

Guido Mazzuca, PhD

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EDUCATION

SISSA, Trieste, Italy
PhD Mathematics with honors
Thesis: *Nonlinear Lattices and Random Matrices*
Advisors: Tamara Grava and Alberto Maspero.

University of Milan, Italy
MSc. in Mathematics with honors

University of Milan, Italy
BSc. in Mathematics

RESEARCH INTERESTS

My research focuses on integrable systems, spanning both continuous partial differential equations (such as NLS, KdV, and mKdV) and discrete lattice models (including Toda and Ablowitz-Ladik systems). I investigate the long-time behavior and dispersive properties of solutions, with a particular interest in the dynamics of soliton gases. A significant part of my work explores the deep connections between these integrable systems and Random Matrix Theory, primarily through the application of the Riemann-Hilbert problem approach, both in its standard and random formulations.

RESEARCH EXPERIENCE

Postdoctoral researcher, Tulane University
New Orleans, Louisiana, USA.
Mentor: Professor Kenneth McLaughlin

08/11/2023 – Present

- Deduce the behaviour of correlation functions for the Volterra lattice applying the theory of Generalized Hydrodynamics.
- Studied the behaviour of the NLS with random initial data, joint work with Prof. E. Girotti, Prof. R. Jenkins, Prof. M. Yattselev, Prof. T. Grava and Prof. K. McLaughlin.
- Studied the behaviour of the NLS equation in the *condensed soliton gas* regime, joint work with Prof. K. McLaughlin and Dr. A. Gkogkou.
- Deduce a Large Deviation principle for the Jacobi-Muttalib-Borodin ensemble and compute its density of states in collaboration with Prof. A. Occhelli and Prof. J. Husson.
- Describe the combinatorial and analytical properties of the density of states of the q -Laguerre polynomials.
- Investigate the universal behaviour of the N -soliton solution with maximal modulus; joint work with Prof. K. McLaughlin and Dr. A. Gkogkou.

- Initiate a collaboration with Dr. G. Orsatti and Dr. A. Gkogkou to study the long-time behaviour of the NLS soliton gas.
- This work resulted in five papers - two published and three are now submitted for publication. In addition, two manuscripts are in preparation.

Junior Fellow, Mittag-Leffler Institute
Stockholm, Sweden

09/01/2024 – 12/13/2024

- Initiated a collaboration with Dr. M. Piorkowski at KTH to compute the correlation functions of the infinite Toda lattice with random initial data.
- Initiated a collaboration with Dr. D. Ofner at KTH to define a new exactly solvable random matrix ensemble related to the *Itoh–Narita–Bogoyavlenskii* lattice.
- This position was funded by the Junior Fellowship awarded by the Mittag-Leffler institute; both manuscripts are in preparation.

Postdoctoral researcher, KTH
Stockholm, Sweden
Mentor: Professor Håkan Hedenmalm

10/01/2021 – 08/10/2023

- Performed a deep numerical investigation of the correlation functions of the Toda lattice and we compared the numerical simulations with the Generalized Hydrodynamic predictions showing an astonishing agreement. Joint work with Prof. K. McLaughlin, Prof. T. Kriecherbauer, Prof. H. Spohn, Prof T. Grava and Prof. C. Mendl.
- Established a connection between the Circular β ensemble and the Ablowitz-Ladik lattice. This connection enable us to compute the moments and the density of states for the Ablowitz-Ladik lattice. Joint work with Prof. T. Grava.
- Established a connection between several random matrix ensembles and integrable systems, this enabled us to compute the density of states for these models. Joint work with Prof. T. Grava, Dr. M. Gisonni and Prof. G. Gubbiotti
- Proved a central limit theorem type result for all the classical β ensemble at high temperature and several integrable models. Joint work with Dr. R. Memin.
- This work resulted in four publications and it was funded by the KAW grant 2018.0344

Program Associate, SLMATH (ex MSRI)
Berkeley, California, USA

08/16/2021 – 09/15/2021

- I participated to the program “Universality and Integrability in Random Matrix Theory and Interacting Particle Systems”
- Obtained a large deviation principle for the Ablowitz-Ladik lattice and for the Circular β ensemble at high temperature. Joint work with Dr. R. Memin.
- This work resulted in one publication, and it was partially funded by the IPaDEGAN grant and the Simons Laufer Mathematical Sciences Institute (ex MSRI).

