# DR. ANDREA TONONI

## PERSONAL DETAILS

Birth: 21/05/1994 in Borgo Maggiore, San Marino

Nationality: Italian, Sammarinese Email: andrea.tononi@upc.edu Webpage: www.andreatononi.com

Google Scholar: link



#### SCIENTIFIC CAREER

Marie-Skłodowska Curie Postdoctoral Fellow,

Universitat Politècnica de Catalunya, Barcelona, Spain.

Supervisor: Prof. Pietro Massignan.

Funding source: Marie Skłodowska-Curie actions (Horizon Europe).

Postdoctoral researcher,

ICFO, Castelldefels, Spain.

Supervisor: Prof. Maciej Lewenstein.

Funding source: PASQuanS2.1 (EU Quantum Flagship).

Postdoctoral researcher,

Université Paris-Saclay, CNRS, LPTMS, France.

Supervisor: Dr. D. S. Petrov.

Funding source: ANR grant "Droplets".

12/2021 - 10/2023

06/2025 - present

11/2023 - 05/2025

## **EDUCATION**

PhD in Physics (excellent, cum laude),

University of Padova, Italy.

Supervisor: Prof. Luca Salasnich.

Thesis title: Low-dimensional Quantum Gases in Curved and Flat Geometries

Master of Science in Physics (110/110, L),

University of Padova, Italy.

Thesis: Bose-Einstein condensation and Superfluidity in 3D and 2D bosons

Supervisor: Prof. Luca Salasnich.

Bachelor of Science in Physics (105/110),

University of Padova, Italy.

Thesis: *On the diffusive approximation of the Master Equation* Supervisors: Dr. Gianluigi Serianni, Dr. Fabio Sattin.

09/2013 - 07/2016

10/2018 - 12/2021

10/2016 - 09/2018

## PUBLICATIONS AND PREPRINTS

**24.** A. Tononi, M. Lewenstein, and L. Santos, Geometric filtering effect in expanding Bose-Einstein condensate shells, arXiv.2510.12309 (2025).

**23.** G. Müller-Rigat, D. Farina, M. Lewenstein, and A. Tononi, *Spatial Leggett-Garg inequalities*, arXiv.2507.03440 (2025).

22. A. Tononi and G. E. Astrakharchik,

Bose-Einstein condensation on axially-symmetric surfaces, Phys. Rev. A 112, 023302 (2025).

21. A. Tononi, D. S. Petrov, and M. Lewenstein,

Dimer problem on a spherical surface,

Phys. Rev. A 111, L051304 (2025).

Editor's suggestion.

20. A. Tononi and M. Lewenstein,

Temporal Bell inequalities in non-relativistic many-body physics,

Quantum Sci. Technol. 10, 03LT01 (2025).

Focus issue on "Quantum Entanglement: State of the Art and Open Questions", in honor of Prof. Ryszard Horodecki.

19. A. Tononi, L. Salasnich, and A. Yakimenko,

Quantum Vortices in Curved Geometries,

AVS Quantum Sci. 6, 030502 (2024).

18. J. Givois, A. Tononi, and D. S. Petrov,

Heavy-light N+1 clusters of two-dimensional fermions,

SciPost Physics **17**, 050 (2024).

17. A. Tononi, G. Astrakharchik, and D. S. Petrov,

Gas-to-soliton transition of attractive bosons on a spherical surface,

AVS Quantum Science 6, 023201 (2024).

16. A. Tononi and L. Salasnich,

Shell-shaped atomic gases,

Physics Reports 1072, 1 (2024).

15. A. Tononi and L. Salasnich,

Low-dimensional quantum gases in curved geometries,

Nature Reviews Physics 5, 398 (2023).

14. J. Givois, A. Tononi, and D. S. Petrov,

Self-binding of one-dimensional fermionic mixtures with zero-range interspecies attraction, SciPost Physics 14, 091 (2023).

