Erbil Can Artun

Statistical Physics and Data-Driven Approaches to Complex Systems

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Research Statement — I develop renormalization-group theory for systems that resist standard treatment — long-range interactions, quenched disorder, multi-component and continuous spins, fractal geometries — and characterize the phase structures (reentrant, algebraic, multistructured, chaotic) that emerge in these settings. My work has identified new ordered phases and chaos mechanisms in spin-glass, Potts, Blume–Capel, and Ashkin–Teller systems across dimensions one through three. My current research extends this background into data-driven complex-systems science: reconstructing the dynamics of complex networks from observational data using reservoir computing, and detecting seismic precursors in geomagnetic signals through statistical and machine-learning methods. I aim to develop a research program in which exactly tractable theory and complex empirical data inform and constrain each other — using the structural understanding gained from statistical physics to guide data-driven inference, and using empirical signatures to test theoretical claims about complexity.

Education

PhD in Computational Sciences and Engineering **2020 – 2026**
Kadir Has University *Nominated for the Best PhD Thesis Award (under review)*
Thesis: "Scale and Complexity: Renormalization-Group Theory of Phase Transitions, Spin-Glass Chaos, and Emergent Order in Complex Spin Systems" (Advisor: Prof. A. Nihat Berker)

MA in Philosophy **2015 – 2018**
Yeditepe University *Graduated with Honors*
Thesis: "From Metaphysics to Physics Emerging Human Social Life: On Spinoza's Ethics" (Advisor: Prof. Saffet Babur)

MS in Physics **2011 – 2015**
Yeditepe University *Graduated with Honors*
Thesis: "Nonlinear Dynamics and Possible Chaoticity in Condensed Matter Systems" (Advisor: Prof. Avadis S. Hacinliyan)

BS in Physics **2008 – 2011**
Yeditepe University *Ranked 1st in Department*
Thesis: "Transport Properties of Quantum Point Contacts in The Presence of Edge States" (Co-advisors: Prof. Avadis S. Hacinliyan, Prof. Afif Sıddıki)

Schools & Intensives

- **Understanding and Shaping Complex Social Psychological Systems**, New England Complex Systems Institute (2024) — *Full Scholarship*
- **Introduction to Concepts and Applications of Complexity Science**, New England Complex Systems Institute (2024) — *Full Scholarship*
- **Magnetic Properties of Two-Dimensional Materials from First Principles**, Eskişehir Technical University (2021)
- **Quantum Field Theory School**, Boğaziçi University (2020)
- **Phase Transitions and Renormalization Group Theory**, Kadir Has University (2019) — *Outstanding Success Recognition; among 3 selected participants out of ∼200*
- **Geometry and Symmetry School**, Istanbul Center for Mathematical Sciences (2019)
- **Quantum Field Theory Summer School**, Mimar Sinan University of Fine Arts (2018)

Research Visits & External Collaborations

Ongoing Collaborations

Reservoir Computing for Reconstruction of Complex Network Dynamics **2026 – Present**
with Assoc. Prof. Deniz Eroğlu (Imperial College London) and Assist. Prof. Thomas Geert de Jong (Temple University)

- Independent research collaboration developing reservoir-computing methods to reconstruct the dynamics of

complex networks from observational data.

Research Visits

Visiting Graduate Researcher, *Soft-Condensed Matter Physics Lab, Boğaziçi University, Istanbul* **2013 – 2015**

- Hosted by Prof. Yani Skarlatos (Department Head) within a Turkey–Ukraine joint research project on advanced humidity sensors. Supervised laboratory work for the MS thesis project; thesis advised by Prof. A. S. Hacinliyan.

Visiting Undergraduate Researcher, *Quantum Technologies Laboratory, Istanbul University* **2010 – 2011**

- Conducted BS senior thesis research on quantum transport in 2D electron systems, hosted by co-advisor Prof. Afif Sıddıki.

Visiting Researcher, *Physics Department, Harvard University, Boston, USA* **Summer 2010**

- Hosted by Prof. Richard Wilson; statistical and risk analysis of long-term effects of the Chernobyl nuclear disaster. Supported by a special travel grant awarded by the Board of Trustees of Yeditepe University on individual academic merit.

