

Nicolò Defenu – Research Output List

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1 Publications in peer-reviewed scientific journals

1.1 Publications resulting from the PhD

- **A. Codello, N. Defenu, and G. D'Odorico**

Critical exponents of $O(N)$ models in fractional dimensions,
Phys. Rev. D **91**, 105003 (2015).
arXiv:1410.3308

Author Contributions: Authors are listed in alphabetical order. N. Defenu conceived the study, devised the approach to calculate the correlation length exponent ν , derived the numerical results and conceptualised the manuscript.

- **N. Defenu, A. Trombettoni, and A. Codello**

Fixed Points Structure & Effective Fractional Dimension for $O(N)$ Models with Long-Range Interactions,
Phys. Rev. E **92**, 052113 (2015).
arXiv:1409.8322

Author Contribution: N. Defenu pursued the derivation of the non-perturbative flow equations in the long-range case, derived the numerical results and wrote the manuscript.

- **N. Defenu, P. Mati, I.G. Marian, I. Nandori, and A. Trombettoni**

Truncation effects in the functional renormalization group study of spontaneous symmetry breaking,
JHEP **1505** (2015) 141.
arXiv:1410.7024

Author Contribution: N. Defenu carried on the mathematical proof that the lower order functional RG equations for $O(N)$ field theories are consistent with the Mermin-Wagner theorem.

- **V. Bacso, N. Defenu, A. Trombettoni, and I. Nandori**

c -function and central charge of the sine-Gordon model from the non-perturbative renormalization group flow,
Nucl. Phys. B, **901**, 444-460 (2015).
arXiv:1507.04920

Author Contribution: N. Defenu derived the mathematical expression of the c -function for the sine-Gordon model in the functional RG scheme.

- **N. Defenu, A. Trombettoni and S. Ruffo**

Anisotropic long range spin systems,
Phys. Rev. B **94**, 224411 (2016).
arXiv:1606.07756.

Author Contribution: N. Defenu conceived the study, derived the RG equations for the study of anisotropic long-range $O(N)$ models, performed the numerical calculations and wrote the manuscript.

1.2 1.2 Publications as post-doc

- **G. Gori, M. Michelangeli, N. Defenu, and A. Trombettoni**
Numerical study of one-dimensional long-range percolation,
Phys. Rev. E **96**, 012108 (2017).
arXiv:1610.00200
Author Contribution: N. Defenu contributed to the interpretation of the numerical simulations by mapping the mathematical expressions for critical exponents in the local interaction case to the long-range case under study, using the effective dimension approach.
- **N. Defenu, A. Trombettoni, I. Nandori, T. Enss**
Nonperturbative RG treatment of amplitude fluctuations for $|\varphi|^4$ topological phase transitions,
Phys. Rev. B **96**, 174505 (2017).
arXiv:1706.00618
Author Contribution: N. Defenu initiated the project, revised the previous literature accurately, derived the RG equations for the study of the two dimensional $O(2)$ model in the amplitude and phase representation. The, he performed the numerical calculations and conceptualised the manuscript.
- **N. Defenu, A. Trombettoni and S. Ruffo [1st most important research output]**
Criticality and Phase Diagram of Quantum Long-Range $O(N)$ models,
Phys. Rev. B **96**, 104432 (2017).
arXiv:1704.00528
Author Contribution: N. Defenu conceived the study, derived the RG equations for the study of quantum long-range $O(N)$ models. By an extension of the functional RG approach developed during his PhD, he extracted the quantum critical behaviour of long range ferromagnetic quantum spins on the lattice, leading to the best estimates of their critical exponents up to date. These curves represent the current benchmark for experimental and numerical investigations of the equilibrium long-range universal scaling. N. Defenu also conceptualised the manuscript, deriving the connections with previous investigations.
- **N. Defenu, and A. Codello**
Scaling solutions in the derivative expansion,
Phys. Rev. D **98**, 016013 (2018).
arXiv:1704.00528
Author Contribution: N. Defenu derived the mathematical expressions for the flow equations, pursued the numerical calculations, analysed the results and wrote the manuscript.
- **N. Defenu, T. Enss, M. Kastner and G. Morigi [2nd most important research output]**
Dynamical Critical Scaling of Long-Range Interacting Quantum Magnets,
Phys. Rev. Lett. **121**, 240403 (2018).
arXiv:1805.00008
Author Contribution: N. Defenu initiated the study by mapping the slow drive universal behaviour of the fully connected quantum Ising model. He recognised the analogy between the problem of universal dynamical scaling of fully-connected models with the one of a single Boson mode. Then, he was able to derive an analytical solution to the problem, also settling an apparent controversy in the literature. Then, he pursued both the numerical and analytical calculations, analysed the results in the light of previous investigations and substantially contributed to the draft.
- **P. M. Preiss, J. H. Becher, R. Klemt, V. Klinkhamer, A. Bergschneider, N. Defenu, and S. Jochim**
High-Contrast Interference of Ultracold Fermions,
Phys. Rev. Lett. **122**, 143602 (2019).
arXiv:1811.12939
Author Contribution: N. Defenu supported the experimental investigations with theoretical insight, deriving the exact mathematical expressions for the correlation functions of the few particle system.
- **I. G. Marian, N. Defenu, U. D. Jentschura, A. Trombettoni, I. Nándori**