Graduate Student, SISSA
Trieste, Italy
Advisor: Professor Tamara Grava and Professor Alberto Maspero

10/01/2017 – 09/24/2021

- Computed the density of states and the moments of the classical β ensemble at high temperature using loop equations. Furthermore, we defined the anti-symmetric Gaussian α ensemble. Joint work with Prof. P. J. Forrester.

- Compute the correlation functions for the short-range harmonic chain asymptotically describing the behaviour of their peaks in terms of special functions. Joint work with Prof. K. McLaughlin, Prof. T. Grava and Prof. T. Kriecherbauer.
- Established a relation between the classical β ensemble at high-temperature and some integrable model, this connection enable us to compute the density of states for these models in some particular regime. We also define the α -ensembles, which are related to the classical β ensembles.
- Proved that the conserved quantities of the Toda lattice are adiabatic invariants for the Fermi-Pasta-Ulam-Tsingou model, explaining its almost periodic behaviour. Joint work with Prof. A. Ponno, Prof. T. Grava and Prof. A. Maspero.
- This work resulted in four publications, it was partially funded by the IPaDEGAN grant.

PUBLICATIONS

Published papers:

1. M. Girotti, T. Grava, R. Jenkins, G. Mazzuca, K. McLaughlin, M. Yattselev: *Soliton Synchronization with Randomness: Rogue Waves and Universality*. To appear in *Nonlinearity*.
2. A. Gkogkou, G. Mazzuca, K. McLaughlin. *The formation of a soliton gas condensate for the focusing nonlinear Schrödinger equation*. Journal of Nonlinear Waves. 2025;1:e14. doi:10.1017/jnw.2025.10016
3. G. Mazzuca : *Generalized Hydrodynamics for the Volterra lattice: ballistic and nonballistic behavior of correlation functions*. Journal of Physics A: Mathematical and Theoretical. DOI: 10.1088/1751-8121/ad742b
4. G. Mazzuca, R. Memin: *CLT for β ensembles at high-temperature, and for integrable systems: a transfer operator approach* Ann. Henri Poincaré (2024). DOI: 10.1007/s00023-024-01435-0
5. G. Mazzuca, T. Grava, T. Kriecherbauer, K. T-R McLaughlin, C. B. Mendl, H. Spohn: *Equilibrium Spacetime Correlations of the Toda Lattice on the Hydrodynamic Scale*, Journal of Statistical Physical Physics, DOI: <https://doi.org/10.1007/s10955-023-03155-x>
6. G. Mazzuca, and T. Grava: *Generalized Gibbs ensemble of the Ablowitz-Ladik lattice, circular β -ensemble and double confluent Heun equation*. Communication in Mathematical Physics, DOI: 10.1007/s00220-023-04642-8 (2023).
7. M. Gisonni, T. Grava, G. Gubbiotti, G. Mazzuca: *Discrete integrable systems and random Lax matrices*. Journal of Statistical Physics 190, Article number: 10 (2023). DOI: 10.1007/s10955-022-03024-z
8. G. Mazzuca, and R. Memin: *Large Deviations for Ablowitz-Ladik lattice, and the Schur flow*. Electronic Journal of Probability. DOI: 10.1214/23-EJP941.(2023)
9. G. Mazzuca: *On the mean Density of States of some matrices related to the beta ensembles and an application to the Toda lattice*. Journal of Mathematical Physics 63, 043501 (2022). DOI: 10.1063/5.0076539.
10. G. Mazzuca, and P.J. Forrester: *The classical beta ensembles with beta proportional to 1/N: from loop equations to Dyson's disordered chain*. Journal of Mathematical Physics, Special Issue in honour of F. Dyson, 2021. DOI: 10.1063/5.0048481.
11. T. Grava, T. Kriecherbauer, G. Mazzuca, and K. D. T.-R. McLaughlin: *Correlation functions for a chain of short range oscillators*. Journal of Statistical Physics (2021). DOI: 10.1007/s10955-021-02735-z

12. T. Grava, A. Maspero, G. Mazzuca, and A. Ponno: *Adiabatic invariants for the FPUT and Toda chain in the thermodynamic limit.* Communications in Mathematical Physics, 380 (2020), pp. 811-851. DOI: 10.1007/s00220-020-03866-2.