Experience

Research Appointments

Postdoctoral Researcher (Concurrent with final year of PhD) **2025 – Present**
TÜBİTAK National Metrology Institute *Kocaeli, Turkey (Hybrid)*

- Developing theoretical, computational, and machine learning models for geomagnetic signal analysis in earthquake precursor detection (DETAM project, national initiative).
- Designing data-driven pipelines for extracting seismic precursor signals from search-coil and fluxgate magnetometer measurements.
- Independently pursuing development of reservoir-computing methods for reconstructing complex network dynamics from observational data.

Doctoral Researcher **2022 – 2026**
TÜBİTAK Research Institute for Fundamental Sciences *Kocaeli, Turkey (Hybrid)*

- Developed renormalization-group methods for spin systems with long-range, multi-component, and continuous-spin interactions, yielding 8 first-author publications during the appointment.
- Conducted research within the "Complex System Multifractal Dynamics" project on emergence and complexity in physical systems.
- Co-organized international scientific events bringing together leading researchers in complex systems and statistical physics.

Industry & Applied Research

Research Scientist, *TRK Technology, Ankara, Turkey (Part-time, concurrent with PhD)* **2022 – 2025**

- Developed quantitative models for algorithmic trading; established and led the firm's quantum computing program for financial applications; contributed to applied projects with governmental and industrial partners (Ministry of Treasury and Finance, Turkish Airlines, among others).

Data Scientist, *Science to Data Science (S2DS) Program, Pivigo, UK (Remote)* **Winter 2024**

- Built predictive models and automated pipelines for lottery-market forecasting in collaboration with the UK Gambling Commission; developed an interactive visualization tool for policy-oriented data analysis.

Teaching

Teaching Assistant **2019 – 2026**
Berker Research Group *Istanbul, Turkey (Hybrid)*

- *Istanbul Technical University*
  - **Universality, Scaling, and Fluctuations** (FIZ621, graduate) — Spring 2026
    Delivering recitations.
- *Kadir Has University*
  - **Phase Transitions and Renormalization-Group Theory** (graduate) — Multiple semesters
    Adapted from Phys 8.334, designed and taught by Prof. Nihat Berker at MIT.

  - **MasterClass: New Developments in Quantum Technologies and Quantum Computing** — Fall 2023
    Open-enrollment intensive course; instructor: Dr. Doga Kurkcuoglu (Fermilab Quantum Institute, FNAL, USA).
  - **Brain Science, Artificial Intelligence and Neuroscience: Science of the Future** — Summer 2021, Fall 2021
  - **Augmented Electricity and Magnetism**; **Augmented Mechanics** — Multiple semesters
    Open-enrollment intensive courses for top-performing students from multiple institutions.
  - **Physics I and II** — Multiple semesters
- *Council of Higher Education – High Performers Natural Sciences Program (TEBIP)*
  - **Mechanics** — Fall 2022

Earlier Teaching

Assistant Lecturer, *Department of Molecular Biology and Genetics, Biruni University* **2018**

- Taught Physics and Mathematics, alternating with Prof. Afif Sıddıki.

Teaching Assistant, *Physics Department, Yeditepe University* **2013 – 2018**

- Electricity & Magnetism Laboratory and Mechanics Laboratory, multiple semesters.

Publications

A list of publications is also available at: Personal Website, Google Scholar, ORCiD.