Pseudo-Periodic Natural Higgs Inflation,
Nucl. Phys. B, **945**, 114642 (2019).
arXiv:1705.10276

Author Contribution: N. Defenu supported the mathematical analysis with technical knowledge on the RG approach.

■ **N. Defenu, T. Enss and J. C. Halimeh**

Criticality and Phase Dynamical criticality and domain-wall coupling in long-range Hamiltonians,
Phys. Rev. B **100**, 014434 (2019).
arXiv:1902.08621

Author Contribution: N. Defenu together with Jad C. Halimeh realised the connection between the absence of anomalous dynamical phase and absence of domain wall couplings in the Kitaev chain representation of the long-range Ising model. He performed the numerical calculations to prove the conjecture and substantially contributed to the draft.

■ **V. Karle, N. Defenu, T. Enss**

Coupled superfluidity of binary Bose mixtures in two dimensions,
Phys. Rev. A **99**, 063627 (2019).
arXiv:1903.06759

Author Contribution: N. Defenu supported the analysis with technical knowledge on the RG calculations and on the physics of topological phase transitions.

■ **N. Defenu, V. Bacsó, I. G. Márián, I. Nándori, and A. Trombettoni**

Berezinskii-Kosterlitz-Thouless transition and criticality of an elliptic deformation of the sine-Gordon model,
J. Phys. A: Math. Theor. **52**, 345002 (2019).
arXiv:1706.01444

Author Contribution: N. Defenu initiated the project and supported the investigations with insight on topological phase transitions.

■ **G. Bighin^{*}, N. Defenu^{*}, T. Enss, I. Nandori, L. Salasnich, A. Trombettoni [3rd most important research output]**

BKT-paired phase in coupled XY models,
Phys. Rev. Lett. **123**, 100601 (2019).
arXiv:1907.06253

Author Contribution: N. Defenu devised the mean-field+RG approach suited to study topological phase transitions in coupled bilayer models, pursued the numerical calculations for the phase boundaries and analysed the results in comparison with exact numerical simulations. The curves obtained by this approach are in quantitative agreement with exact Monte Carlo simulations. N. Defenu and G. Bighin contributed equally to the work.

■ **P. A. Murthy^{†,*}, N. Defenu^{†,*}, L. Bayha, M. Holten, P. M. Preiss, T. Enss, and S. Jochim**

[4th most important research output]

Quantum scale anomaly and spatial coherence in a 2D Fermi superfluid,
Science **365**, 268-272 (2019).
arXiv:1805.04734

[†] corresponding authors.

Author Contribution: N. Defenu devised the strategy to compare the real and momentum space imaging of a two dimensional cold atom cloud, in order to quantify quantum anomaly. Then, the experimental group of Prof. S. Jochim, led by P. A. Murthy performed the measurement, leading to the first evidence of quantum anomaly in the dynamical evolution of 2d Fermi gases. N. Defenu and P. A. Murthy contributed equally to the work.

■ **N. Defenu, G. Morigi, L. Dell'Anna, and T. Enss**

Universal dynamical scaling of long-range topological superconductors,
Phys. Rev. B **100**, 184306 (2019).
arXiv:1906.09425

Author Contribution: N. Defenu conceived the study, derived the analytical expressions for the universal scaling exponent in the slow drive limit, by solving the Landau-Zener problem. He performed the numerical calculations and conceptualised the manuscript.

