Nayara Fonseca

Curriculum Vitae

May 2025

Contact

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Positions

Current

Senior Research Associate   May 2025 – Present
The Alan Turing Institute   London, UK

Previous

Research Fellow   May 2023 – May 2025
University of Oxford, Rudolf Peierls Centre for Theoretical Physics   Oxford, UK
UKRI Horizon Europe Guarantee Marie Skłodowska-Curie Fellowship
- Project: Phenomenology of Deep Learning.

Research Scientist   May 2022 – April 2023
IBM Research   Daresbury, UK
- Search for physics extremes with generative deep learning; machine learning for equation solving; optimization in physics-informed neural networks.

Postdoctoral Researcher   October 2019 – September 2021
International Centre for Theoretical Physics (ICTP)   Trieste, Italy
- Dark matter model building and phenomenology; machine learning for field localization in theory space.

Postdoctoral Researcher   October 2016 – September 2019
Deutsches Elektronen-Synchrotron (DESY)   Hamburg, Germany
- Physics beyond the Standard Model; interplay between particle physics and early universe cosmology; effective field theory tools to generate large hierarchy of scales.

Exchange PhD Student   January 2014 – December 2014
Center for Theoretical Physics, MIT   Cambridge, USA
Host: Prof. Jesse Thaler.
- Dark matter phenomenology combining complementary data from astrophysics, cosmology, and collider physics.

Education

Ph.D. in Theoretical Physics, August 2016.
Thesis: "Theories with Large Hierarchy of Scales".
Master of Science in Physics, August 2011.
Department of Mathematical Physics, University of São Paulo, Brazil.
Advisor: Prof. Gustavo Burdman.

Bachelor of Science in Physics, June 2009
Gleb Wataghin Physics Institute, University of Campinas, Brazil.
Advisor: Prof. Alberto Saa.

Skills and Other Experience in ML and AI

- **OpenAI Contractor** (Summer 2024): Expert-level data and model evaluation.

- **AI Safety:** AI Alignment Course by BlueDot Impact (AI Safety Fundamentals) with the final project titled: "Polygenic skills: What is the effect of combined tasks?" (March–June 2024).

- **Programming and ML/Stat Libraries/Packages:** Python, Mathematica, TensorFlow, PyTorch, NumPy, Scikit-learn, Pandas.

- **Formal Education in Mathematics:** Calculus, Linear Algebra, Differential Equations, Numerical Calculus, Complex Analysis, Probability, Algorithms and Programming, etc.

- **Optimization using a Genetic Algorithm for Particle Physics:** Parameter space searching of physical observables via a genetic algorithm used in two publications (JHEP and PRD) which are part of my Doctoral Thesis.

Awards, Funding, and Distinctions

2022: Marie Skłodowska-Curie Postdoctoral Fellowship Award at the University of Oxford (EUR 236,000).
2019: 3-year Postdoctoral Research Fellow Position at ICTP, Trieste.
2018: European Union's Horizon 2020 Research and Innovation Staff Exchange Program (Berkeley Lab).
2016: 3-year Postdoctoral Research Fellow Position at DESY Theory Group, Hamburg.
2015 − 2016: FAPESP* Exchange Program Fellowship (DESY Theory Group).
2014: CNPq† Exchange Program Fellowship (Center for Theoretical Physics, MIT).
2011 − 2016: FAPESP Ph.D. Fellowship.
2009 − 2011: FAPESP MSc. Fellowship.
2008 − 2009: FAPESP Undergraduate Scholarship.
2007 − 2008: CNPq Undergraduate Scholarship.
2006: CNPq Undergraduate Scholarship.
2006: Santander Scholarship (Complutense University of Madrid).

*FAPESP: São Paulo Research Foundation.
†CNPq: National Council for Scientific and Technological Development (Brazil).

Publications

– In machine learning papers, an asterisk (*) denotes equal contribution. In theoretical high energy physics, the convention is to order the author list alphabetically.

