

Nayara Fonseca

Curriculum Vitae

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Contact

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Experience

Current Position

Research Fellow

UKRI Horizon Europe Guarantee Marie Skłodowska-Curie Fellowship Award.

Project: *Phenomenology of Deep Learning*.

[Rudolf Peierls Centre for Theoretical Physics](#),

Department of Physics, University of Oxford.

May 2023 – Present.

Previous Positions

Research Scientist

[IBM Research, Daresbury Lab](#), Warrington, United Kingdom.

May 2022 – April 2023.

- Search for physics extremes with generative deep learning; machine learning for equation solving; optimization in physics-informed neural networks.

Postdoctoral Researcher

[International Centre for Theoretical Physics \(ICTP\)](#), Trieste, Italy.

October 2019 – September 2021.

- Dark matter model building and phenomenology; machine learning for field localization in theory space.

Postdoctoral Researcher

[Deutsches Elektronen-Synchrotron \(DESY\)](#), [Theory Group](#), Hamburg, Germany.

October 2016 – September 2019.

- 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

[Center for Theoretical Physics](#), MIT, Cambridge, USA.

Host: [Prof. Jesse Thaler](#).

January 2014 – December 2014.

- Dark matter phenomenology combining complementary data from astrophysics, cosmology, and collider physics.

Education

Ph.D. in Theoretical Physics (Particle Physics), August 2016.
Department of Mathematical Physics, University of São Paulo, Brazil.
Thesis: “[Theories with Large Hierarchy of Scales](#)”.
Advisor: [Prof. Gustavo Burdman](#).

Master of Science (Physics), August 2011.
Department of Mathematical Physics, University of São Paulo, Brazil.
Dissertation: “[Dimensional Deconstruction and Flavor Violation](#)”.
Advisor: [Prof. Gustavo Burdman](#).

Bachelor of Science (Physics), June 2009
Gleb Wataghin Physics Institute, University of Campinas, Brazil.
Monograph: “Classical Solutions in Yang-Mills Theory”.
Advisor: [Prof. Alberto Saa](#).

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.

Analytical Skills and Background in CS, ML, and AI

- **AI Safety:** AI Alignment Course by BlueDot Impact ([AI Safety Fundamentals](#)), Final project: Polygenic skills: What is the effect of combined tasks? (March–June 2024).
- **Programming:** Python, Mathematica, C.
- **ML/Statistical Libraries/Packages:** TensorFlow, PyTorch, NumPy, Scikit-learn, Pandas, Statsmodels.
- **Formal Education in Mathematics:** Calculus, Linear Algebra, Differential Equations, Numerical Calculus, Complex Analysis, Probability, Algorithms and Programming, etc.
- **Related Coursework and Self-Study:** Generative AI with Large Language Models (Coursera, 2023); Custom Models, Layers, and Loss Functions with TensorFlow (Coursera, 2021); [ML Theory for Physicists](#) (DESY, Dec. 2020–Mar. 2021); Data Science Bootcamp (Udemy, 2020); Algorithmic Toolbox (Coursera, 2020); Open sources such as freeCodeCamp.
- **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.
- **High School with a dual degree in Informatics (Programming, Database, Web design, Hardware):** Awarded internship at the National Siderurgy Company (Brazil) (1.5% top), prize for best Informatics Final Project team (2.5% top).