- **N Defenu, A. Codello, S. Ruffo, and A. Trombettoni.**
Criticality of Spin Systems with Weak Long-Range Interactions,
J. Phys. A: Math. Th. **53**, 143001 (2020).
arXiv:1908.05158
Special issue of J. Phys. A on ‘Long-range Interactions and Synchronization’
Author Contribution: N. Defenu wrote the manuscript, which summarises his previous investigations.
- **I. G. Marian, N. Defenu, U. D. Jentschura, A. Trombettoni, and I. Nandori.**
Renormalization-Group Running Induced Cosmic Inflation,
J. Cosmol. Astropart. Phys. **06**, 028 (2020).
arXiv:1909.00580
Author Contribution: N. Defenu supported the analysis with technical knowledge on the functional RG approach.
- **P. Uhrich, N. Defenu, R. Jafari, J. C. Halimeh.**
Out-of-equilibrium phase diagram of long-range superconductors,
Phys. Rev. **B 101**, 245148 (2020)
arXiv:1910.10715
Author Contribution: N. Defenu suggested the analysis, performed the calculation on the return rates of the Loschmidt echo and supported the work with knowledge on the physics of long-range interacting quantum systems.
- **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)
arXiv:1907.05417
Author Contribution: N. Defenu supported the analysis with knowledge on critical phenomena in bilayer magnetic systems, helping in the construction of a machine vision algorithm capable to recognize these phases from numerical Monte-Carlo configurations.
- **I. Maccari, N. Defenu, L. Benfatto, C. Castellani, and T. Enss**
Interplay of spin waves and vortices in the two-dimensional XY model at small vortex-core energy
Phys. Rev. **B 102**, 104505 (2020)
arXiv:2007.01526
Author Contribution: N. Defenu conceived the idea and supervised the Monte-Carlo analysis of the generalised XY model performed by I. Maccari. Then, I benchmarked the MC results with the RG analysis and substantially contributed to the manuscript.
- **A. Colcelli, N. Defenu, G. Mussardo, A. Trombettoni**
Finite Temperature Off-Diagonal Long-Range Order for Interacting Bosons
Phys. Rev. **B 102**, 184510 (2020)
arXiv:2007.01403
Author Contribution: N. Defenu supervised the study of Off-Diagonal Long-Range Order in 2D systems.
- **N. Defenu, A. Trombettoni, D. Zappalà**
Topological phase transitions in four dimensions
Nucl. Phys. B **964** 115295 (2021)
arXiv:2003.04909
Author Contribution: N. Defenu conceived the study and performed the functional RG calculation, which proved the possibility to extend the Kosterlitz-Thouless argument to Lifshitz points in 4 dimensions.
- **M. Syed, T. Enss, N. Defenu**
Dynamical quantum phase transition in a bosonic system with long-range interactions
Phys. Rev. B **103**, 064306 (2021)
arXiv:2007.01526
Author Contribution: N. Defenu conceived the idea and supervised the execution of the study. He substantially contributed to the completion of the manuscript.

- **A. P. Millán, G. Gori, F. Battiston, T. Enss, N. Defenu**
Complex networks with tuneable dimensions as a universality playground
Phys. Rev. Research **3**, 023015 (2021)
arXiv:2006.10421
Author Contribution: N. Defenu conceived the idea and supervised the entire numerical and analytical study. He conceived the field theoretic interpretation of the numerical results and he substantially contributed to the completion of the manuscript.
- **G. Giachetti, N. Defenu, S. Ruffo, A. Trombettoni**
Self-consistent harmonic approximation with non-local couplings
EPL, **133**, 57004 (2021).
arXiv:2005.10827
Author Contribution: N. Defenu furnished theoretical insight on the interpretation of the self-consistent harmonic approximation in presence of non-local couplings. He gave major contributions to the manuscript.
- **T. Botzung, D. Hagenmüller, G. Masella, J. Dubail, N. Defenu, A. Trombettoni, G. Pupillo**
Effects of energy extensivity on the quantum phases of long-range interacting systems
Phys. Rev. B **103**, 155139 (2021).
arXiv:1909.12105
Author Contribution: N. Defenu suggested the implementation of the Kac's rescaling and helped with the interpretation of numerical simulations.
- **N. Defenu**
Quantum adiabatic cycles and their breakdown: an analytic solution
Comm. Phys. **4**, 150 (2021)
arXiv:2011.14846
Author Contribution: single author.
- **N. Defenu [5th most important research output]**
Metastability and discrete spectrum of long-range systems
Proc. Nat. Acad. Sci. **118**, e210178511 (2021)
arXiv:2012.15808
Author Contribution: As already noticed by Boltzmann in his early investigations on classical systems, the divergence of Poincaré recurrence times in the large size limit reconciles the deterministic description of quantum/classical systems with the ergodic hypothesis of statistical mechanics. I was able to prove that such a scenario does not apply to long-range with $\infty < d$. There, the emergence of long-lived quasi-stationary states (QSSs) finds a natural and elegant justification in their discrete excitations spectrum. Despite the QSSs' ubiquity [46], the fundamental mechanism at the root of their existence had remained unknown until my recent investigations. N. Defenu is single author.
- **G. Giachetti, N. Defenu, S. Ruffo, A. Trombettoni**
Berezinskii-Kosterlitz-Thouless phase transitions with long-range couplings
Phys. Rev. Lett. **127**, 156801 (2021)
arXiv:2104.13217
Author Contribution: N. Defenu supervised the derivation and interpretation of the flow equations for long-range deformations of the BKT theory. N. Defenu substantially contributed to the writing of the manuscript.
- **A. P. Millán, R. Ghorbanchian, N. Defenu, F. Battiston, G. Bianconi**
Local topological moves determine global diffusion properties of hyperbolic higher-order networks
Phys. Rev. E **104**, 054302 (2021)
arXiv:2102.12885
Author Contribution: N. Defenu supervised the numerical analysis and contributed to the interpretation of the numerical results and to the manuscript.

