

Emanuele Zappala.

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Positions

- 2023- “Assistant Professor”, **Idaho State University**, Pocatello, ID.
2022-2023 “Associate Research Scientist”, **Yale University**, New Haven, CT.
2021-2022 “Postdoctoral Research Associate”, **Yale University**, New Haven, CT.
2020– 2021 “Research Fellow”, (visiting) sponsored by **Estonian Research Council**, host institution **University of Tartu**.
2020 “Temporary Research Associate” and “Research fellow” (postdoc), **University of Michigan**, Ann Arbor, MI.
2016–2020 “Graduate Teaching & Research Associate”, **University of South Florida**, Tampa, FL.

Short-Term Research Activities

- Spring 2025 “Research Visit”, North Dakota State University. Visiting: A. Wagner.
Fall 2023 “Research Visit”, University of Trieste, Trieste, Italy. Visiting: M. Stener and E. Greco.
Fall 2019 “Visiting Student”, University of Michigan, Ann Arbor, Michigan.
October 2019 “Research Visit”, Mälardalen University, Västerås, Sweden. Visiting: S. Silvestrov.
6/25 to 7/6 “Derived Categories”, Summer School at Mathematical Sciences Research Institute (MSRI),
2018 Berkeley, California.

Education

- 9/16 - 05/20 **Ph.D. in Mathematics** Department of Mathematics and Statistics, **University of South Florida**, Tampa, Florida.
Advisors: Mohamed Elhamdadi and Masahico Saito.
Dissertation Title: “*Non-associative Algebraic Structures in Knot Theory*”.
9/15 - 9/16 **M.Sc. in Pure Mathematics** (with Merit), Department of Mathematics, **University of Glasgow**, Glasgow, United Kingdom.
Advisor: Andrew Baker.
Dissertation Title: “*Cohomology of Iterated Loops of Suspended Spaces*”.
9/14 - 8/15 **Graduate Diploma in Mathematics** (with Distinction), Department of Mathematics, **King’s College London, University of London**, United Kingdom.
9/10 - 3/14 **B.Sc. in Physics**, Department of Physics, **University of Catania**, Catania, Italy.
Dissertation Title: “*Quantum Space-Time*” (in Italian).

Publications & Pre-prints

- (with A. Giola, A. Kramer, E. Greco) “Neural Integral Operators for Inverse problems in Spectroscopy”, arXiv:2505.03677 (submitted).
- (with Zhang, He, Ying, van Dijk et al.) “Non-Markovian Discrete Diffusion with Causal Language Models”, arXiv:2502.09767 (submitted).
- (with C. Fields, J. Glazebrook, A. Marciano) “Whether a quantum computation employs nonlocal resources is operationally undecidable”, arXiv:2501.14298.
- (with C. Fields, J. Glazebrook, A. Marciano) “ER = EPR is an operational theorem”, arXiv:2410.16496, **Physics Letters B** <https://doi.org/10.1016/j.physletb.2024.139150>.
- “Leray-Schauder Mappings for Operator Learning”, arXiv:2410.01746 (submitted).