– Journal of High Energy Physics (JHEP) and Physical Review D (PRD) are top journals in the field, see, e.g., Google Scholar High Energy and Nuclear Physics top publications.

[18] Y. Nam*, N. Fonseca*, S. H. Lee, C. Mingard, A. A. Louis, *An exactly solvable model for emergence and scaling laws.* [NeurIPS 2024] [arXiv].

[17] N. Fonseca*, V. Guidetti*, and Will Trojak*, *Probing optimisation in physics-informed neural networks.* ICLR 2023 Workshop on Physics for Machine Learning [Physics4ML] [arXiv].

[16] N. Fonseca* and V. Guidetti*, *Generalizing similarity in noisy setups: the DIBS phenomenon.* European Conference on Artificial Intelligence (ECAI) 2023 [ECAI 2023] [arXiv].

[15] N. Fonseca and E. Morgante, *Probing photophobic (rel)axion dark matter.* Physical Review D [PRD] [arXiv].

[14] N. Fonseca, E. Morgante, R. Sato, G. Servant, *Relaxion Fluctuations (Self-stopping relaxion) and Overview of Relaxion Stopping Mechanisms.* Journal of High Energy Physics [JHEP] [arXiv].

[13] N. Fonseca, E. Morgante, R. Sato, G. Servant, *Axion Fragmentation.* Journal of High Energy Physics [JHEP] [arXiv].

[12] N. Fonseca, B. von Harling, L. de Lima, C. S. Machado, *Super-Planckian axions from near-conformality.* Physical Review D [PRD] [arXiv].

[11] N. Fonseca and E. Morgante, *Relaxion Dark Matter.* Physical Review D [PRD] [arXiv].

[10] N. Fonseca, E. Morgante and G. Servant, *Higgs relaxation after inflation.* Journal of High Energy Physics [JHEP]; [arXiv].

[9] N. Fonseca, B. von Harling, L. de Lima, and C. S. Machado, *A warped relaxion.* Journal of High Energy Physics [JHEP] [arXiv].

[8] N. Bernal, C. S. Fong, and N. Fonseca, *Sharing but not caring: Dark Matter and the Baryon Asymmetry of the Universe.* Journal of Cosmology and Astroparticle Physics [JCAP] [arXiv].

[7] N. Fonseca, L. de Lima, C. S. Machado, and R. D. Matheus, *Large field excursions from a few site relaxion model (N-Relaxion).* Physical Review D [PRD] [arXiv].

[6] N. Fonseca, L. Necib and J. Thaler, *Dark Matter, Shared Asymmetries, and Galactic Gamma Ray Signals.* Journal of Cosmology and Astroparticle Physics [JCAP] [arXiv].

[5] N. Fonseca, R. Z. Funchal, A. Lessa, and L. Lopez-Honorez, *Dark Matter Constraints on Composite Higgs Models.* Journal of High Energy Physics [JHEP] [arXiv].

[4] G. Burdman, N. Fonseca, and G. Lichtenstein, *Resonances from Quiver Theories at the LHC.* Physical Review D [PRD] [arXiv].

[3] G. Burdman, N. Fonseca, and L. Lima, *Full-hierarchy Quiver Theories of Electroweak Symmetry Breaking and Fermion Masses.* Journal of High Energy Physics [JHEP] [arXiv].

– Thesis and Dissertation

[2] *Theories with Large Hierarchy of Scales.*
    Ph.D. Thesis, University of São Paulo.

[1] *Dimensional deconstruction and flavor violation.*
    Master's Dissertation (In Portuguese), University of São Paulo.

Organization of International Events

- Mainz Institute for Theoretical Physics Scientific Program (Particle Physics and Cosmology), July 2022 [link].

- Joint Workshop between the Institute for Basic Science (Korea) and the ICTP (Italy), Oct. 2021 [link].

- Joint Workshop between the Institute for Basic Science (Korea) and the ICTP (Italy), Oct. 2020 [link].

