
“Quantum Bubbles in Microgravity”,
Phys. Rev. Lett. **125**, 010402 (2020).

We calculated for the first time the dynamical and thermodynamical properties of shell-shaped Bose-Einstein condensates with realistic bubble-trap parameters by using both mean-field techniques and path-integral Monte Carlo simulations. I conceived the work and coordinated the team.

[LS-2] C. D'Errico, A. Burchianti, M. Prevedelli, L. Salasnich, F. Ancilotto, M. Modugno, F. Minardi, and C. Fort, “Observation of quantum droplets in a heteronuclear bosonic mixture”,
Phys. Rev. Res. **1**, 033155 (2019).

This is the first experimental observation of heteronuclear quantum droplets in an attractive bosonic mixture of ^{41}K and ^{87}Rb atoms. I did, with Ancilotto and Modugno, the theoretical modeling of the system, which is made stable by quantum fluctuations (beyond-mean-field one-loop corrections).

[LS-3] A. Tononi and L. Salasnich,
“Bose-Einstein Condensation on the Surface of a Sphere”,
Phys. Rev. Lett. **123**, 160403 (2019).

This is a groundbreaking theoretical paper, where we investigated for the first time the BEC thermodynamics on the surface of a sphere obtaining analytical formulas for the critical temperature and the condensate fraction of an interacting Bose gas. We also analyzed the inclusion of a zero-range interatomic potential, extending the noninteracting results at zero and finite temperatures. I conceived and coordinated the activity.

[LS-4] L. Salasnich, A.A. Shanenko, A. Vagov, and A. Perali,
“Screening of pair fluctuations in superconductors with coupled shallow and deep bands: A route to higher-temperature superconductivity”,
Phys. Rev. B **100**, 064510 (2019).

This is a very important and innovative theoretical paper in the field of superconductivity. We demonstrate that the coexistence of a shallow carrier band with strong pairing and a deep band with weak pairing, together with the Josephson-like pair transfer between the bands to couple the two condensates, realizes an optimal multicomponent superconductivity regime. I coordinated the team with Perali and I also did the analytical calculations.

[LS-5] F. Cinti, A. Cappellaro, L. Salasnich, and T. Macri,
“Superfluid Filaments of Dipolar Bosons in Free Space”,
Phys. Rev. Lett. **119**, 215302 (2017).

This is the first systematic investigation of the zero-temperature phase diagram of bosons interacting via dipolar interactions in three dimensions in free space via path integral Monte Carlo simulations with a few hundred particles and periodic boundary conditions based on the worm algorithm. Upon increasing the strength of the dipolar interaction and at sufficiently high densities we found a wide region where filaments are stabilized along the direction of the external field. I coordinated the team with Macri.

[LS-6] A. Cappellaro, T. Macri, G.F. Bertacco, and L. Salasnich,
“Equation of state and self-bound droplet in Rabi-coupled Bose mixtures”,
Sci. Rep. **7**, 13358 (2017).

We studied for the first time the effects of quantum fluctuations on a Rabi-coupled two-component Bose gas of interacting alkali atoms, finding that the quantum pressure arising from Gaussian fluctuations can prevent the collapse of the mixture with the creation of a self-bound droplet. We characterized the droplet phase and discover an energetic instability above a critical Rabi frequency provoking the evaporation of the droplet. I conceived the work and coordinated the team.

[LS-7] L. Salasnich and F. Toigo,
 “Zero-point energy of ultracold atoms”,
 Phys. Rep. 640, 1 (2016).

For bosonic atoms, we explicitly show how to regularize this divergent contribution, which appears in the Gaussian fluctuations of the functional integration, by using three different regularization approaches: dimensional regularization, momentum cutoff regularization, and convergence-factor regularization. We also investigate the regularization in the case of fermions in the BCS-BEC crossover. The two authors contributed equally to this paper.

[LS-8] G. Bighin and L. Salasnich,
 “Finite-temperature quantum fluctuations in two-dimensional Fermi superfluids”,
 Phys. Rev. B **93**, 014519 (2016).

We were the first to include one-loop Gaussian fluctuations in the theoretical description of resonant Fermi superfluids in two dimensions demonstrating that first and second sounds, and also critical temperature, are strongly renormalized, away from their mean-field values. I conceived and coordinated the activity.

[LS-9] L. Salasnich, W.B. Cardoso, and B.A. Malomed,
 “Localized modes in quasi-two-dimensional Bose-Einstein condensates with spin-orbit and Rabi couplings”,
 Phys. Rev. A **90**, 033629 (2014).

This is a groundbreaking theoretical paper, where we considered a two-component pancake-shaped Bose-Einstein condensate coupled by the spin-orbit and Rabi terms, finding novel localized solutions which are dynamically stable. I and Malomed developed the analytical part, while Cardoso did the numerical simulations.

[LS-10] M.-A. Garcia March, G. Mazarella, L. Dell'Anna, B. Julia-Diaz, L. Salasnich, and A. Polls,
 “Josephson physics of spin-orbit-coupled elongated Bose-Einstein condensates”,
 Phys. Rev. A **89**, 063607 (2014).

For a binary bosonic confined in a quasi-one-dimensional double-well trap, we disentangled the different macroscopic quantum tunneling and self-trapping scenarios in terms of the interplay between the interatomic interactions and the other relevant energies in the problem, like the spin-orbit coupling. I proposed the problem and coordinated the team with Polls.

Invited talks at International Conferences/Schools

In the last 10 years, I gave more than 40 invited talks at International Conferences/Workshops, Winter/Summer Schools, and Research Centers/Universities. A short selection of the last two years:

- “Thermodynamics and sound modes of the unitary Fermi superfluid”, Newcastle University, Newcastle (UK), November 2022.
- “Bose-Einstein condensate on the Surface of a Sphere”, International Workshop ‘Prospects of Quantum Bubble Physics’, Hanover (Germany), April 2022.
- “Unitary Fermi superfluid: thermodynamics and sound modes from elementary excitations”, MiniColloquium ‘Collective Effects and Non-Equilibrium Phenomena in Quantum Gases and Superconductors’, CMD29, Manchester (UK), August 2022.
- “First and second sound in two-dimensional bosonic and fermionic systems”, International Workshop ‘Quantum Transport with ultracold atoms’, Dresden (Germany), September 2022.
- “Bright and dark solitons of atomic Bose-Einstein condensates”, at the workshop “Soliton-22”, Thapar Institute of Engineering and Technology, Patiala, Punjab (India), March 2022.
- “Bose-Einstein Condensation on Curved Surfaces”, Physics Institute of Sao Carlos (IFSC) of the University of Sao Paulo (USP), Sao Carlos (Brazil), October 2021.
- “Dissipation and fluctuations in Josephson junctions”, invited talk at the 29th International Laser Physics Workshop, online, July 2021.

Major Contribution to the Early Careers of Excellent Researchers

Barnali Chakrabarti (4 joint papers): she was a postdoc and now she is an Associate Professor at the Presidency University (India). Luca Barbiero (3 joint papers): he was a postdoc and now he is an Assistant Professor at Politecnico di Torino (Italy). Luca Lepori (2 joint papers): he was a postdoc and now he is an Assistant Professor at the University of Parma (Italy). Armando Relano (1 joint PRL paper): he was a PhD student and now he is an Associate Professor at the “Complutense” University of Madrid (Spain). Several former students of mine have relevant research positions in Public Institutes and Private Companies in Europe.