Luis Enrique Padilla Albores

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Nationality: Mexican · Updated 30 October 2026

Research Profile

My research focuses on early-Universe physics, particularly the poorly constrained period between inflation and Big Bang nucleosynthesis. I am interested in understanding how primordial black holes (PBHs) and gravitational waves (GWs) can help us investigate the physical conditions of this era. My work began with scalar-field dark matter and later expanded to PBH formation during reheating, nonlinear gravitational collapse, kination, and critical phenomena. More recently, I have studied how these processes affect PBH mass distributions and their possible observational signatures. An important part of my research involves developing numerical methods and implementing the Einstein–scalar-field equations to study gravitational collapse beyond commonly used approximations. Although much of my work has focused on scalar fields, I am also interested in other high-energy physics scenarios that could leave observable signatures in PBHs and GWs.

Selected Scientific Contributions

- **Critical phenomena in cosmology.** Demonstrated discrete self-similarity (DSS) and logarithmic mass-scaling structure in cosmological PBH formation during kination (*Physical Review D* Letter, 2026); subsequently examined its consequences for PBH mass functions (arXiv:2608.21834).
- **Numerical gravitational collapse.** Derived and implemented the original coupled Einstein–scalar-field–fluid evolution solver for published PBH simulations; investigated how oscillating scalar fields depart from effective-fluid descriptions, including near-critical collapse (*JCAP*, 2025–2026).
- **Reheating and observable early-Universe physics.** Proposed PBH formation involving inflaton halos and stars and connected these mechanisms with constraints on inflationary models, PBH populations, and induced stochastic GW backgrounds (*Physical Review D*, 2022–2023; *JCAP*, 2024).
- **Scalar-field dark matter and new field potentials.** Studied compact scalar cores and supermassive-black-hole seed formation; contributed to fully nonlinear simulations of metastable Higgs-like fields and black-hole-forming branches (*Physical Review D*, 2021; arXiv:2608.23367).

Academic Appointments

JSPS International Postdoctoral Fellow, Rikkyo University, Japan Nov. 2025–present
Host: Prof. Tomohiro Harada. Fellowship awarded through Nov. 2027; PBHs, critical collapse, and GW signatures.

Postdoctoral Researcher, Queen Mary University of London, United Kingdom Jan. 2024–Nov. 2025
Research with Dr. David Mulryne and Dr. Karim A. Malik. Developed relativistic simulation infrastructure; studied scalar-field collapse and induced GWs. Post funded through the host research group's Royal Society University Research Fellowship (not a fellowship independently awarded to me).

DGAPA–UNAM Postdoctoral Fellow, Instituto de Ciencias Físicas, Mexico Sep. 2021–Aug. 2023
Host: Dr. Juan Carlos Hidalgo. PBHs from reheating structures, inflationary constraints, and non-standard early-Universe histories.

CONACyT-Supported Postdoctoral Researcher, Instituto de Ciencias Físicas, UNAM Oct. 2020–Jun. 2021
Host: Dr. Juan Carlos Hidalgo. Scalar-field cosmology and primordial black holes.

Education

Ph.D. in Physics, CINVESTAV–IPN, Mexico 2020
Thesis adviser: Prof. Tonatiuh Matos. Research on scalar-field dark matter, cosmology, and compact structures.

B.Sc. in Physics, Universidad de Guadalajara, Mexico 2014

Publications

Author's name is emphasized in bold. Public papers and unpublished manuscripts are listed separately. For the updated publication and citation record, see INSPIRE-HEP.

Peer-reviewed Journal Publications (22)

[J1] **Luis E. Padilla**, Tomohiro Harada, Ethan Milligan, David Mulryne, "Cosmological discrete self-similarity in primordial black hole formation," *Physical Review D* 114 (2026), Letter, arXiv:2604.21520.

[J2] **Luis E. Padilla**, Ethan Milligan, David Mulryne, Juan Carlos Hidalgo, "Primordial Black Hole Formation in a Scalar Field Dominated Universe: Investigation of the Critical Nature of the Collapse," *JCAP* 04 (2026) 049, arXiv:2509.10431.

[J3] Raphael Picard, **Luis E. Padilla**, Karim A. Malik, David Mulryne, "Suppression of the induced gravitational wave background due to third-order perturbations," *JCAP* 01 (2026) 056, arXiv:2509.07811.

