Felipe Herrera

Department of Physics, Universidad de Santiago de Chile USACH. http://fherreralab.com
Av. Víctor Jara 3493, Estación Central, Santiago - Phone: (56 2) 27181203 - Email: felipe.herrera.u@usach.cl

Academic Experience

Universidad de Santiago de Chile **Since 2019**
Assistant Professor. Department of Physics. [tenured]

Universidad de Santiago de Chile **2014 – 2019**
Associate Researcher. VRIDEI – Department of Physics.

Harvard University, *Postdoctoral Fellow***.** **2012 – 2014**

Education

University of British Columbia, Ph.D. Chemistry **2007 – 2012**
Universidad de Chile, B.Sc. Chemistry **2007 – 2002**

Honors & Awards

Royal Society Wolfson Visiting Fellowship 2022
Award *Inserción en la Academia* PAI, Conicyt 2014
Four Year Fellowship, University of British Columbia 2009
Gladys Estella Laird Fellowship, University of British Columbia 2007
Best Student of Chemistry Award, Universidad de Chile 2007

Teaching

- **Undergraduate:** *Physics (Mechanics) for Engineering, Physics for Computer Science, Electricity and Magnetism for Engineers.*
- **Graduate:** *Introduction to Atomic, Molecular and Optical Physics; Nanophotonics***.**

External Grant Funding

- US Air Force Office of Scientific Research (AFOSR) FA9550-22-1-0245, **2022-2024** [US$151,000, **PI**]
- Fondecyt Regular **2022-2026** [US$280,000, **PI**].
- FONDEF IT20I0127, **2021-2023** [US$ 456,000, **co-PI**].
- ANID-ECOS Collaborative Grant (Chile-France), **2021-2023** [US$20,000, **co-PI**].
- US Office of Naval Research Global (ONRG) CSP N62909-20-1-2005, **2019** [US$ 14,500, **PI**].
- Millennium Institute for Research in Optics (MIRO) **2018-2028** [US$ 16,130,000, **co-PI**].
- Fondecyt Regular **2018-2022** [US$290,000, **PI**].
- CORFO Technological Contracts for Innovation. **2018-2020** [US$ 290,000, **co-PI**].
- Conicyt PAI **2014-2016** [US$ 69,500, **PI**].
- Fondecyt Iniciación **2014-2016** [US$ 72,500, **PI**].

Academic Service and Leadership

- **Conference Organization**
  - "3rd *Workshop on Molecular Quantum Technologies*", Puerto Varas, Chile, Dec. 12-16, 2022.
  - "2nd *Workshop on Molecular Quantum Technologies*", Puerto Natales, Chile, Dec. 12-16, 2022.
  - "1st *Workshop on Molecular Quantum Technologies*", Puerto Natales, Chile, Dec. 16-20, 2019.
  - *APS March Meeting DCP Focus Session* "*Strong light-matter coupling: Enhanced spectroscopy, modified molecular dynamics and altered chemical reactions*", March 5-9, 2018.
  - "2nd *International Workshop on Quantum Coherence and Decoherence*", Medellin, August 25-29, 2014.

- **Editorial Service**
  - Philosophical Magazine C, Quantum Materials and Devices, Associate Editor, 2023 – 2026.
  - ChemrXiv Preprint Server, Scientific Advisory Board, 2023 – 2025.
  - The Journal of Chemical Physics, Editorial Advisory Board member, 2022 – 2024.
  - Proceedings of the National Academy of Science (PNAS), Ad-hoc Editor 2022.

- **Journal Review**
  Nature Physics, Physical Review Letters, Physical Review X, Science, PNAS, New Journal of Physics, Physical Review A, Journal of Chemical Physics, European Journal of Physics D, Molecular Physics, Scientific Reports, Physics Letters A, Optics Express, Chemical Reviews, Journal of Physical Chemistry Letters, Nano Letters, Chem, Journal of Physical Chemistry C, RCS Advances, Chemical Science, Optik.

- **Grant Review**
  ANID Fondecyt (Chile), ANID Fondef IT (Chile), DOE Early Career (USA), AFOSR (USA).