13. N. Lundblad, D. C. Aveline, A. Balaž, E. Bentine, N. P. Bigelow, P. Boegel, M. A. Efremov, N. Gaaloul, M. Meister, M. Olshanii, C. A. R. Sá de Melo, A. Tononi, S. Vishveshwara, A. C. White, A. Wolf, and B. M. Garraway,

Perspective on Quantum Bubbles in Microgravity,

Quantum Science and Technology 8, 024003 (2023).

12. L. Salasnich, A. Cappellaro, K. Furutani, A. Tononi, and G. Bighin

First and Second Sound in Two-Dimensional Bosonic and Fermionic Superfluids,

Symmetry 14, 2182 (2022).

**11.** A. Tononi, J. Givois, and D. S. Petrov, *Binding of heavy fermions by a single light atom in one dimension*, Physical Review A **106**, L011302 (2022).

10. A. Tononi,

Scattering theory and equation of state of a spherical two-dimensional Bose gas, Physical Review A **105**, 023324 (2022).

**9.** A. Tononi, A. Pelster, and L. Salasnich, *Topological superfluid transition in bubble-trapped condensates*, Physical Review Research **4**, 013122 (2022).

**8.** A. Tononi, A. Cappellaro, G. Bighin, and L. Salasnich, *Propagation of First and Second Sound in a Two-Dimensional Fermi Superfluid*, Physical Review A **103**, Lo61303 (2021).

7. K. Furutani, A. Tononi, and L. Salasnich, Sound modes in collisional superfluid Bose gases, New Journal of Physics 23, 043043 (2021).

**6.** A. Tononi, F. Toigo, S. Wimberger, A. Cappellaro, and L. Salasnich, *Dephasing-rephasing dynamics of one-dimensional tunneling quasicondensates*, New Journal of Physics **22**, 073020 (2020).

5. A. Tononi, F. Cinti, and L. Salasnich, *Quantum Bubbles in Microgravity*, Physical Review Letters **125**, 010402 (2020).

**4.** A. Tononi and L. Salasnich, *Bose-Einstein Condensation on the Surface of a Sphere*, Physical Review Letters **123**, 160403 (2019).

3. A. Tononi, Y. Wang, and L. Salasnich, Quantum Solitons in Spin-Orbit Coupled Bose-Bose Mixtures, Physical Review A 99, 063618 (2019).

2. A. Tononi,

Zero-Temperature Equation of State of a Two-Dimensional Bosonic Quantum Fluid with Finite-Range Interaction,

Condensed Matter 4(1), 20 (2019).

**1.** A. Tononi, A. Cappellaro, and L. Salasnich, *Condensation and superfluidity of dilute Bose gases with finite-range interaction*, New Journal of Physics **20**, 125007 (2018).

## GRANTS, PRIZES AND AWARDS

- **Postdoctoral fellowship** grant (181 k€) for the proposal "Quantum mixtures in flat and curved geometries", submitted under the Horizon Europe Marie Skłodowska-Curie actions call MSCA-2023-PF.
- **Seal of excellence**, delivered by the European Commission for the proposal "Self-binding and emergent structures in low-dimensional quantum mixtures" (score 90.6%/100%), submitted under the Horizon Europe Marie Skłodowska-Curie actions call MSCA-2022-PF.
- **Special mention**, awarded by the Italian Conference of Presidents and Directors of University Departments of Science and Technology to underline the scientific validity of my doctoral thesis. This mention was attributed within the framework of the "con.Scienze 2021-2022" prize (www.conscienze.it/premi\_2122\_vincitori.asp).

#### GUEST POSITIONS AND RESEARCH STAYS

**Visiting Scientist** in the group of Prof. Maciej Lewenstein, ICFO, Castelldefels, Spain. **Research stay** of three weeks,

06/2025 -

01/2023

Universitat Politècnica de Catalunya, Barcelona, Spain.

#### CONFERENCES AND SEMINARS

More than 35 oral presentations (including 2 invited colloquia) and 18 posters.

