

Marios Mattheakis (Matthaiakis)

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Current Position

2018– **Research Associate, Machine Learning and Applied Physics**
Institute for Applied Computational Science (IACS), Harvard University, USA

Education

- 2015–18 **Postdoctoral Fellow, Computational Applied Physics**
School of Engineering and Applied Sciences (SEAS), Harvard University, USA
Advisor: Prof. Efthimios Kaxiras
- 2014 **Ph.D. in Physics**
Department of Physics, University of Crete, Greece
Advisor: Prof. Giorgos Tsironis
Dissertation: Electromagnetic wave propagation in gradient index metamaterials, plasmonic systems and optical fiber networks
- 2012 **M. Sc., Computational Physics**
Department of Physics, University of Crete, Greece
Advisor: Prof. Giorgos Tsironis
Thesis: Wave propagation in networks of Luneburg lenses
- 2010 **B. Sc., Physics**
Department of Physics, University of Crete, Greece
Advisor: Prof. Giorgos Tsironis
Thesis: Numerical Methods in Electromagnetism

Research Experience

- 2018– **Research Associate, Harvard University**
Research Areas: Machine Learning, Data Science, Deep Learning, Applied Physics
- Physics-informed machine learning
 - Neural network solvers for differential equations and eigenvalue problems
 - Machine learning forecasting of spatiotemporal dynamics and autonomous systems
 - Two-dimensional materials, heterostructures, and metamaterials
 - Neuromorphic computing
- 2015–18 **Postdoctoral, Harvard University**
Research Areas: Two dimensional materials, plasmonics, metamaterials
- Plasmonic quantum metamaterials based on two-dimensional solids
 - Ultra-relativistic branched electronic flows in graphene and other Dirac materials
 - Manipulating light polarization with stacking of two-dimensional Black Phosphorus
 - Quantum plasmons and phonons in graphene multilayers and heterostructures

2010–14 **Graduate Student, University of Crete**

Research Area: Computational physics, photonics, plasmonics, disordered networks

- Branched flows and extreme events (rogue waves) in random photonic media
- Designed electromagnetic waveguides with arrangements of metamaterial lenses
- Non-Hermitian plasmonic systems with Parity-Time symmetry
- Subdiffusive wave propagation in nonlinear and disordered optical discrete networks
- Participated in "MARIE-CURIE Excellence Grant entitled: **ELECTRONCOMPLEXITY**"

2008–10 **Undergraduate Student, University of Crete**

Research Area: Computational Physics

- Developed Finite Difference in Time Domain (FDTD) and ray-tracing algorithms
- Investigated metamaterials, gradient index lenses, and cloaking devices
- Explored nonlinear dynamics and chaotic systems

Teaching Experience

2018–21 **Instructor, Institute of Applied Computational Science, Harvard University**

Courses: Introduction to Data Science I (CS-109a) & II (CS-109b)

- Instructed students in machine learning, data science, and deep learning
- Prepared curriculum, lectures, exercises
- Leading advanced sections and Labs

2011–14 **Teaching Assistant, Department of Physics, University of Crete**

Courses: Introduction to Programming, Labs in MATHEMATICA, and Electromagnetism

- Leading computational Labs in FORTRAN and MATHEMATICA
- Grading homework and exams
- Held weekly office hours

Invited Presentations

Jan 2022 **Workshop on Computational Scientific Research, Chile**

Title: *One-shot Transfer Learning of Physics-Informed Neural Networks*

Dec 2021 **Crunch Seminar of Applied Mathematics at Brown University, RI, USA**

Title: *One-shot Transfer Learning of Physics-Informed Neural Networks*

Dec 2021 **Food For Thought Hour, Seminar of Applied Mathematics at Harvard University, MA, USA**

Title: *Transfer Learning of Physics-Informed Neural Networks*

Jul 2021 **Workshop on Machine Learning in astronomy: From classical to physics-informed, Chile**

Title: *Physics-Informed Hamiltonian Neural Networks*

Apr 2021 **DAiTA Labs, Universidad Mayor, Chile**

Title: *Artificial neural networks for solving differential equations*

Mar 2021 **Colloquium of Math at Florida State University, Florida, USA**

Title: *Artificial neural networks for solving differential equations*

Jan 2021 **ComputeFest 2021 at Harvard, MA, USA**

Title: *Transfer Learning: How to use existing models for transfer learning, identify similarity in the embedding space, and distilling knowledge from pre-trained neural networks*