Student and Early-Career Mentoring

- **Postdoctoral (5)**:
  Rubén Fritz, Federico Hernández, Johan Triana, Thulasi Bikku, Adrián Rubio.

- **PhD Students (6)**:
  Katy Aruachan (candidate), Athul Sambasivan (candidate), Felipe Recabal (candidate), Mauricio Arias (candidate), Gastón González (candidate), Javier Enriquez (Materials Science).

- **MSc Students (5):**
  Vanessa Olaya, Jonathan Sepúlveda, Simón Paiva, Gastón González, Felipe Recabal.

- **Undergraduate Students (9)**:

  Engineering Physics: Jonathan Sepúlveda, Iván Jara, Simón Paiva, Gastón González, Felipe Recabal, Osmar Aravena, Andrea Alarcón.

  Computer Science**:** Bastian Martínez, Fernanda Véliz, Felipe Osorio

  Engineering Mathematics**:** Diego Carvajal.

PUBLICATIONS

[50] S. Paiva, R.A. Fritz, S. Raj, Y.J. Colón, F. Herrera, *Giant Generation of Polarization-Entangled Photons in Metal Organic Framework Waveguides,* arXiv:2311.17263, **2023.**

[49] M. Arias, J.F. Triana, A. Delgado, **F. Herrera**, *Coherent anharmonicity transfer from matter to light in the THz regime*, arXiv:2309.12216, **2023**.

[48] S. Raj, S. Paiva, R.A. Fritz, **F. Herrera**, Y.J. Colón, *First-Principles Screening of Metal-Organic Frameworks for Entangled Photon Pair Generation*, arXiv:2309.04781, **2023.**

[47] F. Recabal, **F. Herrera**, *Driven-Dissipative Conductance in Nanojunction Arrays: Negative Conductance and Light-Induced Currents*, arXiv:2306.16789, **2023**.

[46] K. Aruachan, Y. J. Colón, D. Aravena, **F. Herrera**, *Semi-Empirical Haken-Strobl Model for Molecular Spin Qubits*, New J. Phys. 25, 093031, **2023**.

[45] D. Hidalgo, J. M. García-Garfido, J. Enríquez, R. Rojas-Aedo, R. A. Wheatley, R. A. Fritz, D. P. Singh, **F. Herrera**, B. Seifert, *Phase-Coherent Optical Frequency Up-Conversion with Millimeter-Size Zn(3-ptz)2 Metal-Organic Framework Single Crystals*, Adv. Opt. Mat. 2300142, **2023**.

[44] S. Raj, R.A. Fritz, **F. Herrera**, Y. Colón, *Understanding Correlation Between Structure and Entangled Photon Pair Properties with Metal-Organic Frameworks*, J. Phys. Chem. C, 127, 10987, **2023**

[43] W. Ahn, J. F. Triana, F. Recabal, **F. Herrera**, B. Simpkins, *Modification of ground state chemical reactivity via light-matter coherence in infrared cavities*, Science 380, 1165, **2023**.

[42] R. Wilcken, J. Nishida, J. F. Triana, A. John-Herpin, H. Altug, S. Sharma, **F. Herrera**, M. B. Raschke, *Antenna-coupled infrared nanospectrocopy of intramolecular vibrational interaction,* Proc. Natl. Acad. Sci. 120, e2220852120, **2023.**

[41] G. González, R. A. Fritz, Y. J. Colón, **F. Herrera**, *Model reduction for molecular diffusion in nanoporous media,* Phys. Rev. Materials 7, 036001, **2023.**

[40] T. Bikku, R. A. Fritz, Y. J. Colón, **F. Herrera**, *Machine learning identification of organic compounds using visible light,* J. Phys. Chem. A 127, 2407, **2023.** Code DOI: 10.5281/zenodo.6419971.

[39] J. F. Triana and **F. Herrera**, *Open quantum dynamics of strongly coupled oscillators with multi-configuration time-dependent Hartree propagation and Markovian quantum jumps*, J. Chem. Phys. 157, 194104, **2022**.