(full list at the end of the curriculum vitae)

#### PEER REVIEW

More than 35 peer reviews (verifiable on Web of Science) for the following journals:

Physical Review Letters, Physical Review A, Physical Review B, New Journal of Physics, SciPost Physics, EPL, Communications physics.

#### **TEACHING**

• **Teaching 4 hours** to university first-year students within the course "Fundamentals of quantum mechanics" organized at ICFO by Prof. Maciej Lewenstein. Topics: wave-particle duality, quantum statistics, Bose-Einstein condensation, superfluidity.

11/07/2024 - 12/07/2024

• **Teaching 4 hours** to PhD students within the course "Bose-Einstein condensation, Superfluidity, Superconductivity", held at the University of Padova by Prof. Luca Salasnich. Topics: Bose-Einstein condensation, superfluidity.

28/11/2019, 20/12/2019

• Qualifying habilitation as high-school teacher of mathematics and physics in Italy (competition classes Ao2o, Ao26, Ao27, Ao47).

since 08/2021

## ACADEMIC DUTIES

• **Coordination of ICFO reporting** on the EU Quantum Flagship project PASQuanS2.1 (due mid-funding period).

09/2024 - 10/2024

• Co-organizer of the LPTMS laboratory weekly seminar.

09/2022 - 10/2023

• **PhD students representative** at the council of the Department of Physics and Astronomy, University of Padova.

10/2018 - 12/2021

• Local organizing committee member for the SuperFluctuations 2019 conference.

02/09/2019 - 04/09/2019

### SUPERVISION ACTIVITIES

• Supervision of the BSc stage (6-weeks) of Pierre-Louis Premoli.

12/06/2023 - 28/07/2023

#### SCIENCE COMMUNICATION

• European Researchers' Night: speaker of 'Conversations with International Researchers", held at the Science Museum CosmoCaixa (Barcelona, Spain).

26/09/2025

• Interview by the science writer Avery Thompson for a highlight of my review article "Quantum vortices in curved geometries" published in AVS communications.

09/10/2024

• Writing a **non-specialist article on my paper** "Low-dimensional quantum gases in curved geometries" for the University of Padova's press office. The popular science magazine "le Scienze" republished our press release.

05/07/2023

• "Fête de la science": presenting quantum mechanics concepts to six high-school classes (in French).

07/10/2022

• Interview for a promotional video of the Physics PhD school at the University of Padova.

05/05/2022

• "Percorsi Galileiani PhD Edition": videomaking of my research for a non-specialist public, https://www.andreatononi.com/video.html.

04/06/2021

• "Veneto Research Night": local edition of the European Researchers' Night (videomaking and discussion with the general public, https://venetonightpadova.it/).

27/11/2020

• Writing a **non-specialist article on my paper** "Quantum Bubbles in Microgravity" for the University of Padova's press office.

02/07/2020

## LANGUAGES

Italian (native); English (proficient); French (proficient); Spanish (independent); Catalan (basic).

### TRAINING

• Training course "Empower: leadership training for postdoctoral scientists", organized by the Barcelona Institute of Science and Technology with the trainer Dr. Alícia Marin (16 h).

30/04/2025 - 11/06/2025

 Workshop "Writing Under Pressure", held at ICFO by Prof. Inger Mewburn (3 h).

12/11/2024

• Training course: "From microaggressions to harassment. Women in scientific research", delivered by Centres de Recerca de Catalunya (CERCA) (1h).

04/11/2024

• Workshop on "Becoming a Scientific Writer: Putting Why? before How?", held at ICFO by Dr. Gavin Lucas (16 h).

09/07/2024 - 10/07/2024

• Workshop on "Impostor syndrome", held at Barcelona Institute of Science and Technology (BIST) by Dr. Míriam Bayés (4,5 h).

03/05/2024

• Soft-skills "Mentorship training" for the mentor role, held at BIST to support the personal development of young researchers (2 h).