Jan 2020 **ComputeFest 2020 at Harvard, MA, USA**

Title: *How to use existing models for transfer learning*

- Nov 2019 **Colloquium of Physics at Rensselaer Polytechnic Institute**, New York, USA
Title: *Two-dimensional materials, metamaterials & Machine Learning*
- Oct 2019 **Global Innovation Forum, Transforming Intelligence**, Yerevan, Armenia
Title: *Machine Learning for Dynamical Systems*
- Sep 2019 **ACM International Conf. on Nanoscale Computing and Communication**, Dublin, Ireland
Title: *Graphene epsilon-near-zero plasmonic crystals*
- Mar 2016 **Seminar of Crete Center for Quantum Complexity & Nanotechnology**, Crete, Greece
Title: *Plasmonic periodic structures composed by 2D materials*
- Sep 2015 **Colloquium of Physics, Wesleyan University**, Connecticut, USA
Title: *Surface plasmons in active systems and 2D materials*

Conference, Workshops, and Summer School participation

- Dec 2020 **NeurIPS Workshop on Machine Learning and Physical Sciences**, Online
Poster Presentations: (I) *Unsupervised Neural Networks for Quantum Eigenvalue Problems*;
(II) *Semi-supervised Neural Networks Solve an Inverse Problem for Modeling Covid-19 Spread*
- Mar 2019 **APS March Meeting**, Boston, Massachusetts, USA
Oral presentation: *Physical Symmetries Embedded in Neural Networks*
- Mar 2018 **APS March Meeting**, Los Angeles, California, USA
Oral presentation: *Electronic Branched Flow in Graphene: Theory and Machine Learning Prediction*
- Mar 2018 **Workshop on Theory and Computation for Transport Properties in 2D Material**, Minneapolis, Minnesota, USA
- May 2017 **Mathematical Modeling of 2D Materials**, Minneapolis, Minnesota, USA
Poster presentation: *Epsilon-Near-Zero from plasmonic Dirac point: Theory and realization using two-dimensional materials*
- Mar 2017 **APS March Meeting**, New Orleans, Louisiana, USA
Oral presentation: *Epsilon-Near-Zero from plasmonic Dirac point: Theory and realization using two-dimensional materials*
- Feb 2017 **Boston Photonics Centennial Conference**, Cambridge, Massachusetts, USA
Poster presentation: *Epsilon-Near-Zero from plasmonic Dirac point: Theory and realization using two-dimensional materials*
- Jul 2016 **Nanosciences & Nanotechnologies (NN16)**, Thessaloniki, Greece
Oral presentation: *Epsilon-Near-Zero and Plasmonic Dirac Point by using 2D materials*
- Sep 2014 **COMSOL conference**, Cambridge, United Kingdom
Poster Presentation: *Enhanced surface plasmon polariton propagation induced by active dielectrics*
- Jul 2014 **International Workshop on Statistical Mechanics and Dynamical Systems**, Athens, Greece
Poster Presentation: *Linear and nonlinear photonic rogue waves in complex transparent media*
- Jul 2014 **Complex Systems**, Athens, Greece
Poster Presentation: *Linear and nonlinear photonic rogue waves in complex transparent media*
- Jul 2014 **International Conference on Statistical Physics**, held by SigmaPhi Committee, Rhodes, Greece
Poster Presentation: *Linear and nonlinear photonic rogue waves in complex transparent media*
- Mar 2014 **Dynamics Symposium**, organized by the Max Planck Institute for Dynamics and Self Organization (Goettingen) on Mandarfen in Austria
- Dec 2013 **Light in Disordered Photonic Media**, held by the Physikzentrum Bad Honnef, Germany.
Poster Presentation: *Observation of photonic rogue waves in strongly scattering random media*
- Jul 2013 **Third European Ph.D. School on Mathematical Modeling of Complex Systems**, organized by the Department of Physics, University of Crete, Greece
Oral & Poster Presentation: *Linear optical rogue waves in disordered photonic networks*
- Aug 2012 **International Workshop on Statistical Mechanics and Dynamical Systems**, held by ITAP, Turunc, Turkey
Poster Presentation: *Luneburg lens waveguide networks*