[38] V. Hernandez, D. Ibarra, J. F. Triana, B. Martínez-Soto, M. Faúndez, D. A. Vasco, L. Gordillo, **F. Herrera**, C. García-Herrera, A. Garmulewicz, *Agar Biopolymer Films for Biodegradable Packaging A Reference Dataset for Exploring the Limits of Mechanical Performance*, Materials 15, 3954, **2022**.

[37] **F. Herrera**, M. Litinskaya, *Ensembles of single-molecule picocavities as nonlinear optical metamaterials,* J. Chem. Phys 156, 114702, **2022.**

[36] J. F. Triana and **F. Herrera**, *Ultrafast modulation of vibrational polaritons for controlling the quantum field statistics at mid-infrared frequencies*, New J. Phys 24, 023008, **2022**.

[35] J. Triana, M. Arias, J. Nishida, E. Muller, R. Wilcken, S. C. Johnson, A. Delgado, M. B. Raschke, **F. Herrera**, *Semi-empirical quantum optics for mid-infrared molecular nanophotonics*, J. Chem. Phys. 156, 124110, **2022**.

[34] I. Chi-Durán, R.A. Fritz, V. Olaya, R. Urzúa-Leiva, G. Cárdenas-Jirón, D.P. Singh, **F. Herrera**, *Anisotropic absorption of millimeter-sized Zn(3-ptz)$_2$ metal-organic framework single crystals,* ACS Omega 7, 24432, **2022.**

[33] V. Olaya, J. Pérez-Ríos, **F. Herrera**, *Laser-assisted binding of ultracold polar molecules with Rydberg atoms in the van der Waals regime* [submitted], arxiv:2109.06411, **2021**.

[32] A.B. Grafton, A.D. Dunkelberger, B. S. Simpkins, J. F. Triana, F. Hernandez, **F. Herrera**, J.C. Owrutsky, *Excited-State vibration-polariton transitions and dynamics in nitroprusside,* Nature Communications 12, 214, **2021.**

[31] R.A. Fritz, Y. Colón, **F. Herrera**, *Engineering entangled photon pairs using metal-organic frameworks*, Chemical Science 12, 3475-3482, **2021**.

[30] J. García-Garfido, J. Enríquez, I. Chi-Durán, I. Jara, L. Vivas, F.J. Hernández, **F. Herrera**, D.P. Singh, *Millimeter-Scale Zn(3-ptz)$_2$ Metal–Organic Framework Single Crystals: Self-Assembly Mechanism and Growth Kinetics,* ACS Omega 6, 27, 17289–17298, **2021**.

[29] J. F. Triana, **F. Herrera**, *Self-dissociation of polar molecules in a confined infrared vacuum*, DOI:10.26434/chemrxiv.12702419.v1, **2020**.

[28] J. F. Triana, F. J. Hernández, **F. Herrera**, *The shape of the electric dipole function determines the sub-picosecond dynamics of anharmonic vibrational polaritons*, J. Chem. Phys. 152, 234111, **2020**.

[27] V. Olaya, J. Pérez-Ríos, **F. Herrera**, *C_6 coefficients for interacting Rydberg atoms and alkali-metal dimers,* Phys. Rev. A 101, 032705, **2020.**

[26] **F. Herrera**, J. Owrutsky, *Perspective: Molecular polaritons for controlling chemistry with quantum optics,* J. Chem. Phys. 152, 100902, **2020**.

[25] **F. Herrera**, *Photochemistry with Quantum Optics from a Non-Adiabatic Quantum Trajectory Perspective*, Chem 6, 5-18, **2020.**

[24] M. Wersäll, B. Munkhbat, D. G. Baranov, **F. Herrera**, J. Cao, T. J. Antosiewicz, T. Shegai, *Correlative dark-field and photoluminescence spectroscopy of individual plasmon-molecule hybrid nanostructures in strong coupling regime*, ACS Photonics 6, 2570-2576, **2019.**

[23] F. Hernández and **F. Herrera**, *Multi-level quantum Rabi model for anharmonic vibrational polaritons,* J. Chem. Phys. 151, 144116, **2019**.