2 Oral contributions at conferences

2.1 Selected Invited Speakers

- *Conference on Long-Range-Interacting Many Body Systems.*, 25–29 July 2016, ICTP, Trieste.
- *CQD mini symposium*, April 19–20, 2017, Physikalisches Institut, Heidelberg.
- *Stochastic Dynamics Out of Equilibrium.*, 24–05 April-May 2017, Inst. Henri Poincare, Paris.
- *Conference on Frontiers in Two-Dimensional Quantum Systems* , 13–17 Nov. 2017, International Center for Theoretical Physics (ICTP).
- *Quantum Many-Body Systems out-of-equilibrium*, 12–16 Mar. 2018, NITheP, South Africa.
- *Quantum Paths*, 28–1 May-June 2018, Erwin Schrödinger Institute, Vienna.
- *EXPLORING NUCLEAR PHYSICS WITH ULTRACOLD ATOMS*, 8–12 July 2019, ECT*, Trento.
- *QUANTUM AND CLASSICAL SYSTEMS WITH LONG-RANGE INTERACTIONS*, 15–19 July 2019, International Institute of Physics, IIP (Natal).
- *Functional RG methods-Italian Meeting*, 16–20 Sept. 2019, ECT*, Trento, Italy.
- *FRGIM@Trieste*, 26 Sept. 2019, SISSA, Trieste, Italy.
- *Exact Renormalization Group 2020*, 2–6 Nov. 2020, Yukawa Inst. Th. Phys., Kyoto University.
- *Non-Equilibrium Universality: From Classical to Quantum and Back*, 13-Sep. to 8-Oct., 2021, Kavli Institute for Theoretical Physics, UCSB.
- *Exact Renormalization Group 2022*, 25 - 29 July 2022, Harnack-Haus, Berlin.

2.2 Selected Contributed Speakers

- *Probing and Understanding Exotic Superconductors, ICTP* , 27–31 October 2014, Trieste.
- *20th National Conference on Statistical Physics and Complex Systems*, 29 June–1 July 2015, Parma.
- *Hungary-Croatia-Austria-Triangle (ACHT2015) Workshop* 7–9 October 2015, Leibnitz, Austria.
- *8th International conference on the Exact Renormalization Group*, 19–23 September 2016, Trieste.
- *ERG2018 : Exact Renormalization Group 2018*, 9–13 July 2018, Jussieu campus, Paris.
- *Deutsche Physikalische Gesellschaft (DPG), Rostock 2019*, 10–15 March 2019, Rostock University, Rostock.
- *MACHINE LEARNING FOR QUANTUM DESIGN*, 8–12 July 2019, Perimeter Institute, Waterloo.