[J4] Ethan Milligan, **Luis E. Padilla**, David Mulryne, Juan Carlos Hidalgo, "Primordial Black Hole Formation in a Scalar Field Dominated Universe," *JCAP* 10 (2025) 025, arXiv:2504.02600.

[J5] E. Di Valentino *et al.* (including **L. E. Padilla**), "The CosmoVerse White Paper: Addressing observational tensions in cosmology with systematics and fundamental physics," *Physics of the Dark Universe* 49 (2025) 101965, arXiv:2504.01669.

[J6] **Luis E. Padilla**, Juan Carlos Hidalgo, Karim A. Malik, David Mulryne, "Detecting the Stochastic Gravitational Wave Background from Primordial Black Holes in Slow-reheating Scenarios," *JCAP* 12 (2024) 011, arXiv:2405.19271.

[J7] **Luis E. Padilla**, Juan Carlos Hidalgo, Tadeo D. Gómez, Karim A. Malik, Gabriel Germán, "Primordial Black Hole Formation during Slow-reheating: A Review," *Frontiers in Astronomy and Space Sciences* 11 (2024), arXiv:2402.03542.

[J8] Gabriel Germán, Juan Carlos Hidalgo, **Luis E. Padilla**, "Inflationary models constrained by reheating," *European Physical Journal Plus* 139 (2024) 302, arXiv:2310.05221.

[J9] Tadeo D. Gómez-Aguilar, **Luis E. Padilla**, Encieh Erfani, Juan Carlos Hidalgo, "Constraints in primordial black holes for nonstandard cosmologies," *JCAP* 11 (2024) 005, arXiv:2308.04642.

[J10] Gabriel Germán, Juan Carlos Hidalgo, **Luis E. Padilla**, "Solution for cosmological observables in the Starobinsky model of inflation," *European Physical Journal Plus* 139 (2024) 295, arXiv:2307.08257.

[J11] Jordi Solís-López, **Luis E. Padilla**, Tonatiuh Matos, "Simple test with rotation curves for the multistate Scalar Field Dark Matter model," *Physical Review D* 109 (2024) 083034, arXiv:2103.05190.

[J12] **Luis E. Padilla**, Juan Carlos Hidalgo, Gabriel Germán, "Constraining Inflationary Potentials with Inflaton PBHs," *Physical Review D* 108 (2023) 063511, arXiv:2303.16428.

[J13] Juan Carlos Hidalgo, **Luis E. Padilla**, Gabriel Germán, "Production of PBHs from Inflaton Structure," *Physical Review D* 107 (2023) 063519, arXiv:2208.09462.

[J14] **Luis E. Padilla**, Juan Carlos Hidalgo, Karim A. Malik, "New mechanism for primordial black hole formation during reheating," *Physical Review D* 106 (2022) 023519, arXiv:2110.14584.

[J15] **Luis E. Padilla**, Juan Carlos Hidalgo, Darío Núñez, "Long-wavelength non-linear perturbations of a complex scalar field," *Physical Review D* 104 (2021) 083513, arXiv:2107.01187.

[J16] Karim Carrion, Juan Carlos Hidalgo, Ariadna Montiel, **Luis E. Padilla**, "Complex scalar field reheating and primordial black hole production," *JCAP* 07 (2021) 001, arXiv:2101.02156.

[J17] **Luis E. Padilla**, Tanja Rindler-Daller, Paul R. Shapiro, Tonatiuh Matos, Alberto Vázquez, "Core-Halo Mass Relation in Scalar Field Dark Matter Models and its Consequences for the Formation of Supermassive Black Holes," *Physical Review D* 103 (2021) 063012, arXiv:2010.12716.

[J18] **Luis E. Padilla**, Jordi Solís, Tonatiuh Matos, Ana Avilez López, "Consequences for the Scalar Field Dark Matter model from the McGaugh Observed-Baryon Acceleration Correlation," *Astrophysical Journal* 909 (2021) 162, arXiv:2008.13455.

[J19] **Luis E. Padilla**, Luis O. Tellez, Luis A. Escamilla, J. Alberto Vázquez, "Cosmological parameter inference

with Bayesian statistics," *Universe* 7 (2021) 213, arXiv:1903.11127.

[J20] Alberto Vázquez, **Luis E. Padilla**, Tonatiuh Matos, "Inflationary Cosmology: From Theory to Observations," *Revista Mexicana de Física E* 17 (2020) 1, arXiv:1810.09934.