Preprint :

1. J. Husson, G. Mazzuca, A. Occhelli: *Discrete and Continuous Muttalib–Borodin process: Large deviations and Riemann–Hilbert analysis.* ArXiv preprint arXiv:2505.23164
2. S. Byun, Y. Jung, G. Mazzuca : *q-deformation of the Marchenko-Pastur law .* ArXiv preprint arXiv:2601.09427

RESEARCH GRANTS

Contribution to prior funded research

IPaDEGAN

2018–2023

- Principal Investigator: Professor Gregorio Falqui
- Funded Under: Marie Skłodowska-Curie Actions
- MSCA RISE 778010, 886500€ (\$ 970000)
- Role: Contributor. I took part in this project during my PhD, developing new approach to study integrable dynamical systems with randomness.

Personal Grant

MATRIX-Simon Travel Grant

2025

- Awarded by the MATRIX institute in Australia
- \$ 2000 (2500 AUD)
- Participate in the research program “Log-gases in Caeli Australi: Recent Developments in and around Random Matrix Theory” in Creswick.

Postdoc Travel Grant

2024-2025

- Awarded by the Office of Graduate and Postdoctoral Studies of Tulane University
- \$ 2500 (3 diffent awards over 2 years)
- Participate in a series of conferences held in Europe and in the USA

Research grant

2019

- Awarded by LYSM
- 2000€ (\$ 2200)
- Attend the semester “Integrability and Randomness in Mathematical Physics” at CIRM

FELLOWSHIP

Junior Fellowship

Fall 2024

- Award Institution: Mittag-Leffler Institute, Stockholm, Sweden
- Role: Postdoctoral researcher
- 80000 SEK (\$ 7500), and housing

Marie-Curie Fellowship

2023

- Award Institution: European Research Council
- Role: Principal Investigator
- 200000€ (\$ 220000)
- Declined for personal reasons

PhD Fellowship

2017-2021

- Award Institution: SISSA(International School for Advanced Studies)
- Role: Graduate Student
- 57000€ (\$ 62500)

HONORS & AWARD

Lutman Prize

2022

Best PhD thesis in Mathematics, 1000€(\$ 1100)

SERVICE

Summer School: “Mini Math School”

2025-2024

Scope: Summer School for PhD students of Tulane Mathematics department
Tulane University, New Orleans, USA

Role: Creator and Organizer

Conference: Integrable Systems in Geometry and Mathematical Physics

2021

Conference in memory of Boris Dubrovin
SISSA, Trieste, Italy
Role: Co-organizer

Workshop: Integrable Systems Around the World

2020

Online Workshop
Role: Co-organizer

Conference: Integrability and Randomness in Mathematical Physics and Geometry

2019

CIRM, Marseilles, France
Role: Co-organizer

Research School: Coulomb Gas, Integrability and Painlevé Equations

2019

CIRM, Marseilles, France
Role: Co-organizer

SELECTED TALKS

For a complete list of my talk, you can visit my personal web-page.

“CLT for the real β ensemble and the Toda lattice”
Institute Mittag-Leffler, Program Seminar, Stockholm, Sweden

September 2024

“Ablowitz-Ladik lattice and the Circular β -ensemble: a surprising connection”
Conference: *4th Italian Meeting on Probability and Mathematical Statistics*, Rome, Italy

June 2024

“LDP for the Ablowitz-Ladik lattice and the circular β ensemble at high-temperature”
KTH departmental seminar, Stockholm, Sweden

May 2023

“From the Ablowitz-Ladik lattice to the Circular beta-ensemble” MEGA seminar series, Lyon, France	May 2022
“Alpha ensembles and integrable systems” Mathematical Science Research Institute (MSRI)	September 2021
“Adiabatic Invariants for Toda and FPUT” Workshop “Integrability and Nonlinear Dispersive Equations” CIRM Marseille, France.	June 2019

TEACHING EXPERIENCE

Instructor Complex Analysis, Tulane university.	Spring 2026
Instructor Calculus III, Tulane university.	Fall 2025
Instructor and coordinator Calculus II, Tulane university.	Spring 2024 and Spring 2025
Instructor Calculus I, Tulane university.	Fall 2023
Tutor Graduate Course “Integrable systems with random initial data” LMS-CMI Research School “Methods for Random Matrix Theory and Applications” Reading, UK	May 2022

VOLUNTEER WORK

GiST (Girls in Stem at Tulane) and BATS I participated in a series of events designed for high school students.	Fall and Spring 2025
SISSA 4 School I participated in a series of events designed for high school students.	2017–2021
Trieste NEXT I participated in this scientific fair, designing activities for high-school and middle school students.	2017–2019