



Education

- 2024 – present **PhD Candidate in Physics, Joint Program between Universidad Técnica Federico Santa María (UTFSM) and Pontificia Universidad Católica de Valparaíso (PUCV).**
Research focus: Quantum thermodynamics and magnetic systems.
Thesis: *Qubit-based quantum heat engines*
Funded by the ANID National Doctoral Fellowship (No. 21250015).
- 2020 – 2023 **Bachelor of Science in Physics, Universidad Técnica Federico Santa María (UTFSM).**
Graduated *Summa Cum Laude*.
Thesis: *Otto and Stirling Engines in a System of Three Entangled Qubits in a Ring Topology*.

Scientific Publications and Contributions

Articles

- 1 B. Castorene, M. H. Groves, F. J. Peña, et al. “Caloric phenomena and Stirling-cycle performance in Heisenberg-Kitaev magnon systems”. In: *Phys. Rev. E* 114 (1 July 2026), p. 014132. [DOI: 10.1103/msbk-z1mc](#).
- 2 B. Castorene, F. J. Peña, M. H. Groves, and P. Vargas. “Exact Combinatorial Density of States for the Critical 1D Ising Model”. In: *Entropy* 28.7 (2026). ISSN: 1099-4300. [DOI: 10.3390/e28070821](#).
- 3 B. Castorene, F. J. Peña, E. Suárez Morell, C. Lewenkopf, M. H. Groves, N. Cortés, and P. Vargas. “Reaching maximum efficiency in quantum Stirling engines using multilayer graphene”. In: *Phys. Rev. E* 113 (4 Apr. 2026), p. 044126. [DOI: 10.1103/s59t-ygkq](#).
- 4 N. Cortés, B. Castorene, F. J. Peña, D. Melo, S. E. Ulloa, and P. Vargas. “Thermal Hofstadter Butterflies”. In: *Nano Letters* (July 2026). [DOI: 10.1021/acs.nanolett.6c01000](#).
- 5 B. Castorene, V. G. de Paula, F. J. Peña, C. Cruz, M. Reis, and P. Vargas. “Quantum Level-Crossing Induced by Anisotropy in Spin-1 Heisenberg Dimers: Applications to Quantum Stirling Engines”. In: *Advanced Quantum Technologies* 8.10 (2025), e2500204. [DOI: https://doi.org/10.1002/qute.202500204](#).
- 6 B. Castorene, F. J. Peña, A. Norambuena, S. E. Ulloa, C. Araya, and P. Vargas. “Entropy, entanglement, and susceptibility of three qubits near quantum criticality”. In: *Physical Review E* 111.3 (2025), p. 034118. [DOI: 10.1103/PhysRevE.111.034118](#).
- 7 F. J. Peña, C. D. Nuñez, B. Castorene, M. Aguilera, N. Cortés, and P. Vargas. “Ratio between Seebeck coefficient and entropy per particle as a tool for elementary charge determination”. In: *Phys. Rev. E* 112 (6 Dec. 2025), p. 065508. [DOI: 10.1103/rq83-rwk2](#).
- 8 B. Castorene, F. J. Peña, A. Norambuena, S. E. Ulloa, C. Araya, and P. Vargas. “Effects of magnetic anisotropy on three-qubit antiferromagnetic thermal machines”. In: *Physical Review E* 110.4 (2024), p. 044135. [DOI: 10.1103/PhysRevE.110.044135](#).
- 9 C. Araya, F. J. Peña, A. Norambuena, B. Castorene, and P. Vargas. “Magnetic Stirling Cycle for Qubits with Anisotropy near the Quantum Critical Point”. In: *Technologies* 11.6 (2023), p. 169. [DOI: 10.3390/technologies11060169](#).

Manuscripts

- 1 B. Castorene, M. H. Groves, F. J. Peña, E. E. Vogel, and P. Vargas. “Fundamental Work Scaling and Non-Extensivity in Critical Engines”. Submitted to *Advanced Quantum Technologies*; first-round referee report addressed with minor changes (Aug. 8, 2026). 2026. arXiv: 2510.25533 [cond-mat.stat-mech].
- 2 B. Castorene, F. J. Peña, N. Vidal-Silva, and P. Vargas. “Entropy-Weighted Berry Curvature: A Geometric Diagnostic for Bosonic Topological Transitions”. Submitted to *Physical Review E*. July 29, 2026.
- 3 F. J. Peña, B. Castorene, J. P. Esparza, V. Juričić, and P. Vargas. “Equilibrium Thermodynamics of Non-Hermitian Dirac Fermions: Caloric and Magnetic Responses”. Submitted to *Physical Review E*. Aug. 7, 2026. arXiv: 2608.04369.
- 4 F. J. Peña, B. Castorene, and N. Vidal-Silva. “Coupling-Response Thermodynamic Density of States for Bosonic Working Media”. Submitted to *Physical Review E*. June 29, 2026.