Preprints and Publications

- For all publications see [\[Scholar\]](#) [\[arXiv\]](#) [\[nayarafonseca.com/publications\]](#).
 - In the machine learning papers, an asterisk (*) denotes equal contribution. In theoretical high energy physics, the convention is to order the author list alphabetically.
 - JHEP and Phys. Rev. D 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, A. Louis, *An exactly solvable model for emergence and scaling laws*. Accepted at the ICML 2024 Workshop on High-dimensional Learning Dynamics (HiLD) [\[arXiv:2404.17563\]](#).
- [17] N. Fonseca*, V. Guidetti*, and Will Trojak*, *Probing optimisation in physics-informed neural networks*. ICLR 2023 Workshop on Physics for Machine Learning [\[OpenReview\]](#) [\[arXiv:2303.15196\]](#).
- [16] N. Fonseca* and V. Guidetti*, *Generalizing similarity in noisy setups: the DIBS phenomenon*. European Conference on Artificial Intelligence (ECAI) 2023 [\[10.3233/FAIA230339\]](#) [\[arXiv:2201.12803\]](#).
- [15] N. Fonseca and E. Morgante, *Probing photophobic (rel)axion dark matter*. [\[Phys. Rev. D. 103, 015011 \(2021\)\]](#) [\[arXiv:2009.10974\]](#).
- [14] N. Fonseca, E. Morgante, R. Sato, G. Servant, *Relaxion Fluctuations (Self-stopping relaxion) and Overview of Relaxion Stopping Mechanisms*. [\[JHEP 05 \(2020\) 080\]](#) [\[arXiv:1911.08473\]](#).
- [13] N. Fonseca, E. Morgante, R. Sato, G. Servant, *Axion Fragmentation*. [\[JHEP 04 \(2020\) 010\]](#) [\[arXiv:1911.08472\]](#).
- [12] N. Fonseca, B. von Harling, L. de Lima, C. S. Machado, *Super-Planckian axions from near-conformality*. [\[Phys. Rev. D 100, 105019 \(2019\)\]](#) [\[arXiv:1906.10193\]](#).
- [11] N. Fonseca and E. Morgante, *Relaxion Dark Matter*. [\[Phys. Rev. D 100, 055010 \(2019\)\]](#) [\[arXiv:1809.04534\]](#).
- [10] N. Fonseca, E. Morgante and G. Servant, *Higgs relaxation after inflation*. [\[JHEP 1810 \(2018\) 020\]](#) [\[arXiv:1805.04543\]](#).
- [9] N. Fonseca, B. von Harling, L. de Lima, and C. S. Machado, *A warped relaxion*. [\[JHEP 1807 \(2018\) 033\]](#) [\[arXiv:1712.07635\]](#).
- [8] N. Bernal, C. S. Fong, and N. Fonseca, *Sharing but not caring: Dark Matter and the Baryon Asymmetry of the Universe*. [\[JCAP 1609 \(2016\) 005\]](#) [\[arXiv:1605.07188\]](#).
- [7] N. Fonseca, L. de Lima, C. S. Machado, and R. D. Matheus, *Large field excursions from a few site relaxion model (N-Relaxion)*. [\[Phys. Rev. D94 \(2016\) 015010\]](#) [\[arXiv:1601.07183\]](#).
- [6] N. Fonseca, L. Necib and J. Thaler, *Dark Matter, Shared Asymmetries, and Galactic Gamma Ray Signals*. [\[JCAP 1602 \(2016\) 052\]](#) [\[arXiv:1507.08295\]](#).
- [5] N. Fonseca, R. Z. Funchal, A. Lessa, and L. Lopez-Honorez, *Dark Matter Constraints on Composite Higgs Models*. [\[JHEP 1506 \(2015\) 154\]](#) [\[arXiv:1501.05957\]](#).
- [4] G. Burdman, N. Fonseca, and G. Lichtenstein, *Resonances from Quiver Theories at the LHC*. [\[Phys. Rev. D88 \(2013\) 116006\]](#) [\[arXiv:1308.5988\]](#).
- [3] G. Burdman, N. Fonseca, and L. Lima, *Full-hierarchy Quiver Theories of Electroweak Symmetry Breaking and Fermion Masses*. [\[JHEP 1301 \(2013\) 094\]](#) [\[arXiv:1210.5568\]](#).
- Thesis and Dissertation
- [2] *Theories with Large Hierarchy of Scales*. Ph.D. Thesis, University of São Paulo, 2016.
- [1] *Dimensional deconstruction and flavor violation*. Master’s Dissertation (In Portuguese), University of São Paulo, 2011.

Organization of International Events

- Joint Workshop between the Institute for Basic Science (Korea) and the ICTP (Italy), <https://indico.ibs.re.kr/event/445/>, October 2021.
- Joint Workshop between the Institute for Basic Science (Korea) and the ICTP (Italy), <https://indico.ibs.re.kr/event/366/>, October 2020.
- Mainz Institute for Theoretical Physics Scientific Program (Particle Physics and Cosmology), <https://indico.mitp.uni-mainz.de/event/262/>, July 2020 (Postponed to July 2022 due to COVID-19).

Awards, Funding, and Distinctions

- 2022:** Marie Skłodowska-Curie Postdoctoral Fellowship Award at the University of Oxford (236k EUR).
- 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 M.S. 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).

Talks and Seminars (Selected)

- Machine Learning at the Galileo Galilei Institute [[YouTube](#)], 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 (SILAFEA) [[YouTube](#)], November 2021.
- ‘Theory of Deep Learning and Physics’, Institute for Fundamental Physics of the Universe in 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.

Participation in Events Connecting ML, Science, and Mathematics

- 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 Scientist 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.

Service

- *Examiner for DPhil Confirmation of Status*, University of Oxford, January 2024.
- *Dissertation Assessor*, University of Oxford, June 2023 and June 2024.
- *Peer Review*: [ICML 2022](#), [JHEP](#) (Since 2020). [PRD](#) (Since 2017); [PRL](#) (Since 2017).

Student Supervision

- *Master Dissertation Supervisor*; Lysander Mawby, Title: Scale in Deep Learning: Algorithmic Datasets and Sudden Performance Changes, University of Oxford, Oct. 2023 – June 2024.
- *Master Dissertation Tutor*; Fidele Twagirayezu, East African Institute of Fundamental Research – Rwanda, Sep. 2020 – Feb. 2021.
- *Master Internship Co-supervisor at DESY*; Augustin Vanrientvelde, École Polytechnique – France, June 2017 – Sep. 2017.

Community

- 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