Talks and Seminars

- AI Security Reading Group, Mathematical Institute, University of Oxford, November 2024.
- 'An exactly solvable model for emergence and scaling laws' (joint presentation with Y. Nam), Oxford group meeting, Rudolf Peierls Centre for Theoretical Physics, University of Oxford, April 2024.
- 'About Scaling, Emergence, and Quanta' – Part 2, Oxford group meeting, Rudolf Peierls Centre for Theoretical Physics, University of Oxford, February 2024.
- 'About Scaling, Emergence, and Quanta' – Part 1, Oxford group meeting, Rudolf Peierls Centre for Theoretical Physics, University of Oxford, January 2024.
- 'An overview of Transformers and Attention Mechanisms', Oxford group meeting, Rudolf Peierls Centre for Theoretical Physics, University of Oxford, September 2023.
- 'Generalization in Contrastive Learning', Oxford group meeting, Rudolf Peierls Centre for Theoretical Physics, University of Oxford, May 2023.
- 'Physics-Informed Artificial Intelligence', Hartree Centre, Sci-Tech Daresbury, November 2022.

- Machine Learning at the Galileo Galilei Institute [YouTube] (joint presentation with V. Guidetti), Florence, September 2022.
- IBM Research Brazil, Rio de Janeiro, August 2022.
- 'Pheno DL: Similarity Learning and Double Descent' [YouTube], U. Autónoma de Madrid, April 2022.
- 'Phenomenology of Deep Learning', The Latin American Symposium of High Energy Physics (SILAFAE) [YouTube], November 2021.
- 'Theory of Deep Learning and Physics', Institute for Fundamental Physics of the Universe, Trieste, April 2021.
- Workshop on probing beyond Standard Model physics at different scales, Magnus-Haus Berlin, January 2020.
- Scuola Internazionale Superiore di Studi Avanzati, ICTP-SISSA Pheno Postdoc Day, Trieste, Italy, December 2019.
- Invisible 2019 Workshop (Neutrinos, Dark Matter and Dark Energy), Valencia, Spain, June 2019.
- Workshop 'Search for New Physics in the Horizon', Korea University, Seoul, May 2019.
- Stanford Institute for Theoretical Physics, USA, November 2018.
- Lawrence Berkeley National Laboratory, USA, October 2018.
- Workshop 'Beyond Standard Model: Where do we go from here?', The Galileo Galilei Institute, Florence, Italy, September 2018.
- CERN TH Institute on Physics at the LHC and Beyond, Geneva, Switzerland, August 2018.
- Mainz Institute for Theoretical Physics, Johannes Gutenberg Universität Mainz, Germany, June 2018.
- 21st International Conference From the Planck Scale to the Electroweak Scale, Bonn, Germany, May 2018.
- Workshop on Cosmological Probes of BSM - from the Big Bang to the LHC, Benasque, Spain, May 2018.
- Institut de Física d'Altes Energies, Universitat Autònoma de Barcelona, May 2018.
- Dalitz Seminar in Fundamental Physics, Department of Physics, University of Oxford, UK, April 2018.
- Confronting Naturalness: from LHC to Future Colliders, DESY Hamburg, Germany, April 2018.
- Workshop on Axions at the crossroads, European Centre for Theoretical Studies in Nuclear Physics and Related Areas, Trento, Italy, November 2017.
- DESY Theory Workshop – Fundamental physics in the cosmos: The early, the large and the dark Universe, Hamburg, Germany, September 2017.
- Theory Seminar at the Bethe Center for Theoretical Physics, Bonn, Germany, June 2017.
- The 29th Rencontres de Blois on Particle Physics and Cosmology, Blois, France, May 2017.
- DESY Theory Workshop – Rethinking Quantum Field Theory, Hamburg, Germany, September 2016.
- ICTP South American Institute for Theoretical Physics, São Paulo, Brazil, August 2015.
- MIT Center for Theoretical Physics Journal Club, Cambridge, March 2014.