- *Quantum Systems in Extreme Conditions*,
23-27 September 2019, Heidelberg University (Germany)
- *7th SwissMAP General Meeting*,
6-9 September 2020, Golfhotel "Les Hauts de Gstaad", Switzerland
- *Joint Annual Meeting of ÖPG and SPS 2021*,
30 August - 3 September, Campus Technik, University of Innsbruck, Austria

2.3 Selected Scientific Visits

- *MTA Atomki, Hungarian Academy of science, Debrecen*.
Repeated visits starting from December 2014. [Seminar Presentation](#).
- *International Institute of Physics, Natal (Brasil)*,
1-7 December 2013, Natal. [Seminar Presentation](#).
- *Theoretical Quantum Physics Group, Universitaat des Saarlandes*,
Repeated visits starting from February 2016.
- *La Sapienza University, Rome*,
Repeated visits starting from March 2016. [Seminar Presentation](#).
- *International School for Advanced Studies, SISSA, Trieste*,
Repeated visits starting from January 2017. [Seminar Presentation](#).
- *ETH, Zürich*,
02nd-04th October 2017, Zürich. [Seminar Presentation](#).
- *University of Colorado, Boulder, JILA*,
09th-12th October 2017, Boulder. [Seminar Presentation](#).
- *Los Alamos National Laboratory, LANL*,
13th-25th October 2017, Los Alamos. [Seminar Presentation](#).
- *Boston University, BU*,
3rd-17th May 2018, Boston.
- *Weizmann Institute of Science*,
Rehovot, Israel. Repeated visits starting from November 2018. [Seminar Presentation](#).
- *Massachusetts Institute of Technology, MIT*,
22th-30th April 2019, Boston, USA.
- *Simons Center for Geometry and Physics, SCGP*,
1st-2nd May 2019, Stony Brook, USA. [Seminar Presentation](#).
- *Georgetown University, GU*,
3rd-6th May 2019, Washington, USA. [Invited Seminar](#).
- *Swinburne University of Technology, SUT*,
20th-24th January 2020, Melbourne, Australia. [Seminar Presentation](#).

3 Submitted papers & Preprints on arXiv

■ N. Defenu, A. Codello

The fate of $O(N)$ multi-critical universal behaviour
arXiv:2005.10827

Submitted to *Phys. Rev. Lett.*, see the submission confirmation

Author Contribution: N. Defenu first realised the discrepancy between odd and even multi-critical behaviour in the large N limit and performed the functional RG calculation.

- **I. G. Marian, U. D. Jentschura, N. Defenu, A. Trombettoni, I. Nandori**
Renormalization of Field-Independent Term in the Cosmological Constant Problem
arXiv:2107.06069
Submitted to JCAP, see the submission confirmation
Author Contribution: N. Defenu supervised the derivation and analysis of the renormalization group equations.
- **N. Defenu, T. Donner, T. Macrì, G. Pagano, S. Ruffo, A. Trombettoni**
Long-range interacting quantum systems
arXiv:2109.01063
Invited Submission by *Rev. Mod. Phys.*, see the submission confirmation
Author Contribution: N. Defenu lead the team, assigned the tasks and wrote most of the manuscript.
- **G. Giachetti, N. Defenu**
Entanglement propagation and dynamics in non-additive quantum systems
arXiv:2112.11488
Submitted to *Nat. Phys.*, see the submission confirmation
Author Contribution: N. Defenu had the idea and supervised the execution of the analysis. He also wrote the manuscript.
- **M. Syed, T. Enss, N. Defenu**
Universal scaling at a pre-thermal dark state
Under review on *Phys. Rev. Lett.*, see the submission confirmation
arXiv:2112.14180
Author Contribution: N. Defenu had the idea and supervised the execution of the analysis. He substantially contributed to the manuscript.
- **J. Alexandre, N. Defenu, G. Grigolia, I. G. Marian, D. Mdivaradze, A. Trombettoni, J. Turoci, I. Nandori**
Quantization and renormalization of non-differentiable potentials
Under review on JHEP, see the submission confirmation
arXiv:2112.14696
Author Contribution: N. Defenu provided insight on the functional RG investigations.
- **Guido Giachetti, Andrea Trombettoni, Stefano Ruffo, Nicolò Defenu**
BKT transitions in classical and quantum long-range systems
Submitted to *Phys. Rev. B*, see the submission confirmation
arXiv:2201.03650
Author Contribution: N. Defenu supervised the investigation and substantially contributed to the manuscript.
- **Nicolò Defenu, Alessio Lerose, Silvia Pappalardi**
Out-of-equilibrium dynamics and criticality of quantum systems with long-range interactions
Invited Review by *Phys. Rep.*, see the commission agreement.
Author Contribution: N. Defenu supervises the investigation and leads the team.

3.1 Notes

- The symbol * indicates equal contributions.
- Selecting the title or the arXiv reference shall automatically open the corresponding website.