Emanuele Zappala.

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Website: https://emazap7.github.io/

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.

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).*

Short-Term Research Activities

Summer 2026 "Research Visit", Kobe University. Visiting: Shin Satoh

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 2018 "Derived Categories", Summer School at Mathematical Sciences Research Institute (MSRI), Berkeley, California.

Publications & Pre-prints

- (with M. Saito) "Surface Braid Invariants from Yang-Baxter Operators and Their Cohomology", arXiv:2610.08837 (submitted).
- "Universal approximation of continuous maps between topological vector spaces", arXiv:2609.07942 (submitted).
- (with A. Kramer, S. Acharya, A. Giola) "Nonlocal operator learning for fMRI encoding and decoding tasks", arXiv:2605.20389 (submitted).
- (with C. Fields, J. Glazebrook, A. Marciano) "Operational protocols cannot certify classicality", arXiv:2510.08239.

- (with C. Fields, J. Glazebrook, A. Marciano) "Amplituhedra for Generic Quantum Processes from Computation-Scattering Correspondence", arXiv:2509.19772 (submitted).
- (with M. Saito) "Quantum Cocycle Invariants of Knots from Yang-Baxter Cohomology", **J. Geometry and Physics**, 10.1016/j.geomphys.2026.105985.
- (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", **Advances in Neural Information Processing Systems 38 (NeuRIPS 2025)**.
- (with C. Fields, J. Glazebrook, A. Marciano) "Whether a quantum computation employs nonlocal resources is operationally undecidable", **Europhysics Letters**, `10.1209/0295-5075/adfd0e`.
- (with C. Fields, J. Glazebrook, A. Marciano) "ER = EPR is an operational theorem", **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, **International Conference on Learning Representations (ICLR) 2025**, `https://openreview.net/pdf?id=IeRcpsdY7P`.
- (with M. Bagherian) "Universal Approximation of Operators with Transformers and Neural Integral Operators", **Axioms**, Special issue on Functional Data Analysis, `https://doi.org/10.3390/axioms15090676`.
- (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", **Michigan Math. J.** 10.1307/mmj/20246604.
- "Projection Methods for Operator Learning and Universal Approximation", arXiv:2406.12264 (submitted).
- "Perturbative Expansion of Yang-Baxter Operators", **Publ. RIMS Kyoto Univ.**, `https://ems.press/journals/prims/articles/14299219`.
- "Spectral methods for Neural Integral Equations", arXiv:2312.05654, **Ricerche di Matematica**, `https://doi.org/10.1007/s11587-025-01021-4`.
- (with M. Saito) "Yang-Baxter Solutions from Categorical Augmented Racks", **J. Knot Theory Ramifications**, `https://doi.org/10.1142/S0218216526400122`.
- (with M. Lulli & A. Marciano) "Exact Evaluation of Hexagonal Spin-Networks for Topological Quantum Neural Networks", **Fortschritte der Physik**, `https://doi.org/10.1002/prop.70005`.
- (with Rizvi, Nguyen, Lyu, Christensen, Caro, Brbic, Dhodapkar and van Dijk) "FIMP: Foundation Model-Informed Message Passing for Graph Neural Networks", **Transactions on Machine Learning Research**, available online at `https://openreview.net/forum?id=fj7sjOwtXc`.
- (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", **J. Algebra and its Applications**, `https://doi.org/10.1142/S0219498827500022`.
- (with M. Saito) "Yang-Baxter Hochschild Cohomology", **International J. Math.**, `https://doi.org/10.1142/S0129167X25500624`.

- (with A. Fonseca, J. Ortega Caro & D. van Dijk) "Continuous spatiotemporal transformers", **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", **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", **Illinois J. Math.** (2023) https://doi.org/10.1215/00192082-10972597.
- (with Marcianó, Chen, Fabrocini, Fields, Greco, Gresnigt, Jinklub, 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", **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", **Journal of Geometry and Physics** https://doi.org/10.1016/j.geomphys.2022.104687.
- "Quantum invariants of framed links from ternary self-distributive cohomology", **Osaka J. Math.**, Vol. 59 No.4 (October 2022).
- (with M. Saito) "Braided Frobenius Algebras from certain Hopf Algebras", **J. Algebra Appl.**, https://doi.org/10.1142/S0219498823500123.
- (with M. Saito) "Fundamental heap for framed links and ribbon cocycle invariants", **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", **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

Aug 2026 EKOOK conference, "Quantum invariants of knots and knotted surfaces from Yang-Baxter cohomology", Kindai University, Osaka, Japan.

Jun 2026 Joint seminar Radon Institute of Computational and Applied Mathematics and Interdisciplinary Transformation University, "Operator Learning for Structured Dynamical Data: Nonlocal Methods and Applications", Linz, Austria, EU.

Jun 2026 BIMSA Seminar: "Disquisitions on Monoidal Categories and Operads", "Yang–Baxter Cohomology with a view toward quantum invariants of knots and knotted surfaces", Beijing Institute of Mathematical Sciences and Applications, Beijing, China.

Nov 2025 ICONIP 2025 workshop "Quantifying and simulating multi-neuromodulatory dynamics in the biological brain: Experimental advances, data-centric practices, and computational models", "Nonlocal operator learning for brain dynamics and neuromodulation", Okinawa Institute of Technology (OIST), Okinawa, Japan.

Aug 2025 AMS Sectional meeting Denver, CO, "Yang-Baxter cohomology and perturbative invariants of knots".