Sep 2011 **Nanoantennas and Hybrid Quantum Systems**, held by the Physikzentrum Bad Honnef, Germany

Aug 2011 **Charged Particle Optics: Theory and Simulations (CPOT)**, organized by the Department of Physics, University of Crete, Greece

Jul 2011 **First European Ph.D. School on Mathematical Modeling of Complex Systems**, organized by the Department of Mathematics, University of Patras, Greece

Professional Activities, Service, and Career development

Fellowships and Awards

2021 Selected as the SEAS single nominee for the Harvard University-wide competition for the Aramont Fund Postdoctoral Fellowship

2021 Awarded as an *IOP Trusted Reviewer*

Reviewer for International Journals and Conferences

- Nature Communications
- Physical Review Letters
- Physical Review Research
- Nano Letters
- J. of Computational Physics
- Chaos Solitons & Fractals
- Optical Materials Express
- Optics Express
- Nanotechnology
- NeurIPS 2021
- AAAS Science Advances
- Physical Review Applied
- Physical Review B
- Applied Nano Materials
- Wave Motion
- Applied Physics Letters
- JOSA B
- Continuum
- Physica Scripta
- AISTATS 2022
- Royal Society Proceedings A
- Physical Review A
- European Phys. Journal B
- Selected Topics in Quantum Electronics
- Optical Materials
- J. of Applied Physics
- Applied Optics
- Engineering Research Express
- J. of Applied Math and Physics
- ACM NanoCom 2019-2021 conference

Memberships

- American Physical Society (APS)
- Association for Computing Machinery (ACM)

Committees/Organizational Services

2019–21 Technical Program Committee for ACM International Conference on Nanoscale Computing and Communication

2020–21 Master's Thesis committee for CSE Master's program at Harvard

2020–21 Co-organizer of Transfer Learning workshops for ComputeFest at Harvard

2020–21 Judging committee for the National Collegiate Research Conference

2020–21 Assisting prospective graduate students from underrepresented and/or historically minoritized communities in STEM. Harvard Graduate School Application Assistance Initiative

2021 Mentoring female or nonbinary high-school students, Talaria Research Program held by ATHENA

2021 Co-organizer of the Data Science Pedagogy Workshop held by Harvard IACS

2021-22 Judging committee for the science competition ENVISION held by Women in STEM

Students Advisor & Mentor

2021– **Raphael Pellegrin**, Master student at Harvard University

2021– **Madison Shirazi** undergraduate student at Harvard University

2021– **Aidan Carey**, undergraduate student at Harvard University

2021– **Edward Koh**, undergraduate student at Harvard University

- 2021– **Emin Berker**, undergraduate student at Harvard University
- 2021 **John Chen**, undergraduate student at Harvard University
- 2020– **Henry Jin**, Master student at Harvard University
- 2020– **Hayden Joy**, Research Assistant at Harvard University and Rensselaer Polytechnic Institute
- 2020–21 **Anwesh Bhattacharya**, Ph.D student at Birla Institute of Technology & Science
- 2020 **Alessandro Paticchio**, Master student at Politecnico di Milano
- 2020 **Tommaso Scarlatti**, student at Politecnico di Milano
- 2019–21 **Jing Tang**, Undergraduate student at Nanjing University

References

1. **Prof. Efthimios Kaxiras**, Department of Physics and John A. Paulson School of Engineering and Applied Sciences, Harvard University
2. **Prof. Georgios Tsironis**, Department of Physics, University of Crete
3. **Dr. Pavlos Protopapas** John A. Paulson School of Engineering and Applied Sciences, Harvard University
4. **Prof. Stephen Roberts** Man Group Chair in Machine Learning, University of Oxford

Relevant Skills

Programming languages: Python, MATLAB, MATHEMATICA, Fortran, C, C++, Java, UNIX shell