Conferences and Presentations

Oral Presentations

- June 2026 ■ **Talk at Panoramas 2026, Pontificia Universidad Católica de Valparaíso, Campus Curauma, Chile.**
Fundamental Work Scaling and Non-Extensivity in Critical Quantum Stirling Engines.
- May 2026 ■ **Talk at XXIII TREFEMAC 2026, Centro Atómico Bariloche-Instituto Balseiro, Argentina.**
Fundamental Work Scaling and Non-Extensivity in Critical Quantum Stirling Engines.
- Mar 2026 ■ **Talk at MARCh 2026, Universidad Técnica Federico Santa María, Valparaíso, Chile.**
Qubit-based quantum heat engines: Maximum quantum work at criticality.
- Dec 2025 ■ **Talk at the IV International Workshop on Statistical Physics, Antofagasta, Chile.**
Exact Conditions for Carnot Efficiency in Quantum Stirling Engines at Criticality.
- **Talk at the 20th International Seminar on Condensed Matter Physics and Statistical Physics (SIMAFE 2025), Temuco, Chile.**
On the Maximum Quantum Work in Critical Stirling Engines: Applications to Fibonacci–Lucas Degeneracies.
- Nov 2025 ■ **Talk at the VIII National Congress on Nanotechnology, La Serena, Chile.**
Qubit vs. Qutrit: Efficiency and Entanglement in Stirling Cycles.
- Oct 2025 ■ **Talk at XXIII B-MRS Meeting, Salvador de Bahía, Brazil.**
Quantum Level-Crossing Induced by Anisotropy in Spin-1 Heisenberg Dimers: Applications to Quantum Stirling Engines.
- Sep 2025 ■ **Co-speaker at Café de Investigación V20, Departamento de Ingeniería en Diseño, UTFSM, Valparaíso, Chile.**
Quantum Thermal Machines in Two-Dimensional Materials, with Dr. Francisco J. Peña. [Link](#)
- Jun 2025 ■ **Co-speaker at DFI Seminar, Universidad de Chile, Santiago.**
Quantum Thermodynamic Cycles: Otto & Stirling, with Dr. Francisco J. Peña.
- May 2025 ■ **Talk at Panoramas 2025, Pontificia Universidad Católica de Valparaíso, Campus Curauma, Chile.**
Spin-1/2 vs. Spin-1: A Quantum Thermodynamic Study of Anisotropic XXX Heisenberg Models. [Link](#)
- Apr 2025 ■ **Talk at IV QUSantiago, Universidad de Santiago, Santiago, Chile.**
Quantum Thermodynamic Cycles: Stirling & Otto. [Link](#)
- Mar 2025 ■ **Talk at MARCh 2025, Universidad de Mendoza, Mendoza, Argentina.**
Spin-1/2 vs Spin-1: Comparisons of Stirling Engines.
- Jan 2025 ■ **Talk at XIII Escuela de Nanoestructuras, UTFSM, Campus Casa Central, Chile.**
Spin-1/2 vs Spin-1: A Quantum Thermodynamic Study.
- Oct 2024 ■ **Final Presenter at SOCHIFI 2024, Universidad de la Frontera, Temuco, Chile.**
Reduced Entropy and the Effective Temperature of a Three-Qubit System.
- May 2024 ■ **Talk at Panoramas 2024, Pontificia Universidad Católica de Valparaíso, Campus Curauma, Chile.**
Effects of Magnetic Anisotropy on Three-Qubit Antiferromagnetic Thermal Machines. [Link](#)
- Jan 2024 ■ **Talk at XII Escuela de Nanoestructuras, UTFSM, Campus Casa Central, Chile.**
Otto and Stirling Engines in a System of Three Entangled Qubits in a Ring Topology.
- Oct 2023 ■ **Talk at LAW3M, Puerto Varas, Chile.**
Magnetic Stirling Cycle for Qubits with Anisotropy near the Quantum Critical Point.

Conferences Attended

- May 2026 ■ **Postgraduate Course: Active Matter and Non-equilibrium Phenomena, Centro Atómico Bariloche-Instituto Balseiro, Argentina.**
Intensive course attended prior to the XXIII TREFEMAC congress.
- Apr 2026 ■ **Attendee at V QuSantiago 2026, Universidad Diego Portales, Santiago, Chile.**
V edition of the quantum technologies conference (Apr 14–16).
- Jan 2026 ■ **Attendee at Congreso Futuro 2026: Humanidad, ¿Hacia Dónde Vamos?, Centro Cultural CEINA, Santiago, Chile.**
Full participation in the six-day program (Jan 12–17), featuring over 120 international speakers on science, technology, and humanities.
- Nov 2025 ■ **Invited Attendee at Science 2030: Sowing Innovation, Projecting the Future, Viña del Mar, Chile.**
- **Attendee at the IX Quantum Optics and Solid State Conference, Valparaíso, Chile.**

Academic Service & Organization

- Apr 2026 – Present ■ **Representative of the PhD Students, Joint PhD Program in Physics, UTFSM & PUCV.**
Elected to represent the student body of the joint doctoral program across both institutions, coordinating student affairs and academic initiatives.
- Mar 2026 ■ **Scientific & Organizing Committee Member, MARCh 2026, Universidad Técnica Federico Santa María, Valparaíso, Chile.**
Oversaw the conference digital infrastructure and abstract submission pipeline. Orchestrated the scientific peer-review process and curated the final academic program.