Student Supervision and Teaching

- *MSc Dissertation Supervisor; Theme: Machine Learning.* Thomas Weatherbee, University of Oxford, 2024 – Present.
- *MSc Dissertation Supervisor; Theme: Machine Learning.* Runze Feng, University of Oxford, 2024 – Present.
- *MSc Dissertation Supervisor; Theme: Machine Learning.* Samuel Dudley, University of Oxford, 2024 – Present.
- *MSc Dissertation Supervisor; Theme: Machine Learning.* Lysander Mawby, Title: "Scale in Deep Learning: Algorithmic Datasets and Sudden Performance Changes", University of Oxford, 2023 – 2024.
- *MSc Dissertation Tutor; Theme: Particle Physics.* Fidele Twagirayezu, Title: "New Light Neutral Particles in Meson Decays", East African Institute of Fundamental Research (Rwanda), 2020 – 2021.
- *Internship Co-supervisor at DESY; Theme: Particle Physics and Cosmology.* Augustin Vanrientvelde, École Polytechnique (France), June 2017 – Sep. 2017.

Academic Visits and Other Positions

Queen Mary University of London, United Kingdom.
Postdoctoral Researcher at the Centre for Theoretical Physics.
October 2021 – November 2021.

Lawrence Berkeley National Laboratory, Berkeley, USA.
Visitor Research Scholar.
October 2018 – November 2018.

DESY Theory Group, Hamburg, Germany.
Host: Prof. Géraldine Servant.
Exchange PhD Student.
September 2015 – May 2016.

Complutense University of Madrid, Spain.
Undergraduate Exchange Program.
September 2006 – February 2007.

Participation in Events Connecting ML and Sciences (Selected)

– Physics for AI and AI for Physics: Landscaping Workshop, Institute of Physics, London, November 2024.
– 'Beyond the symbols vs signals debate' meeting, The Royal Society, London, October 2024.
– Workshop on 'Theoretical Physics for Deep Learning', Aspen Center for Physics, Colorado US, June 2023.
– Machine Learning Program at the Galileo Galilei Institute, Florence, September 2022.
– IBM-Oxford Alliance Symposium, Oxford UK, June 2022.
– Workshop on Theory of Deep Learning, Isaac Newton Institute for Mathematical Sciences, Cambridge UK, August 2021.
– Conference on Mathematics of Machine Learning, Center for Interdisciplinary Research, Bielefeld University, August 2021.
– 'Youth in High-Dimensions' Conference, International Centre for Theoretical Physics in Trieste, June 2021.
– Workshop on Artificial Scientific Discovery, Max Planck Institute for the Science of Light in Erlangen, June 2021.
– 'Youth in High-dimensions': Machine Learning, High-dimensional Statistics and Inference for the New Generation, International Centre for Theoretical Physics in Trieste, June 2020.
– Workshop on Science of Data Science, International Centre for Theoretical Physics in Trieste, September 2019.

Professional Activities and Community

– *Dissertation Assessor*, University of Oxford, June 2023 and June 2024.

– *Examiner for DPhil Confirmation of Status*, University of Oxford, January 2024.

– *Peer Review:* ICML 2022, JHEP (Since 2020); PRD (Since 2017); PRL (Since 2017).

– IBM Geometric Deep Learning Journal Club (organizer), Dec. 2022.

– ICTP Phenomenology Virtual Journal Club (organizer), May 2020 – June 2021.

– ICTP Particle Physics Seminars (co-organizer), Oct. 2019 – Sep. 2021.

– DESY Theory Journal Club (co-organizer), Oct. 2017 – Sep. 2019.

– DESY Theory Friday Cookies (co-organizer), Nov. 2016 – July 2019.

– DESY Theory Christmas Party (co-organizer), 2015.

– DESY Theory Works Outing (co-organizer), 2015.