[22] I. Chi-Duran, Z. Setifi, F. Setifi, C. Jelsch, B. Morgenstern, A. Vega, **F. Herrera**, D. P. Singh, K. Hegetschweiler and R. Boyaala *Crystal structure and Hirshfeld surface analysis of tris-(2,2'-bi-pyridine)-nickel(II) bis-(1,1,3,3-tetra-cyano-2-eth-oxy-propenide) dihydrate,* Acta Cryst. E75, 867-871, **2019**

[21] M. J. Carreño, J. Sepúlveda, S. Tecpan, C. Hernández, **F. Herrera**, *An Instrument-Free Demonstration of Quantum Key Distribution for High-School Students*, Physics Education 54, 065006, **2019**.

[20] J. Enríquez, I. Chi-Durán, C. Manquián, **F. Herrera**, D. P. Singh, *Controlled growth of the non-centrosymmetric Zn(3-ptz)$_2$ and Zn(OH)(3-ptz) metal-organic frameworks*, ACS Omega 4, 7411–7419, **2019.**

[19] I. Chi-Duran, J. Enríquez, C. Manquian, R. A. Fritz, D. Serafini, **F. Herrera**, D. P. Singh, *Azide-based high-energy metal-organic framework with enhanced thermal stability*, ACS Omega 4, 11, 14398-14403, **2019**.

[18] M. Litinskaya and **F. Herrera,** *Vacuum-enhanced optical nonlinearities with organic molecular photoswitches*, Phys. Rev. B 99, 041107(R), **2019**.

[17] I. Chi-Duran, J. Enríquez, A. Vega, **F. Herrera**, D. P. Singh, *Hexa-aqua-zinc(II) dinitrate bis-[5-(pyridinium-3-yl)tetra-zol-1-ide],* Acta Cryst. E74, 1231-1234, **2018.**

[16] I. Chi-Duran, J. Enríquez, C. Manquian, K. Wrighton-Araneda, W. Cañon-Mancisidor, D. Venegas-Yazigi, **F. Herrera**, D. P. Singh, *pH-Controlled Assembly of 3D and 2D Zinc-based Metal-Organic Frameworks with Tetrazole Ligands,* ACS Omega 3, 801–807, **2018.**

[15] **F. Herrera**, F. C. Spano, *Theory of nanoscale organic cavities: The essential role of vibration-photon dressed states,* ACS Photonics 5, 65, **2018.**

[14] **F. Herrera,** F. C. Spano, *Absorption and photoluminescence in organic cavity QED,* Phys. Rev. A 95, 053867, **2017.**

[13] **F. Herrera** and F. C. Spano, *Dark vibronic polaritons and the spectroscopy of organic microcavities*, Phys. Rev. Lett. 118, 223601, **2017.**

[12] **F. Herrera** and F. C. Spano, *Cavity-controlled chemistry in molecular ensembles*, Phys. Rev. Lett. 116, 238301, **2016.**

[11] M. Moebius, **F. Herrera**, S. Griesse-Nascimento, O. Reshef, C. Evans, G. G. Guerreschi, Alan Aspuru-Guzik, Eric Mazur, *Effcient photon triplet generation in integrated nanophotonic waveguides*, Opt. Express 24, 9932, **2016**.

[10] B. Zhu, J. Schachenmayer, M. Xu, **F. Herrera**, J. G. Restrepo, M. J. Holland, A. M. Rey, *Synchronization of interacting quantum dipoles*, New J. Phys. 17, 083063, **2015**.

[9] **F. Herrera**, B. Peropadre, L. A. Pachon, S. Saikin, A. Aspuru-Guzik, *Quantum nonlinear optics with polar J-aggregates in microcavities*, J. Phys. Chem. Lett. 5, 3708, **2014**.

[8] **F. Herrera**, Y. Cao, S. Kais, K. B. Whaley, *Infrared-dressed entanglement of cold open-shell polar molecules for universal matchgate quantum computing*, New J. Phys. 16, 075001, **2014**.