[J21] **Luis E. Padilla**, Alberto Vázquez, Gabriel Germán, Tonatiuh Matos, "Scalar Field Dark Matter spectator during inflation: the effect of self-interaction," *JCAP* 05 (2019) 056, arXiv:1901.00947.

[J22] Ana Avilez López, Tula Bernal Marín, **Luis E. Padilla**, Tonatiuh Matos, "On the possibility that ultra-light boson halos host and form super-massive black holes," *Monthly Notices of the Royal Astronomical Society* 477 (2018) 3257, arXiv:1704.07314.

Public Preprints

[P1] Ethan Milligan, **Luis E. Padilla**, David Mulryne, "Black holes from a Higgs-like field in the radiation era," arXiv:2608.23367.

[P2] **Luis E. Padilla**, Tomohiro Harada, Hayami Iizuka, "Discrete self-similarity imprints on primordial-black-hole mass functions," arXiv:2608.21834.

Current Manuscripts and Software in Preparation

- **L. E. Padilla**, "Robustness of discrete self-similarity in primordial-black-hole mass functions: Phase mixing and non-Gaussianity" (single-author manuscript; not publicly indexed).
- **L. E. Padilla** and T. Harada, "Logarithmic fine structure of primordial-black-hole formation during kination" (manuscript in preparation).
- K. Carrion, **L. E. Padilla**, G. Germán and J. C. Hidalgo, "Reheating Constraints on the α-Starobinsky Model with Planck and DESI Data" (manuscript in preparation).

Numerical Methods, Research Software, and Computing

- **Numerical-relativity and code development:** derived and implemented an extended Misner–Sharp evolution system coupling a self-gravitating scalar field to a cosmological fluid. Developed the core numerical solver and contributed to diagnostic and production workflows in collaboration with E. Milligan and colleagues. Applications include superhorizon perturbations, cosmological collapse, and scalar potentials.
- **Strong-field diagnostics:** apparent-horizon identification, Misner–Sharp mass evaluation, numerical determination of collapse thresholds, critical mass scaling, DSS residuals, initial-profile families, constraint monitoring, convergence and sensitivity tests.
- **High-performance scientific computing:** large parameter scans on Linux clusters, batch-job arrays, computational workflow and data management, analysis of extensive simulation ensembles and automated post-processing.
- **Programming and quantitative methods:** Python and Fortran; differential-equation solvers, scientific visualization, statistics and Bayesian inference; Mathematica, Scilab and Maxima for analytical and semi-analytical calculations.
- **Public research software:** contributor to PBH-β, a computational package for PBH abundance constraints and primordial power-spectrum bounds in non-standard cosmologies.
- **In preparation:** public release of the extended Misner–Sharp code (with E. Milligan and D. Mulryne); not yet a publicly released software package.

Competitive Fellowships and Research Support

- **Japan Society for the Promotion of Science (JSPS) International Postdoctoral Fellowship**, Japan, 2025–2027 (awarded). Associated **Grant-in-Aid for JSPS Research Fellows**, approximately JPY 2 million total research support, 2025–2027.
- **DGAPA–UNAM Postdoctoral Fellowship**, Instituto de Ciencias Físicas, UNAM, 2021–2023 (awarded).
- **CONACyT-funded Postdoctoral Appointment**, Instituto de Ciencias Físicas, UNAM, 2020–2021 (supported by CB-2016-282569).

- **CONACyT Ph.D. Scholarship**, 2014–2019; **CONACyT scholarship for an overseas research visit**, The University of Texas at Austin, 2018–2019; CINVESTAV doctoral-completion support, 2019.
- **Queen Mary University of London (2024–2025):** research appointment supported through my host's **Royal Society University Research Fellowship**.

Research-project participation (not principal-investigator awards). Participated in group projects supported by FORDECYT–PRONACES/Ciencia de Frontera (2021), PAPIIT–DGAPA IA-104221 (2021), SEP–CONACyT A1-S-21925 (2019), and CB-2016-282569 (2018).