Peer-Reviewed Articles

1. E. C. Artun and A. N. Berker (in review, 2026). "Ferromagnetic and Spin-Glass Finite-Temperature Order but no Antiferromagnetic Order in the d=1 Ising Model with Long-Range Power-Law Interactions." *In review; preprint available on arXiv*, arXiv:2508.11168.
2. E. C. Artun and A. N. Berker (2026). "Blume-Capel Model in d=1 with Long-Range Interactions: Giant Reentrance in the Finite-Temperature Tricritical Phase Diagrams." *Physica A: Statistical Mechanics and its Applications*, 688, 131387.
3. E. C. Artun and A. N. Berker (2025). "Multiplicity of Algebraic Order from Fixed Lines of Potential Surfaces: XY-Ashkin-Teller in Spatial Dimension d=2." *Physical Review E*, 112, 024126.
4. E. C. Artun, D. Sarman, and A. N. Berker (2024). "Axial, Planar-Diagonal, Body-Diagonal Fields on the Cubic-Spin Spin Glass in d=3: A Plethora of Ordered Phases under Finite Fields." *Physical Review E*, 110, 034123.
5. E. C. Artun, D. Sarman, and A. N. Berker (2024). "Nematic Phase of the n-Component Cubic-Spin Spin Glass in d=3: Liquid-Crystal Phase in a Dirty Magnet." *Physica A: Statistical Mechanics and its Applications*, 640, 129709.
6. Y. E. Pektaş, E. C. Artun, and A. N. Berker (2023). "Driven and Non-Driven Surface Chaos in Spin-Glass Sponges." *Chaos, Solitons & Fractals*, 176, 114159.
7. E. C. Artun and A. N. Berker (2023). "Merged Potts-Clock Model: Algebraic and Conventional Multistructured Multicritical Orderings in Two and Three Dimensions." *Physical Review E*, 108, 024116.
8. E. C. Artun, İ. Keçoğlu, A. Türkoğlu, and A. N. Berker (2023). "Multifractal Spin-Glass Chaos Projection and Interrelation of Multicultural Music and Brain Signals." *Chaos, Solitons & Fractals*, 167, 113005.
9. E. C. Artun and A. N. Berker (2021). "Spin-s Spin-Glass Phases in the d=3 Ising Model." *Physical Review E*, 104, 044131.
10. E. C. Artun and A. N. Berker (2021). "Metastable Potts Droplets." *Physical Review E*, 103, 032102.
11. E. C. Artun and A. N. Berker (2020). "Complete Density Calculations of q-State Potts and Clock Models: Reentrance of Interface Densities under Symmetry Breaking." *Physical Review E*, 102, 062135.
12. A.S. Hacinliyan, Y. Skarlatos, O. Ozgur Aybar, I. Kusbeyzi Aybar, E. Kandiran, A.C. Keles, and E. C. Artun (2013). "Signals of chaos in the transient current through As_2S_3 (Ag) and As_2Se_3 (Al) thin films." *Chaotic Modelling and Simulation*, 4, 591-599.

Book Chapter

1. S. N. Açıkalın and E. C. Artun (2019). "The Concept of Self-Organized Criticality: The Case Study of the Arab Uprising." *Chaos, Complexity and Leadership 2017: Explorations of Chaos and Complexity Theory, Springer*, Online ISBN: 978-3-319-89875-9; Print ISBN: 978-3-319-89874-2.

Talks & Presentations

Invited Talks

1. "Uzun Menzilli Etkileşimli Spin Sistemlerinde Renormalizasyon Grubu: Bir Boyutta Ising Modeli'nden Blume–Capel Modeli'ne." Departmental Seminar, Physics Dept., MSGSU, Istanbul. *30 Apr 2026*
2. "Renormalization-Group Theory for Spin Systems with Long-Range Interactions: Giant Reentrance in the 1D Blume–Capel Model." Graduate Seminar Lecture, Kadir Has University, Istanbul. *27 Mar 2026*
3. "Renormalization Group Studies of Phase Transitions." Departmental Seminar, Physics Dept., Yeditepe University, Istanbul. *7 Mar 2024*
4. "Scientific Mosaic Throughout the Ages." Scientific Thought Workshop, ETWO Youth, Turkey. *2023*
5. "İstatistik Fiziğin Kitle İmha Yöntemi: Renormalizasyon Grubu." National Physics Students Summit, Hacettepe University, Ankara. *16–17 Apr 2022*
6. "Kuantum Mekaniğinin Felsefi Yorumları." MindFusion Days, Data Science Earth, Turkey. *15 Nov 2020*
7. "Uçurumun Kenarında Büyük Dönüşüm: 3. Sanayi Devrimi." Ment College, Istanbul. *24 Mar 2018*
8. "Self-organized Criticality: The Case Study of The Arab Uprising"; "The Work of Art in the Age of Non-material Production." Akyaka Nature Meetings, Mugla. *9–12 Feb 2018*
9. "Düzensizliğin Eşiğinde Değişen Dünya, Toplum ve Bilinç." 10th From Chaos to Cosmos Workshop, Gümüşlük Academy, Mugla. *26–28 Aug 2016*