[7] A.A. Kocherzhenko, J. Dawlaty, B. P. Abolins, **F. Herrera**, D. B. Abraham, K. B. Whaley, *Collective effects in linear spectroscopy of dipole-coupled molecular arrays*, Phys. Rev. A 90, 062502, **2014**.

[6] **F. Herrera**, S. Kais, K. B. Whaley, *Entanglement creation in cold molecular gases using strong laser pulses*, arXiv:1302.6444.

[5] **F. Herrera**, K. W. Madison, R. V. Krems, M. Berciu, *Investigating polaron transitions with polar molecules*, Phys. Rev. Lett. 110, 223002, **2013**.

[4] **F. Herrera** and R. V. Krems, *Tunable Holstein model with cold polar molecules*, Phys. Rev. A 84, 051401(R), **2011.**

[3] J. Perez-Rios, **F. Herrera**, R. V. Krems, *External field control of collective spin excitations in an optical lattice of* $^2\Sigma$ *molecules*, New. J. Phys. 12, 103007, **2010**.

[2] **F. Herrera**, M. Litinskaya, R. V. Krems, *Tunable disorder in a crystal of cold polar molecules*, Phys. Rev. A 82, 033428, **2010**.

[1] **F. Herrera**, *Magnetic field-induced interference of scattering states in ultracold collisions*, Phys. Rev. A 78, 054702, **2008**.

INVITED PRESENTATIONS

1. "*How do Chemical Bonds Break in Ultrastrong Coupling?"*, Quantum Light-Matter Center, Durham University, Nov 29, **2023**
2. "*How do Chemical Bonds Break in Ultrastrong Coupling?"*, Chemical Physics Seminar, Fritz-Haber Institute, Nov 17, **2023**
3. "*How do Chemical Bonds Break in Ultrastrong Coupling?"*, Optics Seminar, University of Warsaw, Faculty of Physics, Oct 26, **2023**
4. "*Modifying chemical reactivity via quantum coherence in infrared cavity QED*", Workshop on Polaritonic Chemistry, Hamburg, Germany, Oct 1-4, **2023**
5. "*Controlling Chemistry with Cavity QED*", Young Science Beyond Borders, Polish Young Academy (virtual), Jun 1-2, **2023**.
6. "*Steady-state chemistry of molecular ensembles in vibrational strong coupling",* Molecular Polaritonics 2022, Straubing, Germany, Sep 12-14, **2022.**
7. "*Semi-empirical quantum optics for mid-infrared molecular nanophotonics*", CINVESTAV seminar (virtual), July 19, **2022**.
8. "*Vacuum-assisted conductivity of organic materials in infrared cavities*", GRC Electronic Processes in Organic Materials, Renaissance Tuscany Il Ciocco, Italy, Jun 26 - Jul 1st, **2022**.
9. "*Steady-state chemistry of molecular ensembles in vibrational strong coupling*", CEAM Flagship Workshop on Polaritonic Chemistry, Bordeaux, June **2022.**
10. "*Controlled Cavity QED with Molecular Ensembles in Infrared Nanocavities",* MRS Spring Meeting 2022, Honolulu, May **2022**.
11. *Exact chemical dynamics tools for scalable simulations of noisy superconducting resonator networks*, Pacifichem 2021, Virtual Conference, December 19, **2021.**
12. *Controlled Cavity QED with Molecular Ensembles in Infrared Nanocavities,* MRS Fall Meeting 2021, Boston, November **2021**.
13. *Vacuum and molecules for useful quantum advantage today*, Physics Colloquium, Ohio University, October **2021.**
14. *Controlled Cavity QED with Molecular Ensembles in Infrared Nanocavities,* SPIE Conference Metamaterials, Metadevices, and Metasystems 2021, San Diego, August **2021**.
15. *Chemical reactivities of vibrational polaritons in the ultrastrong coupling regime,* Strong Coupling in Organic Molecules (SCOM) 2021, Chalmers (virtual), April 27, **2021**.
16. *Molecular materials and devices for scalable optical quantum technologies,* Royal Society Frontiers of Science UK-Chile, London (virtual), March 29, **2021.**
17. *Anharmonic vibrational polaritons: spectroscopy and chemistry*, Polariton Chemistry Webinars, UCSD (virtual), January **2021**.
18. *Controlling the chemistry and dynamics of organic materials with quantum optics at the nanoscale,* International Conference on Materials Science, Valdivia, October **2019.**
19. *Vibrational polaritons in the ultrastrong coupling regime: spectroscopy and chemistry,* Workshop on Molecular Polaritonics, Madrid, July **2019.**
20. *Controlling chemistry with quantum optics at the nanoscale,* Centro de Óptica Cuántica e Información