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, "n-Lie algebra cohomology and Yang-Baxter deformations".

Apr 2023 AMS Spring sectional meeting, University of Cincinnati, "Yang-Baxter Hochschild Cohomology".

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 Universtiy, "n-Lie algebras, their cohomology and the Yang-Baxter equation".

Dec 2021 Knots in Washington 49.5, The George Washington Universtiy, "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 Geoemetry", "Heap Cohomology and Ternary Self-Distributive Cohomology".

October 2019 SPAS, International Conference on Stochastic Processes and Algebraic Structures, Mälardalen Universtiy, 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 , Universty of South Florida, "Distributive groupoids and their cohomologies".

Fall 2017 Discrete Seminar, Universty of South Florida, "The Eilenberg-Moore Spectral Sequence and applications to the Cohomology of Loop of Suspended Spaces".

Scientific event organization

Mar 2026 AMS sectional meeting in Boise: "Algebraic Structures in Knot Theory and 3-dimensional Topology". Co-organized with M. Elhamdadi (University of South Florida) and U. Kaiser (Boise State University).

Jan 2025 Joint Mathematical Meeting (JMM), Washington DC, AMS session: "Mathematical Foundations of Machine Learning". Co-organized with Maryam Bagherian (Idaho State University).

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).

Editorial service

2026 - 2027 Editor for Contemporary Mathematics volume based on Algebraic Structures in Knot Theory and 3-dimensional Topology.

Spring 2026 - Editor for the American Journal of Graduate Mathematics.

Fall 2024-Fall 2025 Guest editor, Mathematics (MDPI), special issue "Bioinformatics, Computational Theory and Intelligent Algorithms", co-edited with G. Chen (Idaho State University), S. Ray (University of Glasgow), A. Banergjee (University of Oxford), `https://www.mdpi.com/journal/mathematics/special_issues/3U93GEQ9GK`.

Spring 2025 - Editorial board member of Quanta (ISSN: 1314-7374).

Grants

Spring 2026 - Fall 2027 **Grant:** "Precast Concrete Testing Support for Nuclear Applications", Battelle Energy Alliance LLC - BEA - INL, $1,549,000 (ISU share $160,000). Role of co-Principal Investigator (AI-ML component of the project).

Summer 2025 - Summer 2028 **Grant**: IGEM-HERC (state board of eductation) funding"A Sustainable AI-Powered Low-Carbon Emission Concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions", ($547,011). Role of co-Principal Investigator (AI-ML component of the project).

Spring 2025 - Spring 2027 **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.

Fall 2024 - Summer 2028 **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 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).

Travel Grants, Awards, Fellowships, & Recognitions

Spring 2026 Impactful Research Recognition at ISU.

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 Universty ($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, MATH 3362 Introduction to Complex Variables, MATH 1187 Applied Discrete Structures.

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

Refereeing Activity

Journals Advances in Thoeretical and Mathematical Physics, Arabian Journal of Mathematics, Neural Networks, Computer Physics Communications, Physica Scripta, Communications in Algebra, Journal of Computer Science and Technology, AIMS Mathematics, Machine Learning: Science and Technology, Journal of Noncommutative Geometry, Linear and Multilinear Algebra, Journal of Knot Theory and its Ramifications, Journal of Geometry and Physics, SciPost Physics, Ricerche di Matematica, Universe, Journal of Algebra and its Applications, Symmetry, Integrability and Geometry: Methods and Applications (SIGMA), Open Mathematics.

Grant review Grant reviewer for Montana INBRE, Austrian Science Fund.

Math servers Reviewer for: zbMATH and MathSciNet.

Theses and Dissertations PhD dissertation evaluation: "Problems in topological quandle theory" by G. Luke, at IISER Tirupati.

Mentoring Activity

Grad students Andreas Kramer (Master's degree co-advisor with L. Kirby). Graduated 2026.

Undergrad students Research Students: Alice Giola, Saugat Acharya, Koras Koirala, Pramesh Shah.

Supervised poster titled "General Nonlocal Operator Learning Framework for fMRI Modeling and Decoding", presented at MAA Sacramento 2025. It received the Outstanding Poster Award from MAA. Students involved: Acharya, Giola, and Kramer.

2021-2024 "Project Advisor" at the Horizon Academic Research Program for the course "Theoretical Mathematics and Knot Theory" (Summer Program), with Vladimir Chernov (Dartmouth College). Several high school student advised on research projects (some of which have been published in peer-reviewed or in undergraduate journals).

Departmental and College Service

2024 Participant of the working group that created the Bachelor's degree in AI at ISU.

2023-2024 Organizer of Colloquium at Idaho State University.

2024 Graduate program committee member (departmental).

2024-2025 ISU Math Club mentor.

2024-2025 Deprartment advisor for mathematics at Idaho State University.

2023 Engineering and Applied Sciences PhD committee member (College level).

Committee Member for Suraj Prasad Dahal's thesis defence at ISU.

2025 Committee Member for Core Program Committee (departmental).

Other Activities

Mathematics advisor for the Undegraduate Journal of Mathematical Modeling, University of South Florida. Founding member of Graduate Chapter of AMS at University of South Florida.

Memberships

Asia Pacific Neural Network Society (APNNS).

Association for the Advancement of Artificial Intelligence (AAAI).

European Mathematical Society (EMS).

American Mathematical Society (AMS).

Programming Skills

Python

Matlab