13/03/2024

• Sensitization session on the prevention of gender-based violence, organized by the Paris-Saclay University (3,5 h).

06/04/2023

• Training course "PhD educational week on transferable skills", organized by the University of Padova (1 week).

21/09/2020 - 25/09/2020

• Attending and passing the final exam of "Cultural anthropology" (9 ECTS) and "Psycho-social processes, development, culture" (9 ECTS), university courses delivered by the University of Padova.

03/2020 - 06/2020

#### FULL LIST OF PRESENTATIONS

## Presentations at international conferences and workshops

- 17. **Low Temperature Physics**, 30th international conference (Bilbao, Spain, Aug 7 13 2025). Contributed talk: *Dimer problem on a spherical surface*.
- 16. **Multi User Quantum Gas Facilities in**  $\mu$ **g**, (Hannover, Germany, Jun 11 13 2025). <u>Invited talk</u>: *An overview on quantum bubbles in microgravity*.
- 15. **Setcases VII** Pyrenees Winter School in Quantum Information and Quantum Science, (Setcases, Spain, Feb 25 28 2025).

<u>Invited talk</u>: Monitoring non-relativistic information dynamics via temporal Bell inequalities.

14. **VI Cold Atom Workshop** - Two-day meeting of the Cold Atom Physics community in Spain, (València, Spain, Jan 30 - 31 2025).

Contributed talk: Cold atoms in curved geometries.

- 13. **Future of Ultracold and Ultrafast Dynamics**, (Dresden, Germany, Oct 21 25 2024). Contributed talk: *Temporal Bell inequalities in a non-relativistic many-body system*.
- 12. **Atomtronics 2024**, (Benasque, Spain, May 19 Jun 1 2024). Contributed talk: *Gas-to-soliton transition of attractive bosons on the surface of a sphere*.
- 11. **Superfluctuations 2022**, (Padova, Italy, Jul 6-8 2022). Invited talk: *How many heavy fermions can be bound by a single light atom in 1D?*
- 10. **ECT\* workshop, Nuclear physics at the edge of stability** (Trento, Italy, Jul 4-8 2022). Invited talk: *Binding of heavy fermions by a single light atom in 1D.*
- 9. **Palaiseau-Florence Workshop on Ultracold Atoms** (Florence, Italy, Apr 19-22 2022). <u>Invited talk</u>: *Scattering theory and equation of state of a spherical 2D Bose gas*.
- 8. **Workshop on Prospects of Quantum Bubble Physics** (online, Apr 6-7 2022). <u>Invited talk</u>: *Scattering theory and equation of state of a spherical 2D Bose gas*.
- SuperFluctuations 2021, Fluctuations and Highly Non Linear Phenomena in Superfluids and Superconductors, (online conference, Jun 14-16 2021).
   Invited talk: Topological BKT transition in bubble-trapped condensates.
- 6. **APS-DAMOP 2021**, 52nd Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics (online conference, May 31 Jun 4 2021).

  Talk: Superfluid BKT transition of 2D bubble-trapped condensates

5. Virtual NASA workshop: New Directions for Cold Atoms in Space (online workshop, Apr 23 2021).

Talk: *Quasi-2D* shell-shaped condensates

4. APS March Meeting 2021 (online conference, Mar 15-19 2021).

Talk: Quantum Statistics of a Shell-Shaped Bose-Einstein Condensate

3. Exploring Quantum Many-Body Physics with Ultracold Atoms and Molecules (online conference,

Dec 14-18 2020).

Talk: Quantum statistical properties of shell-shaped Bose-Einstein condensates

2. SuperFluctuations 2020, Fluctuations and Highly Non Linear Phenomena in Superfluids and Super-

conductors, (online conference, Jun 22-23 2020). Talk: *Quantum bubbles in microgravity*.

1. Spring online Workshop on Ultracold Quantum Matter (online workshop, Jun 4 2020).

Invited talk: Quantum bubbles in microgravity.