- (with He, van Dijk et al.) “CaLMFlow: Volterra Flow Matching using Causal Language Models”, arXiv:2410.05292 (submitted).
- (with Zhang, van Dijk et al.) “Intelligence at the Edge of Chaos”, arXiv:2410.02536, to appear in **International Conference on Machine Learning (ICML) 2025**.
- (with M. Bagherian) “Universal Approximation of Operators with Transformers and Neural Integral Operators”, arXiv:2409.00841 (submitted).
- (with T. Asselmeyer-Maluga, M. Lulli, A. Marciano, R. Pasechnik) “A geometric phase approach to quark confinement from stochastic gauge-geometry flows”, arXiv:2408.15986.
- (with M. Saito) “Deformation Cohomology for Braided Commutativity”, arXiv:2407.02663, to appear in **Michigan Math. J.**.
- “Projection Methods for Operator Learning and Universal Approximation”, arXiv:2406.12264 (submitted).
- “Perturbative Expansion of Yang-Baxter Operators”, arXiv:2403.09796, to appear in **Publ. RIMS Kyoto Univ.**.
- “Spectral methods for Neural Integral Equations”, arXiv:2312.05654 (submitted).
- (with M. Saito) “Yang-Baxter Solutions from Categorical Augmented Racks”, arXiv:2312.01033, to appear in **J. Knot Theory Ramifications**.
- (with M. Lulli & A. Marciano) “The exact evaluation of hexagonal spin-networks and topological quantum neural networks”, arXiv:2310.03632, to appear in **Fortschritte der Physik**.
- (with D. Levine, S. He, S. Rizvi, S. Levy, D. van Dijk) “Operator Learning Meets Numerical Analysis: Improving Neural Networks through Iterative Methods”, arXiv:2310.01618.
- (with J. Ortega Caro, A. Fonseca, & D. van Dijk et al.) “BrainLM: A foundation model for brain activity recordings”, **International Conference on Learning Representations (ICLR)** (2024), <https://iclr.cc/virtual/2024/poster/18625>.
- (with M. Elhamdadi and P. Senesi) “On the representation theory of cyclic and dihedral quandles”, arXiv:2307.03728, to appear in **J. Algebra and its Applications**.
- (with M. Saito) “Yang-Baxter Hochschild Cohomology”, arXiv:2305.04173 (submitted).
- (with A. Fonseca, J. Ortega Caro & D. van Dijk) “Continuous spatiotemporal transformers”, arXiv:2301.13338, **International Conference on Machine Learning (ICML)** (2023), <https://dl.acm.org/doi/10.5555/3618408.3618699>.
- (with Marciano, Chen, Farbocini, Fields, Lulli) “Deep Neural Networks as the Semi-classical Limit of Topological Quantum Neural Networks: The problem of generalisation”, arXiv:2210.13741 (submitted).
- (with Rizvi, Nguyen, Lyu, Christensen, Caro, Brbic, Dhodapkar and van Dijk) “AMPNet: Attention as Message Passing for Graph Neural Networks”, arXiv:2210.09475.
- (with A. Fonseca, J. Ortega Caro, A. Moberly, M. Higley, J. Cardin & D. van Dijk) “Learning integral operators via neural integral equations”, **Nature Machine Intelligence** <https://doi.org/10.1038/s42256-024-00886-8>.
- (with M. Elhamdadi) “Deformations of Yang-Baxter operators via n -Lie algebra cohomology”, **Nuclear Physics B** <https://doi.org/10.1016/j.nuclphysb.2023.116331>.
- (with M. Saito) “Extensions of Augmented Racks and Surface Ribbon Cocycle Invariants”, arXiv:2207.04570, **Topology Appl.** <https://doi.org/10.1016/j.topol.2023.108555>.
- (with A. Fonseca, A. Moberly, M. Higley, C. Abdallah, J. Cardin & D. van Dijk) “Neural Integro-Differential Equations”, **Proceedings of AAAI** (2023) <https://doi.org/10.1609/aaai.v37i9.26315>.
- (with N. Gresnigt and A. Marciano) “On the dynamical emergence of the Turaev-Viro model in 2+1D quantum gravity with cosmological constant”, **Phys. Rev. D** <https://journals.aps.org/prd/abstract/10.1103/PhysRevD.107.046018>.

- (with M. Saito) “Fundamental Heaps for Surface Ribbons and Cocycle Invariants”, arXiv:2109.07569, **Illinois J. Math.** (2023) <https://doi.org/10.1215/00192082-10972597>.
- (with Marciánó, Chen, Fabrocini, Fields, Greco, Gresnigt, Jinkub, Lulli & Terzidis) “Quantum Neural Networks and topological quantum field theories”, **Neural Networks** (2022) <https://doi.org/10.1016/j.neunet.2022.05.028>.
- (with M. Elhamdadi, A. Makhlouf & S. Silvestrov) “Derivation problem for quandle algebras”, arXiv:2106.08289, **Inter. J. of Algebra & Comput.** <https://doi.org/10.1142/S0218196722500424>.
- (with N. Gresnigt and A. Marciano) “Braided matter interactions in quantum gravity via 1-handle attachment”, **Phys. Rev. D**, <https://doi.org/10.1103/PhysRevD.104.086021>.
- (with V. Abramov) “3-Lie Algebras, Ternary Nambu-Lie algebras and link invariants”, arXiv:2103.11472, **Journal of Geometry and Physics** <https://doi.org/10.1016/j.geomphys.2022.104687>.
- “Quantum invariants of framed links from ternary self-distributive cohomology”, arXiv:2102.10776, **Osaka J. Math.**, Vol. 59 No.4 (October 2022).
- (with M. Saito) “Braided Frobenius Algebras from certain Hopf Algebras”, arXiv:2102.09593, **J. Algebra Appl.**, <https://doi.org/10.1142/S0219498823500123>.
- (with M. Saito) “Fundamental heap for framed links and ribbon cocycle invariants”, arXiv:2011.03684, **J. Knot Theory Ramifications** <https://doi.org/10.1142/S0218216523500402>.
- (with Tsukamoto, Kikuchi, Najarian, Kuroda, Yasuhara) “Mechanistic study of membrane disruption by methacrylate random copolymers with antimicrobial activity by the single giant vesicle method”, **Langmuir** (2021), <https://doi.org/10.1021/acs.langmuir.1c01047>.
- (with M. Elhamdadi & M. Saito) “Skein theoretic approach to Yang-Baxter Homology”, arXiv:2004.00691, **Topology Appl.** Volume 302, 1 October 2021, 107836 <https://doi.org/10.1016/j.topol.2021.107836>.
- (with M. Elhamdadi & M. Saito) “Heap Cohomology and Ternary Self-Distributive Cohomology”, **Comm. Algebra**, <https://doi.org/10.1080/00927872.2020.1871484>.
- (with M. Elhamdadi & M. Saito), “Higher Arity Self-Distributive Operations in Cascades and their Cohomology”, **J. Algebra Appl.**, <https://doi.org/10.1142/S0219498821501164>.
- (with M. Elhamdadi & M. Saito) “Continuous Cohomology of Topological Quandles”, **J. Knot Theory Ramifications**, vol 28, no 06, 1950036 (2019). <https://doi.org/10.1142/S0218216519500366>.