Competitive Recognition, Shortlists, and Declined Offers

- **Sistema Nacional de Investigadores (SNI)**, Candidate level, Mexico (2022–2025).
- **Marie Skłodowska-Curie Postdoctoral Fellowship proposal**, assessed at **89.4/100** and awarded a Seal of Excellence; funding not awarded.
- **Faculty shortlists, UNAM (2025):** finalist in separate recruitment processes at the Institute of Physics (IF–UNAM) and the Institute of Astronomy (IA–UNAM); no appointment awarded.
- **Wilczek Quantum Center, University of Science and Technology of China (2025):** postdoctoral offer in theoretical cosmology, declined after accepting JSPS.
- **CONACyT/IF–UNAM postdoctoral opportunity (2024):** offer declined after accepting a research appointment at Queen Mary University of London.
- **Newton International Fellowship, The Royal Society (2024):** application placed on reserve list; fellowship not awarded.
- **University of Aveiro, Portugal (2021):** postdoctoral offer in numerical relativity and scalar-field dynamics, declined in favor of DGAPA–UNAM.
- **State of Chiapas Government Prize for Outstanding Students** (2005), earlier academic distinction.

Teaching Experience

- **Lecturer, Statistical Physics**, Mesoamerican Centre for Theoretical Physics (MCTP–UNACH), Feb.–May 2025.
- **Lecturer, Introduction to Cosmology**, MCTP–UNACH, Feb.–May 2025.
- **Lecturer, Quantum Mechanics**, MCTP–UNACH, Aug.–Dec. 2024.
- **Co-lecturer, Selected Topics in Primordial Black Holes**, master's-level course, Instituto de Ciencias Físicas, UNAM, Feb.–Jun. 2022.
- **Teaching Assistant**, Introduction to General Relativity (2018), Quantum Mechanics II (2017), Advanced Physics Laboratory (2017), and Thermodynamics (2016), CINVESTAV–IPN.

Student Research Supervision and Mentoring

Formal research advising: five diploma-level students

Research adviser for five diploma students, Mesoamerican Centre for Theoretical Physics (MCTP–UNACH). Projects included relativistic collapse, primordial black holes, scalar perturbations, and numerical diagnostics:

- **J. A. Hernández:** Misner–Sharp formalism for studying PBH formation from scalar perturbations: theoretical formulation and gravitational dynamics.
- **A. G. León-Hernández:** numerical implementation and collapse diagnostics for scalar-field perturbations during reheating.
- **Christian Andrade:** numerical analysis and collapse-threshold calculations for PBH formation in scalar-field reheating scenarios.
- **Luis David Jiménez Orozco:** short review on primordial black hole formation in non-standard cosmologies.

- **Balbina Guadalupe Rodríguez Chávez:** Primordial black holes and their observational consequences.

Graduate and undergraduate research mentoring (informal/collaborative roles)

For the students below, I contributed to their research and informal guidance; I was not their formal degree supervisor unless indicated:

- **Ethan Milligan (Ph.D., Queen Mary University of London):** jointly developed scalar-field / fluid collapse simulations and studied Higgs-like vacuum instability; formal supervisor: Dr. David Mulryne.
- **Raphael Picard (Ph.D., Queen Mary University of London):** third-order cosmological perturbations and the induced stochastic GW background; formal supervisor: Dr. Karim A. Malik.
- **Tadeo D. Gómez (Ph.D., ICF–UNAM):** PBH constraints and induced GWs in non-standard cosmologies; formal supervisor: Dr. Juan Carlos Hidalgo.
- **Juliette S. Delphine (M.Sc., Queen Mary University of London):** constraints from spectral distortions and induced GWs; formal supervisor: Dr. David Mulryne.
- **Germán V. (undergraduate project, Universidad Nacional Autónoma de Honduras):** collaborative co-supervision of work on PBH constraints during prolonged reheating.

Academic assessment and examination

Participated in three diploma-thesis evaluation committees at MCTP–UNACH (2022); evaluated student research-stay projects and CONACyT postdoctoral fellowship research proposals. These assessment activities are distinct from the research advising listed above.

Academic Service and International Research Experience

- **Journal referee:** *Physical Review Letters* (PRL), *Physical Review D* (PRD), and *Journal of Cosmology and Astroparticle Physics* (JCAP). The activity reflects peer-review service, not editorial-board membership.
- **Workshop organization:** Local Organizing Committee, international meeting *Dynamics of Primordial Black Hole Formation III*, Rikkyo University, Tokyo (September 2026).
- **Seminar organization:** co-organizer for the Instituto Avanzado de Cosmología, the Gravitation and Cosmology Group at ICF–UNAM, and the gravitation/cosmology group at CINVESTAV–IPN.
- **Academic affiliations:** Associate Junior Researcher, MCTP (honorary appointment, July 2020–May 2022); member of the Mexican Physical Society since 2017.