### **Seminars**

20. Seminar for the Quantum Information Group (GIQ) at the Universitat Autònoma de Barcelona (Barcelona, Spain, Jul 9 2025).

<u>Talk</u>: Monitoring non-relativistic information dynamics via spatio-temporal Bell-like inequalities.

19. Colloquium at the Collaborative Research Centre "Designed Quantum States of Matter" (DQ-mat)

(Hannover, Germany, Nov 7 2024).

Invited talk: Quantum gases in curved geometries.

18. Seminar at the University of Bologna (Bologna, Italy, Oct 9 2024).

Talk: Quantum gases in low-dimensional curved geometries.

17. **Seminar at the LPTMC laboratory** (Paris, France, Oct 1 2024).

Talk: Temporal Bell inequalities in a many-body system.

16. Seminar at the LPTMC laboratory (Paris, France, Feb 5 2024).

Talk: Ultracold atomic gases: from curved geometries to quantum mixtures.

15. Seminar at the INPHYNI institute (Nice, France, Nov 23 2023).

<u>Invited talk</u>: *Ultracold atomic gases: from curved geometries to quantum mixtures.* 

14. Quantum seminar at LPTMS (Orsay, France, Sep 29 2023).

Talk: Gas-to-soliton transition of attractive bosons on the surface of a sphere.

13. Seminar at LPMMC laboratory (Grenoble, France, Sep 22 2023).

Invited talk: *Self-bound fermionic mixtures in 1D*.

12. Seminar at the IJCLab (Orsay, France, Sep 7 2023).

<u>Invited talk</u>: Self-binding of a Fermi-Fermi atomic mixture with zero-range attraction in one dimension.

11. Seminar at the Universitat Politècnica de Catalunya (UPC) (Barcelona, Spain, Jan 25 2023).

<u>Invited talk</u>: *Self-bound fermionic mixtures in 1D.* 

10. Seminar at ICFO (Barcelona, Spain, Jan 24 2023).

Invited talk: Self-bound fermionic mixtures in 1D.

9. Days of LPTMS (Bordeaux, France, May 18-20 2022).

Talk: Binding of heavy fermions by a single light atom in 1D.

8. SIFS Young Seminars (online, Dec 9 2021).

Invited talk: Quantum statistics and BKT transition of a shell-shaped superfluid.

- 7. **Seminar for the Physics of Matter group at the University of Padova** (Padova, Italy, Nov 8 2021). Talk: *Static and dynamic properties of one-dimensional quantum gases.*
- 6. Seminars for the Condensed Matter Theory group at the University of Padova (Padova, Italy, Nov 8 2021).

Talk: Hydrodynamic excitations in bosonic and fermionic 2D superfluids.

- 5. **Seminar for the Physics of Matter group at the University of Padova** (Padova, Italy, Oct 12 2021). Talk: *Ultracold quantum gases: a brief overview and a focus on microgravity experiments.*
- 4. Seminars for the Condensed Matter Theory group at the University of Padova (Padova, Italy, Oct 12 2021).

Talk: Regularized equation of state of a spherical two-dimensional Bose gas.

- 3. **Seminar of Quantech group**, Universidade Federal do Rio Grande do Norte, (online, Sep 2 2021). <u>Invited talk</u>: *Hydrodynamic excitations in bosonic and fermionic 2D superfluids*.
- 2. **Quantum seminar**, seminar series of the quantum theory group at the University of Padova, (online, Jun 21 2021).

Talk: Hydrodynamic excitations in bosonic and fermionic 2D superfluids.

1. **Kaiserslautern TU Theory Colloquium** (online, Feb 11 2021). Invited talk: *The physics of shell-shaped Bose-Einstein condensates* 

#### **Posters**

18. XL Trobades Científiques de la Mediterrània-Josep Miquel Vidal: Ciència i Tecnologies Quàntiques a la Mediterrània, (IME, Maó, Spain, October 15 - 17 2025).

Poster: Spatial Leggett-Garg inequalities.

