# **Tejas Deshpande** | Curriculum Vitae

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# Education

California Institute of Technology (Caltech)	Pasadena
PhD, Development of Tools for Probing Order in Single Crystals Using Electron and Photon Spectroscopy	2011-2019
cperimental Condensed Matter Physics	
McGill University	Montreal
Bachelor of Engineering	2007-2011
Majored in Honors Electrical Engineering with minor in Physics	

# Experience

#### GABRIELSE, GERACI & KOVACHY LABS

Postdoctoral fellow 2020-present I led the design and construction of an ultralight dark matter (UDM) detector at Northwestern University (NU), with Compton frequencies in the 20-90 kHz range, using ultralow vibration cryogenic optical cavities. This experiment (a.k.a. "cavity DM") recently improved on existing UDM bounds by an order of magnitude..

KOVACHY LAB

Postdoctoral fellow

### Northwestern University

University of Southampton

Northwestern University

2019-present

- Tests of gravity and quantum mechanics (QM) on the 10 centimeter to one meter length scales using atom interferometry: I led the design and construction of a two meter tall atomic fountain, at NU, to perform precision measurements of Newton's gravitational constant ("big G") and tests of QM in curved spacetime. By employing state-of-the-art atom interferometry technology like large light-to-atom momentum transfer, spatially-resolved atom detection, and delta-kick cooling to picoKelvin temperatures, projected acceleration sensitivities are in the  $10^{-10}$  m/s<sup>2</sup> range. A quantum sensor with such sensitivities will be combined with a well-characterized single-crystal gravitational source mass to reach a precision of under 10 parts per million (ppm) for big G measurement. An intermediate stage of this apparatus recently demonstrated resonant enhancement of an atom interferometer's sensitivity using multipath interference with a record 504 loops.
- 0 Matter-wave Atomic Gradiometer Interferometric Sensor (MAGIS) collaboration: I led the design and construction of the laser system for a 100 meter tall AF (MAGIS-100) at Fermilab. The goal of MAGIS-100 is to serve as a testbed for future kilometer-scale gravitational wave (GW) detectors operating in the 0.03-3 Hz frequency range. Moreover, MAGIS can be used to detect ultralight dark matter with Compton frequencies in the 0.03-3 Hz range. MAGIS-100 leverages the optical atomic clock technology developed for Strontium with fractional frequency stabilities better that  $10^{-18}$ .
- Superconducting Quantum Material Systems (SQMS) center: I was involved in investigating the quantum sensing aspects of the MAGIS-100 and resonant atom interferometer projects. This involved development, simulation, and empirical testing of quantum optimal control protocols.

#### **ULBRICHT LAB**

#### Visiting postdoctoral fellow

2023-2023 I was involved in the upgrade of a Helium-3 cryostat used for superconducting levitation of millimeter-scale ferromagnets. The upgrade involved designing a vibration isolation system similar to that of the "cavity DM" apparatus. Once operational, this will be the first sub-Kelvin system with unprecedented vibration isolation. Moreover, during my month-long visit, I was involved in sample loading, (wet) cryogenic cooling, feedback cooling of the center of mass motion of the levitated ferromagnet, and data collection.

HSIEH LAB Graduate research assistant

Caltech 2011-2019

- Angle-resolved photoemission spectrocopy (ARPES) on topological superconductors: I led the design and construction of a sub-Kelvin and milli-eV (meV) energy resolution ARPES system to detect 3D topological superconductors by probing said superconductor's bulk energy gap and 2D (Majorana) surface states.
- **Rotationally anisotropic second harmonic generation (RA-SHG) on topological superconductors under hydrostatic pressure:** I studied phase transitions in crystalline materials, by studying breaking of electronic point group symmetries, by measuring the second order optical susceptibility, by monitoring the intensity of SHG from a crystalline sample, which is illuminated by a femtosecond laser, as a function of scattering plane angle and polarization of incident/reflected light. I customized a cryostat for performing RA-SHG on topological superconductors under hydrostatic pressure.

#### SZKOPEK LAB

McGill University

2010–2011 I investigated improvement of carrier mobility in graphene field effect transistors (FETs) as a function of substrate properties. I developed a recipe for integrating poly(vinylidene fluoride-co-trifluoroethylene) into graphene FET fabrication, performed current-voltage and capacitance-voltage characterization of graphene FETs at cryogenic temperatures, and modeled transport in graphene using the Landauer-Buttiker formalism.