Selected presentations

- May 2025 AMS Sectional meeting San Luis Obispo, CA, “Quantum cocycle invariants and Yang-Baxter cohomology”.
- Apr 2025 Instituto Superior Tecnico de Lisboa, Portugal, IX International Workshop on Non-Associative Algebras, “Yang-Baxter-Hochschild Cohomology and its Applications”.
- Feb 2025 North Dakota State University, Physics Department, “Field theory, quantum invariants, and cohomology”.
- Sep 2024 TATERS Boise State University, “Yang-Baxter Cohomology and Perturbative Expansion of Yang-Baxter operators”.
- Oct 2023 Peking University - Jilin University Colloquium, “Perturbative expansion of Yang-Baxter operators and Lie algebra cohomology”.
- Sep 2023 TATERS seminar at Boise State University, “Cohomology and deformations of braided algebras”.
- Jun 2023 Computational chemistry seminar at the University of Trieste, “Operator Learning for Modeling and Interpreting Dynamics”.
- Jun 2023 VI International Workshop on Non-Associative Algebras in Madrid <https://sites.google.com/view/nonassociativemadrid2023/home>.

- Apr 2023 AMS Spring sectional meeting, University of Cincinnati.
- Feb 2023 Association Advancement Artificial Intelligence (2023), Washington DC, “Neural Integro-Differential Equations”.
- Jan 2023 Scuola Superiore Università di Catania, “Learning brain dynamics via integral equations”.
- Jul 2022 Satellite conference of ICM: Knot theory and Applications, Tomsk State University, “n-Lie algebras and the Yang-Baxter equation” (online).
- May 2022 Moscow-Beijing Topology Seminar, “Deformations of Yang-Baxter operators from n-Lie algebra cohomology” (online).
- Apr 2022 Knots in Washington 49.75, The George Washington University, “n-Lie algebras, their cohomology and the Yang-Baxter equation”.
- Dec 2021 Knots in Washington 49.5, The George Washington University, “Ternary self-distributive operations and quantum invariants of knots”.
- Nov 2021 Special session on low-dimensional topology, AMS sectional meeting, Mobile, Alabama, “Fundamental heap and cocycle invariants for compact surfaces with boundary”.
- Sep 2021 Topology Seminar at Dartmouth College, “Cocycle invariants of knots and knotted surfaces”.
- Sep 2021 Institute of Physics, University of Tartu, “Braided matter interactions in quantum gravity via 1-handle attachment”.
- June 2021 8th European Congress of Mathematics, Portoroz, Slovenia (online), “Ternary self-distributive cohomology and invariants of framed links and knotted surfaces with boundary”.
- June 2020 CKVK* webinar, Ohio State University, “Framed link invariants from ternary self-distributive cohomology”. Video available at <https://u.osu.edu/ckvkastrks/>.
- January 2020 Joint Mathematical Meeting (JMM) 2020, Denver, Colorado, contributed session “Algebra and Algebraic Geometry”, “Heap Cohomology and Ternary Self-Distributive Cohomology”.
- October 2019 SPAS, International Conference on Stochastic Processes and Algebraic Structures, Mälardalen University, Västerås, Sweden, “Heap Cohomology and Ternary Self-Distributive Cohomology”.
- Jan 2019 Knots in Washington XLVII, The George Washington University, Washington D.C., “Higher Order Self-Distributivity”.
- Nov 2018 AMS Fall Southeastern sectional meeting, University of Arkansas, Fayetteville, “Continuous Cohomology of Topological Quandles”.
- Apr 2018 Zassenhaus groups and friends conference 2018, University of South Florida, “Distributive groupoids and their cohomologies”.

Scientific event organization and editorial experiences

- Jan 2025 Joint Mathematical Meeting (JMM), Washington DC, AMS session: “Mathematical Foundations of Machine Learning”. Co-organized with Maryam Bagherian.
- April 2024 International school on “Machine Learning approaches for complexity”, Ettore Majorana Foundation and Centre for Scientific Culture, Erice, Italy. Co-organized with Matteo Lulli (Sustech, China), Antonino Marcianò (Fudan University, China, and INFN, Italy), Roman Pasechnik (Lund University, Sweden).
- Fall 2024-Fall 2025 Guest editor, Mathematics (MDPI), special issue “Bioinformatics, Computational Theory and Intelligent Algorithms” https://www.mdpi.com/journal/mathematics/special_issues/3U93GEQ9GK.