17. **BEC 2025**, (Sant Feliu de Guixols, Spain, September 6 - 12 2025).

Poster: Dimer spectrum on a spherical surface.

16. **PASQuanS2.1 Second Year Meeting**, (Heidelberg, Germany, April 3 - 4 2025).

Poster: Temporal Bell inequalities in non-relativistic many-body physics.

15. Atomtronics 2024, (Benasque, Spain, May 19 - Jun 1 2024).

Poster: Few-body bound states in low-dimensional fermionic mixtures.

14. PASQuanS2.1 First Year Meeting, (Castelldefels, Spain, Apr 16-17 2024).

Poster: Binding of bosons with chiral zero-range interactions in one dimension.

13. Quantum simulators workshop @ Institut Henri Poincaré, (Paris, France, Feb 5-9 2024).

Poster: Few-body bound states in low-dimensional fermionic mixtures.

12. Cold atoms workshop, (Barcelona, Spain, Jan 25-26 2024).

Poster: Few-body bound states in low-dimensional fermionic mixtures.

11. **EGAS 54 conference**, (Strasbourg, France, Jun 18-22 2023).

Poster: Self-bound Fermi-Fermi mixtures in 1D.

10. Precision Many-Body Physics, (Paris, France, Jun 12-14 2023).

Poster: Self-binding in one- and two-dimensional mass-imbalanced fermionic mixtures.

9. **Ultracold Quantum Matter: Basic Research and Applications**, (Bad Honnef, Germany, Dec 11-16 2022).

Poster: Self-binding of one-dimensional fermionic mixtures.

8. Workshop of the French national research network on Quantum Gases, (Lille, France, Oct 24-26 2022).

Poster: Self-binding of one-dimensional fermionic mixtures.

7. BEC 2021 conference (Sant Feliu de Guixols, Spain, Sep 11-17 2021).

Poster: Equilibrium and nonequilibrium physics of bubble-trapped condensates.

6. **QFC2019**, Quantum gases, fundamental interactions and cosmology, (Pisa, Italy, Oct 23-25 2019). Poster: *Condensation in 2D: from nonuniversal effects to bubble traps*.

5. **SuperFluctuations 2019**, Fluctuations and Highly Non Linear Phenomena in Superfluids and Superconductors, (Padova, Italy, Sep 2-4 2019).

Poster: Quantum solitons in one-dimensional spin-orbit coupled Bose-Bose mixtures.

4. Workshop on Quantum Mixtures (Trento, Italy, Jul 15-17 2019).

Poster: Condensation in 2D: from nonuniversal effects to bubble traps.

3. New Trends in Complex Quantum Systems Dynamics (Venezia, Italy, Apr 9-12 2019).

Poster: Beyond-mean-field functional integration for Bose-Einstein condensates.

2. **Physics of Strongly Coupled Systems**, Bad Honnef Physics School, (Bad Honnef, Germany, Mar 31 - Apr 5 2018).

Poster: Beyond-mean-field functional integration for Bose-Einstein condensates.

1. **SuperFluctuations 2018**, Fluctuations and Highly Non Linear Phenomena in Superfluids and Superconductors, (San Benedetto del Tronto, Italy, Sep 5-7 2018).

Poster: Low-temperature superfluid density expansion of three- and two- dimensional uniform Bose gases.

## Participation in workshops and schools

- 5. **Topological Quantum Matter with Atoms and Photons**, symposium at Collège de France (Paris, Apr 11 2025).
- 4. **OPENQMBP2024**, out-of-equilibrium physics of open many-body quantum systems (Orsay, Oct 2-4 2024).
- 3. Ultracold quantum gases, Bad Honnef Physics School (Bad Honnef, Aug 8-14 2021).
- 2. BECCAL Brainstorming Workshop (Ulm, Germany, Dec 12-13 2019).
- 1. **Methods of Path Integration in Modern Physics**, Bad Honnef Physics School, (Bad Honnef, Germany, Aug 25 31 2019).