Contributed Talks & Posters

1. Poster: "Renormalization Group Studies of Continuous-Spin Complex Systems." TURAN–Fundamental Sciences Symposium, Yıldız Technical University, Istanbul. *23–25 Jun 2025*
2. Talk: "Spin-Glass Sponges: Spin Glasses with Fractal Surfaces." 11th Intl. Scientific Conf. on Physics and Control, Kadir Has University, Istanbul. *9–12 Sep 2024*
3. Poster: "Spin-Glass Phase Transition in Finite Field." 40th Intl. Physics Cong. of the Turkish Physical Society, Mugla. *2–6 Sep 2024*
4. Poster: "Liquid Crystal Phase in Spin Glasses." 28th Condensed Matter Physics Meeting, Bilkent University, Ankara. *22 Dec 2023*
5. Talk: "Spin-Glass Machine: Music, Brain, and Complex System Classificator." 25th National Liquid Phase Symposium, Piri Reis University, Istanbul. *27 May 2022*
6. Talk: "The Concept of Self-Organized Criticality: The Case Study of the Arab Uprising." 5th Intl. Symposium on Chaos, Complexity and Leadership, Ankara. *11–12 Dec 2017*
7. Poster: "q-Gaussian Analysis of the Electronic Behavior in As_2S_3(Ag) and As_2Se_3(Al) Thin Films." 32nd Intl. Physics Cong. of the Turkish Physical Society, Mugla. *6–9 Sep 2016*
8. Talk: "Signals of Chaos in the Transient Current through As_2S_3(Ag) and As_2Se_3(Al) Thin Films." 6th Chaotic Modeling and Simulation Intl. Conference, Yeditepe University, Istanbul. *11–14 Jun 2013*

Honors & Awards

- **Best PhD Thesis Award Nominee**, Kadir Has University (2026) — *under review*
- **Graduated with Honors**, MA Philosophy, Yeditepe University (2018)
- **Graduated with Honors**, MS Physics, Yeditepe University (2015)
- **Full Merit-Based Scholarship**, MA Philosophy, Yeditepe University (2015–2018)
  Awarded by the Board of Trustees based on exceptional academic promise.
- **Full Merit-Based Scholarship**, MS Physics, Yeditepe University (2011–2015)
- **Ranked 1st in Department**, BS Physics, Yeditepe University (2011)
- **Special Travel Grant**, Yeditepe University Board of Trustees (2010)
  One-time grant established by special decision of the Board of Trustees to support research visit to Harvard University, USA.
- **National Merit-Based Full Scholarship**, Council of Higher Education, Turkey (2007–2011)

Academic Service & Leadership

Mentoring

- **Graduate Student Mentor**, Berker Research Group (2022–Present)
  - Co-authored research with: D. Sarman (2 papers, 2024), Y. E. Pektaş (1 paper, first author, 2023), İ. Keçoğlu and A. Türkoğlu (1 paper, 2023).
  - Mentored and provided technical training to additional graduate students whose research with the group's PI resulted in publications.
- **Intern Supervisor**, TÜBİTAK Research Institute for Fundamental Sciences
  Mentored undergraduate and graduate interns on research projects in statistical physics and complex systems.
- **Coach**, CERN Beamline for Schools Program (2023)
  Mentored a national team of high-school students in developing a competitive experimental physics proposal.
- **Core Member**, QTurkey (2020–2022)
  Organized quantum computing workshops and hackathons; led study groups and mentored participants.

Editorial & Reviewing

- **Reviewer**, Elsevier (2023–Present)
  Chaos, Solitons & Fractals; *The European Physical Journal Special Topics*

Conference & Scientific Event Organization

- **Organizing Committee Member**, 16 international and 3 national events (2017–2026)
  Roles at TÜBİTAK Research Institute for Fundamental Sciences and the International Science Association; interdisciplinary conferences, schools, and workshops in complex systems, quantum technologies, photonics, materials science, life sciences, and high-energy physics (e.g., ICCLS 2018–2020, PQIP 2024, CALSA 2025, HEAP 2026, WCB-5G).
- **Local Organizing Committee Member**, 11th International Conference on Physics and Control, IPACS (2024)

Professional Memberships

- **Complex Systems Society** (May 2024 – Present)
- **International Physics and Control Society (IPACS)** (2024 – Present)

Leadership

- **President**, Yeditepe University Robotics Club (2008–2010)
  Led organizational activities, projects, and technical events.