Academic Service & Organization (continued)

- May 2024

Chair & Lead Organizer, Panoramas 2024, Pontificia Universidad Católica de Valparaíso, Campus Curauma, Chile.
Spearheaded the event organization, managing comprehensive logistics, speaker scheduling, and the selection of scientific contributions.
- Jan 2024

Local Organizing Staff, XII Escuela de Nanoestructuras, UTFSM, Campus Casa Central, Chile.
Facilitated on-site operations and provided audiovisual support for speakers, ensuring the seamless execution of scientific sessions.

Awards, Fellowships and Distinctions

Grants

- Mar 2025 – Present

ANID National Doctoral Fellowship (No. 21250015). Fellowship awarded for doctoral studies in Physics in Chile. [Link](#)
- Jun 2026 – Mar 2027

Scientific Research Initiation Program (PIIC), Universidad Técnica Federico Santa María. Project No. 005/2026: *Non-extensivity in quantum systems with applications in Stirling Engines*.
- Aug 2026 – Nov 2026

UTFSM Research Internship Travel Grant.
Awarded for participation in the *Research Internship Program*, Universitat Autònoma de Barcelona, Spain.
- Feb 2026

ANID Complementary Benefits Grant (National Doctoral Fellowship No. 21250015).
Awarded funding for operating expenses associated with the doctoral thesis project.
- Jun 2025 – Mar 2026

Scientific Research Initiation Program (PIIC), Universidad Técnica Federico Santa María. Project No. 004/2025: *Magnetic Textures and Their Role in Thermodynamic Engines*.
- Dec 2025

UTFSM Conference Travel Grant.
Awarded for participation in the *IV International Workshop on Statistical Physics*, Antofagasta, Chile.
- Nov 2025

National Nanotechnology Congress Grant.
Awarded by the *Ciencia 2030 Consortium* (UTFSM–Universidad de Valparaíso) to support participation in the *VIII National Congress on Nanotechnology*, La Serena, Chile.
- Oct 2025

UTFSM Conference Travel Grant.
Awarded for participation in the *XXIII B-MRS Meeting*, Salvador de Bahía, Brazil.
- Mar 2024 – Mar 2025

UTFSM Internal Doctoral Fellowship. Agreement No. 037/2024: Tuition and financial support for doctoral studies in Physics. [Link](#)

Distinctions

- 2025

Wolfram Research Grant. Awarded a research license for Wolfram Mathematica in recognition of the article *Entropy, Entanglement, and Susceptibility of Three Qubits near Quantum Criticality* (Phys. Rev. E 111, 034118, 2025).
- 2021

Bronze Medal, 2021 University Physics Competition. Team 120 under faculty sponsor Dr. Marat Sidikov (UTFSM). [Link](#)

Research Experience

- Mar 2025 – Present

Research Technician, Fondecyt Project No. 1250173. Principal Investigator: Dr. Francisco J. Peña.
- May 2024 – Present

PhD Thesis Student, Fondecyt Project No. 1240582. Principal Investigator: Prof. Patricio Vargas.
- Aug 2023 – Mar 2025

Research Technician, Fondecyt Initiation Project No. 11221088. Principal Investigator: Dr. Natalia Cortés.
- Jun 2022 – Mar 2023

Research Technician, Fondecyt Regular Project No. 1221827. Principal Investigator: Dr. Taisiya Mineeva.

Teaching Experience

- Mar 2025 – Jul 2025

Teaching Assistant, UTFSM. Course: PhD Program FIS330, Statistical Mechanics.
- Aug 2024 – Dec 2024

Teaching Assistant, UTFSM. Course: PhD Program FIS330, Statistical Mechanics.
- Mar 2024 – Jul 2024

Academic Support Mentor, UTFSM. Course: FIS245, Mathematical Methods in Physics.
Provided specialized tutoring for a visually impaired student. Adapted course materials into accessible Mark-down/LaTeX formats and designed tactile physical models for geometric visualizations.
- Teaching Assistant**, UTFSM. Course: PhD Program FIS330, Statistical Mechanics.
- Mar 2021 – Jul 2021

Teaching Assistant, UTFSM. Course: General Physics I (FIS110), Physics & Astrophysics BSc program.

Languages

Spanish	📖 Native speaker. Full professional proficiency in speaking, reading, and writing.
English	📖 Fluent (C1). Full professional proficiency.
German	📖 Fluent (C1). Certified by <i>Deutsches Sprachdiplom der Kultusministerkonferenz</i> (DSD II).
Chinese	📖 Basic (A1). HSK-1 level.

References

Prof. Patricio Vargas

Full Professor of Theoretical Physics & Director of the PhD Program in Physics, UTFSM

Research areas: Magnetism, Electronic Properties of Modern Materials, Nanotechnology & Medical Physics

✉ patricio.vargas@usm.cl

Dr. Francisco J. Peña

Academic Researcher / Assistant Professor, USS
PhD in Physical Sciences (PUCV, 2015).

Research areas: Quantum Thermodynamics and Energy Transfer in Nanosystems.

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