Grants, Awards & Fellowships

- Spring 2025 - **Grant:** “Deep Learning-Enhanced Automated Visual Inspection for Improved Structural Health Monitoring”, Kuwait Foundation for the Advancement of Sciences (KFAS), Project code CN24-15EV-2305, total of \$55,000.00 (2 years), reduced to \$30,000.00 for lack of funding. Role of co-PI.
- Spring 2027
- Fall 2024 - **Grant:** “Using integral equations to capture spatiotemporal relations in the brain”, National Institutes of Health (NIH), FAIN R16GM154734, total of \$697,563.00 (4 years). Role of PI.
- Summer 2028

- Summer 2024 **Grant:** “Advancing AI Segmentation and Crack Identification”, Battelle Energy Alliance LLC - BEA - INL, Principal Investigator (\$7,439.00), role of co-PI.
- Fall 2020 **Grant:** Mobilitas Pluss, Estonian Research Council, position of Principal Investigator, (€107,500).
- Fall 2019 AMS Graduate Student **Travel Grant**, American Mathematical Society (\$500).
- Fall 2019 International **Travel Award**, University of South Florida (\$1,500).
- Spring 2019 **Travel Grant**, The George Washington University (\$500).
- Fall 2018 **Travel Grant**, University of South Florida (\$400).
- Fall 2018 **Travel Grant**, University of Wisconsin-Madison (\$600).
- Summer 2018 **Travel Grant**, Mathematical Sciences Research Institute, Berkeley, California (\$600).
- Spring 2018 *Tharp Endowed Award*, College of Art and Science, University of South Florida (\$1,974.58).
- Spring 2017 *Tharp Endowed Award*, College of Art and Science, University of South Florida (\$1,255.58).
- Fall 2016 *Tharp Endowed Award*, College of Art and Science, University of South Florida (\$2,000.00).

Teaching Experience

Idaho State University

MATH1170 Calculus I, MATH1175 Calculus II, MATH2240 Linear Algebra, MATH 4463 Data Science and Applied Machine Learning, MATH 4423-4424 Intro to Real Analysis I and II.

Horizon Academic Research Program

- 2021-2024 “Project Advisor” for the course “Theoretical Mathematics and Knot Theory” (Summer Program). Lead Professor: Vladimir Chernov (Dartmouth College).

University of South Florida

Primary Instructor:

- Spring 2019 MAC 2282 Engineering Calculus II.
- Fall 2018 MAC 2281 Engineering Calculus I.

Teaching Assistantships & Help Sessions:

Differential Equations, Elementary Number Theory, Elementary Abstract Algebra II, Business Calculus, Precalculus/Algebra Trigonometry, Life Science Calculus I & II, College Algebra.

Service

- Referee for Advances in Theoretical and Mathematical Physics, International Press Boston.
- Referee for Arabian Journal of Mathematics, Springer.
- Referee for Neural Networks, Elsevier.
- Referee for Computer Physics Communications, Elsevier.
- Referee for Physica Scripta, IOP Science.
- Referee for Communications in Algebra, Taylor and Francis.
- Referee for Journal of Computer Science and Technology, Springer.
- Referee for AIMS Mathematics, AIMS Press.
- Referee for Machine Learning: Science and Technology, IOP Science.
- Referee for Journal of Noncommutative Geometry, European Mathematical Society press.
- Reviewer for zbMATH.
- Referee for Linear and Multilinear Algebra, Taylor & Francis.
- Referee for Journal of Knot Theory and its Ramifications, World Scientific.
- Referee for Journal of Geometry and Physics, Elsevier.
- Neuromorphic Computing and Engineering, IOP Science.
- Referee for SciPost Physics, SciPost Foundation.
- Referee for Ricerche di Matematica, Springer.
- Referee for Universe, MDPI.

- Referee for Journal of Algebra and its Applications, World Scientific.
- Referee for Symmetry, Integrability and Geometry: Methods and Applications (SIGMA), EMIS.
- Reviewer, Mathematical Reviews, American Mathematical Society.
- Referee for Open Mathematics, De Gruyter.
- Mathematics advisor for the Undergraduate Journal of Mathematical Modeling, University of South Florida.
- Founding member of Graduate Chapter of AMS at University of South Florida.

Memberships

- 2023– Association for the Advancement of Artificial Intelligence (AAAI).
- 2021– European Mathematical Society (EMS).
- 2016-2020 and 2023– American Mathematical Society (AMS).

Programming Skills

Python
Matlab