Computational packages: PyTorch, TensorFlow, Keras, COMSOL

Languages: Fluent in English and Greek

Publications

1. M. Angelia, G. Neofotistos, **M. Mattheakis**, E. Kaxiras: *Modeling the effect of the vaccination campaign on the Covid-19 pandemic*, Chaos, Solitons & Fractals **154**, 111621 (2022) [[Link](#)]
2. S. Desai, **M. Mattheakis**, S. Roberts: *Variational Integrator Graph Networks for Learning Energy Conserving Dynamical Systems*, Phys. Rev. E **104**, 035310 (2021) [[Link](#)]
3. S. Desai, **M. Mattheakis**, D. Sondak, P. Protopapas, S. Roberts: *Port-Hamiltonian Neural Networks for Learning Explicit Time-Dependent Dynamical Systems*, Phys. Rev. E **104**, 034312 (2021) [[Link](#)]
4. H. Jin, **M. Mattheakis**, P. Protopapas: *Unsupervised Neural Networks for Quantum Eigenvalue Problems*, NeurIPS Workshop on Machine Learning and Physical Sciences (2020) [[Link](#)]
5. A. Paticchio, T. Scarlatti, **M. Mattheakis**, P. Protopapas, M. Brambilla: *Semi-supervised Neural Networks solve an inverse problem for modeling Covid-19 spread*, NeurIPS Workshop on Machine Learning and Physical Sciences (2020) [[Link](#)]
6. **M. Mattheakis**: *Riding Waves in Neuromorphic Computing*, APS Physics **13**, 132 (2020) [[Link](#)]
7. Y. Luo, R. Engelke, **M. Mattheakis**, M. Tamagnone, S. Carr, K. Watanabe, T. Taniguchi, E. Kaxiras, P. Kim, and W. L. Wilson.: *In-situ nanoscale imaging of moiré superlattices in twisted van der Waals heterostructures*, Nature Communication **11**, 4209 (2020) [[Link](#)]
8. G. A. Tritsarlis, Y. Xie, A. M. Rush, S. Carr, **M. Mattheakis**, E. Kaxiras: *LAN – A materials notation for 2D layered assemblies*, J. Chem. Inf. Model., **60**, 3457-3462 (2020) [[Link](#)]
9. G. A. Tritsarlis, S. Carr, Z. Zhu, Y. Xie, S. Torrisi, J. Tang, **M. Mattheakis**, D. Larson, E. Kaxiras: *Electronic structure calculations of twisted multi-layer graphene superlattices*, 2D Materials **7**, 035028 (2020) [[Link](#)]
10. Feiyu Chen, David Sondak, Pavlos Protopapas, **M. Mattheakis**, Shuheng Liu, Devansh Agarwal, and Marco Di Giovanni: *NeuroDiffEq: A Python package for solving differential equations with neural networks*, Journal of Open Source Software, 5(46), 1931 (2020) [[Link](#)]
11. G. Barmparis, G. Neofotistos, **M. Mattheakis**, J. Hitzanidi, G. P. Tsironis, E. Kaxiras: *Robust prediction of complex spatiotemporal states through machine learning with sparse sensing*, Phys. Let. A, **384**, 126300 (2020) [[Link](#)]
12. G. Neofotistos, **M. Mattheakis**, G. Barmparis, J. Hitzanidi, G. P. Tsironis, E. Kaxiras: *Machine learning with observers predicts complex spatiotemporal behavior*. Front. Phys. - Quantum Computing, **7**, 24 (2019) [[Link](#)]
13. M. Maier, **M. Mattheakis**, E. Kaxiras, M. Luskin, and D. Margetis: *Homogenization of plasmonic crystals: Seeking the epsilon-near-zero behavior*. Proc. R. Soc. A, **475**, 20190220 (2019) [[Link](#)]
14. **M. Mattheakis**, M. Maier, W. Xi Boo, and E. Kaxiras: *Graphene epsilon-near-zero plasmonic crystals*. Proceeding NANOCOM '19 Proceedings of the Sixth Annual ACM International Conference on Nanoscale Computing and Communication, Article No. 2, (2019) [[Link](#)]
15. **M. Mattheakis**, G. P. Tsironis, and E. Kaxiras: *Emergence and dynamical properties of stochastic branching in the electronic flows of disordered Dirac solids*. EPL **122**, 27003 (2018) [[Link](#)]
16. S. N. Shirodkar, **M. Mattheakis**, P. Cazeaux, P. Narang, M. Soljačić, and E. Kaxiras: *Quantum plasmons with optical-range frequencies in doped few-layer graphene*. Phys. Rev. B **97**, 195435 (2018) [[Link](#)]
17. M. Maier, **M. Mattheakis**, E. Kaxiras, M. Luskin, and D. Margetis: *Universal behavior of dispersive Dirac cone in gradient-index plasmonic metamaterials*. Phys. Rev. B **97**, 035307 (2018) [[Link](#)]
18. N. Hassan, **M. Mattheakis**, and M. Ding: *Sensorless Node Architecture for Events Detection in Self-Powered Nanosensor Networks*. Nano Communication Networks **19**, 1-9 (2018) [[Link](#)]