Cuántica, Universidad Mayor, June **2019.**

21. *Controlling chemistry with quantum optics at the nanoscale,* JILA seminar, February **2019**.
22. *Cavity quantum electrodynamics with organic matter,* 2nd Workshop in Optics and Photonics, Universidad de los Andes, December **2018**.
23. *Controlling chemistry with quantum optics in nanoscale cavities,* 10th International Meeting on Photodynamics and Related Aspects, Cartagena, September **2018**.
24. *Holstein-Tavis-Cummings theory of organic polaritons: Spectroscopy and chemistry,* 9th International Conference on Spontaneous Coherence in Excitonic Systems, Montreal, July **2018**
25. *Holstein-Tavis-Cummings theory of organic polaritons: Spectroscopy and chemistry,* Workshop "Quantum Frontiers in Molecular Science", Telluride, June **2018.**
26. *The physics of organic cavities*, Universidad de Chile, Santiago, November **2017**.
27. *Controlling chemistry with quantum optics in nanoscale cavities*, Fac. de Ciencias, Universidad de Chile, Santiago, July **2017.**
28. *Controlling chemistry with quantum optics in nanoscale cavities*, Centre for Quantum Technologies, Singapore, Feb. **2017**
29. *Controlling chemistry with quantum optics in nanoscale cavities*, SMART Centre, Singapore, Feb. **2017**
30. *Cavity-controlled chemistry in molecular ensembles*, CINV, Valparaiso, July **2016**.
31. *Cavity-controlled chemistry in molecular ensembles*, CEFOP, Concepción, June **2016**.
32. *Cavity-controlled chemistry in molecular ensembles*, Photodynamics, Mendoza, May **2016**.
33. *Cavity-controlled chemistry in molecular ensembles*, ICSCE 8, Edinburgh, Abril, **2016**.
34. *Controlling nonlinear optical response and chemical reactions in organic cavities*, Pacifichem, Honolulu, December **2015**.
35. *Matchgate quantum computing with cold polar molecules*, APS March Meeting, San Antonio, March **2015**.
36. *Matchgate quantum computing with cold polar molecules*, JILA, Boulder, December **2014**.
37. *Solid-state nonlinear quantum optics with organic polar molecular aggregates*, IWQCD II, Medellín, August **2014**.
38. *Controlled entanglement manipulation in cold molecular gases with strong laser pulses*, University of British Columbia, Vancouver, May **2013**.
39. *Controlled entanglement manipulation in cold molecular gases with strong laser pulses*, Kavli Institute for Theoretical Physics, Santa Barbara, March **2013**.
40. *Dynamical generation of entanglement in cold molecular gases using strong laser pulses*, Institute for Theoretical AMO Physics, Boston, January **2013**.
41. *Quantum control of binary and many-body interactions with cold molecules*, Quantum Center, University of California Berkeley, May **2012**.
42. *Tunable Holstein Hamiltonian with cold polar molecules*, Institute for Theoretical AMO Physics, Boston, September **2011**.
43. *Tunable Holstein Hamiltonian with cold polar molecules*, Institut fur Theoretische Physik, Universitat Ulm, Ulm, June **2011**.
44. *External field control of collective coherence in optical lattices of polar molecules*, Institut fur Quantenoptik und Quanteninformation, Innsbruck, May **2011**.
45. *Quantum interference induced by external fields in ultracold collisions*, AMO seminar, University of British Columbia, Vancouver, November **2009**.