Selected Research Talks and Seminars

- **Dynamics of Primordial Black Hole Formation III**, Rikkyo University, Tokyo (Sept. 2026): *Primordial black hole formation during kination.*
- **NEHOP'26 – New Horizons in Primordial Black Hole Physics**, CERN, Switzerland (June 2026): *Primordial black hole formation in scalar field cosmologies.*
- **NEHOP'25**, Brussels, Belgium (May 2025): *Primordial black hole formation in a slow-reheating scenario.*
- **Leibniz University Hannover**, Germany, Cosmology Group Seminar (Nov. 2024): *Primordial black holes during slow reheating.*
- **Queen Mary University of London**, UK, Cosmology Group Seminar (Nov. 2024): *Primordial black holes during slow reheating.*
- **Rikkyo University**, Japan, Cosmology Group Seminar (Oct. 2024): *Primordial black holes during slow reheating.*
- **COSMO'22**, Rio de Janeiro, Brazil (Aug. 2022): *A new mechanism of primordial black hole formation during reheating.*
- **ICF–UNAM**, Mexico, Gravitation and Cosmology Seminar (Oct. 2021): *Long-wavelength non-linear*

perturbations of a complex scalar field.

- **VI Scalar Field Dark Matter Workshop**, online (Oct. 2021): *A new mechanism for primordial black hole formation.*
- **Seminar on Theories of Gravitation and Observational Signatures** (May 2022): *Un nuevo mecanismo para la generación de agujeros negros primordiales.*
- **XXX Mexican Society of Physics Gravitation and Mathematical Physics Division Meeting** (Apr. 2022): *Un nuevo mecanismo para la generación de agujeros negros primordiales.*
- **BUAP Particle Theory Seminar**, Puebla, Mexico (Aug. 2019): *Campos escalares para modelos inflacionarios y de materia oscura.*
- **IV Workshop on Numerical and Statistical Methods in Cosmology**, ICF–UNAM (July 2018): *Ajustando una recta con hiperparámetros.*
- **Rikkyo University Cosmology Seminar**, Japan (May 2026), research seminar.
- **Kavli IPMU**, Japan (August 2026), research seminar.

Research Visits and International Collaboration

- **Rikkyo University**, Japan (October 2024), research visit.
- **Nagoya University**, Japan (October 2024), research visit.
- **Queen Mary University of London**, United Kingdom (April–May 2023), research visit.
- **Instituto de Ciencias Físicas, UNAM**, Mexico (August 2019–February 2020), research visit.
- **The University of Texas at Austin, Department of Astronomy**, USA (December 2018–May 2019), visiting scholar, working with Prof. Paul R. Shapiro and Dr. Tanja Rindler-Daller.
- **Universidad Autónoma de Chiapas** (2013) and **CICATA–IPN** (2012), early research stays supported by the Mexican Academy of Sciences.

Additional Scholarly and Outreach Publications

- L. D. Jiménez Orozco, B. G. Rodríguez Chávez, and **L. E. Padilla**, "De las fluctuaciones primordiales a los agujeros negros del universo temprano," *Espacio I+D* **15**(45) (2026), doi:10.31644/IMASD.45.2026.a05 (outreach / education).
- A. Vázquez and **L. E. Padilla**, "Cosmología Observacional y Estadística," conference proceeding, Escuela de Verano en Física, UNAM, ISSN 2594-2697, pp. 157–170.
- **Public outreach talk:** *Una introducción a la relatividad de Einstein*, Universidad Politécnica de Chiapas (November 2021).

Professional References

Prof. Tomohiro Harada	Department of Physics, Rikkyo University, Japan; harada@rikkyo.ac.jp.
Dr. David Mulryne	Queen Mary University of London, United Kingdom; d.mulryne@qmul.ac.uk.
Dr. Juan Carlos Hidalgo	Instituto de Ciencias Físicas, UNAM, Mexico; hidalgo@icf.unam.mx.
Prof. Tonatiuh Matos	CINVESTAV–IPN, Mexico; tmatos@fis.cinvestav.mx.