19. **M. Mattheakis**, G. P. Tsironis, and E. Kaxiras: *Graphene and Active Metamaterials: Theoretical Methods and Physical Properties*, Nanoplasmonics - Fundamentals and Applications, edited by Gregory Barbillon, InTech (2017) [[Link](#)]
20. C. A. Valagiannopoulos, **M. Mattheakis**, S. N. Shirodkar, and E. Kaxiras: *Manipulating polarized light with a planar slab of Black Phosphorus* J. Phys. Commum. **1**, 045003 (2017) [[Link](#)]
21. O. V. Shramkova, **M. Mattheakis**, G. P. Tsironis: *Amplification of surface plasmons in active nonlinear hyperbolic systems* Proceedings of the 47th European Microwave Conference, 488-491 (2017) [[Link](#)]
22. **M. Mattheakis**, C. A. Valagiannopoulos, and E. Kaxiras: *Epsilon-Near-Zero behavior from Plasmonic Dirac Point: theory and realization using two-dimensional materials*, Phys. Rev. B **94**, 201404(R) (2016) [[Link](#)]
23. **M. Mattheakis**, I. J. Pitsios, G. P. Tsironis, and S. Tzortzakis: *Extreme events in complex linear and nonlinear photonic media*, Chaos, Solitons & Fractals **84**, 73-80 (2016) [[Link](#)]
24. **M. Mattheakis**, T. Oikonomou, M. I. Molina, and G. P. Tsironis: *Phase transition in \mathcal{PT} symmetric active plasmonic systems*, IEEE Journal of Selected Topics in Quantum Electronics **22**, Vol.5 (2015) [[Link](#)]
25. **M. Mattheakis**, and G. P. Tsironis: *Extreme waves and branching flows in optical media*, Quodons in mica: nonlinear localized travelling excitations in crystals, Springer series in materials science, pp 425-454 (2015) [[Link](#)]
26. F. Perakis, **M. Mattheakis**, and G. P. Tsironis: *Small-world networks of optical fiber lattices*, J. Opt. **16**, 102003 (2014) [[Link](#)]
27. C. Athanasopoulos, **M. Mattheakis**, and G. P. Tsironis: *Enhanced surface plasmon polariton propagation induced by active dielectrics*, Expert from the Proceedings of the 2014 COMSOL conference in Cambridge (2014) [[Link](#)]
28. **M. Mattheakis**, G. P. Tsironis, and V. I. Kovanis: *Luneburg lens waveguide networks*, J. Opt. **14**, 114005 (2012) [[Link](#)]

Submitted/Preprints

29. **M. Mattheakis**, H. Joy, P. Protopapas: *Unsupervised Reservoir Computing for Solving Ordinary Differential Equations*, arXiv: 2108.11417 (2021, submitted) [[Link](#)]
30. S. Desai, **M. Mattheakis**, H. Joy, P. Protopapas, S. Roberts: *One-Shot Transfer Learning of Physics-Informed Neural Networks.*, arXiv: 2110.11286 (2021, submitted) [[Link](#)]
31. A. Bhattacharya, **M. Mattheakis**, P. Protopapas: *Encoding Involutory Invariance in Neural Networks*, arXiv: 2106.12891 (2021, submitted) [[Link](#)]
32. T. A. E. Ferreira, **M. Mattheakis**, P. Protopapas: *A New Artificial Neuron Proposal with Trainable Simultaneous Local and Global Activation Function*, arXiv: 2101.06100 (2021) [[Link](#)]
33. **M. Mattheakis**, D. Sondak, S. Dogra, P. Protopapas: *Hamiltonian neural networks for solving differential equations*, arXiv: 2001.11107 (2020, submitted) [[Link](#)]
34. **M. Mattheakis**, P. Protopapas, D. Sondak, M. Di Giovanni, E. Kaxiras: *Physical symmetries embedded in Neural Networks*, arXiv: 1904.08991 (2019) [[Link](#)]