# **Publications (including submitted)**

**2025**: **T. Deshpande**, A. Ionescu, N. Miller, Z. Wang, G. Gabrielse, A. Geraci, and T. Kovachy. "Lower Limits on Ultralight Scalar Dark Matter from Optical Cavities." arXiv:2412.20623v1. Submitted to *Physical Review Letters*.

**2024**: Y. Wang,\* J. Glick,\* **T. Deshpande**,\* K. DeRose,\* S. Saraf, N. Sachdeva, K. Jiang, Z. Chen, and T. Kovachy. "Robust Quantum Control via Multipath Interference for Thousandfold Phase Amplification in a Resonant Atom Interferometer." *Physical Review Letters*, **133**, 243403. (\* : equal author contribution).

**2024**: J. Glick, Z. Chen, **T. Deshpande**, Y. Wang, and T. Kovachy. "Coriolis force compensation and laser beam delivery for 100-meter baseline atom interferometry." *AVS Quantum Science*, **6**, 014402.

**2023**: G. Louie, Z. Chen, **T. Deshpande**, and T. Kovachy. "Robust atom optics for Bragg atom interferometry." *New Journal of Physics*, **25**, 083017.

**2023**: K. DeRose, **T. Deshpande**, Y. Wang, and T. Kovachy. "High-power, low-phase-noise, frequency-agile laser system for delivering fiber-noise-cancelled pulses for Strontium clock atom interferometry." *Optics Letters*, **48**, 3893.

**2023**: Z. Chen, G. Louie, Y. Wang, **T. Deshpande**, and T. Kovachy. "Enhancing strontium clock atom interferometry using quantum optimal control." *Physical Review A*, **107**, 063302.

**2022**: C. Li, X. Li, **T. Deshpande**, X. Li, N. Nair, J. G. Analytis, D. M. Silevitch, T. F. Rosenbaum, and D. Hsieh. "High pressure control of optical nonlinearity in the polar Weyl semimetal TaAs." *Physical Review B*, **106**, 014101.

**2021**: M. Abe *et al.* "Matter-wave Atomic Gradiometer Interferometric Sensor (MAGIS-100)." *Quantum Science and Technology* **6**, 044003. I was one of **8 primary contributors** (experimental) to this paper's manuscript.

**2018**: K. Frohna,\* **T. Deshpande**,\* J. Harter,\* W. Peng, B. A. Barker, J. B. Neaton, S. G. Louie, O. M. Bakr, D. Hsieh, and M. Bernardi. (2018). "Inversion symmetry and bulk Rashba effect in methylammonium lead iodide perovskite single crystals." *Nature Communications*, **9(1)**, 1829. (\* : equal author contribution for theory and experiment).

**2011**: S. A. Imam, **T. Deshpande**, A. Guermoune, M. Siaj, and T. Szkopek (2011). "Charge transfer hysteresis in graphene dualdielectric memory cell structures." *Applied Physics Letters*, **99(8)**, 082109.

## **Publications in preparation**

**2025**: D. Antypas *et al.* "New Horizons: Scalar and Vector Ultralight Dark Matter." arXiv:2203.14915. Review article to be submitted to *New Journal of Physics* "Quantum Technologies for Fundamental Physics."

**2025**: **T. Deshpande**, D. Kaplan, T. Kovachy, C. Overstreet, and S. Rajendran. "Proposal for detecting high-frequency vector dark matter using atom interferometry and suspended atom mirrors."

**2025**: K. DeRose, Y. Wang, **T. Deshpande**, and T. Kovachy. "Broadband passively-phase-stable amplitude modulation at high optical power using a double-passed acousto-optic modulator driven at two frequencies."

## **Invited talks**

**2025**: Search for ultralight bosonic dark matter using two optical cavities. Society of Photographic Instrumentation Engineers (SPIE) Photonics West.

**2023**: *Quantum-control-enhanced metrology using resonant atom interferometry with Strontium*. University of California, Los Angeles (UCLA).

**2023**: Search for gravitational waves using resonant atom interferometry. SQMS annual meeting, Fermilab.

**2023**: *Towards tests of causal nonlinear quantum mechanics using light-pulse atom interferometry*. Quantum Technologies for Fundamental Physics, Erice, Italy.

**2022**: Detection of gravitational waves and dark matter using atom interferometry. University of Liverpool.

2022: Fundamental tests of gravity and quantum mechanics using atom interferometry. University of Southampton.

2022: Fundamental tests of gravity and quantum mechanics using atom interferometry. University of Florence.

2022: Progress toward development of a strontium atom interferometer for precise gravitational measurements. SPIE Photonics West.

**2021**: *Gravitational wave and dark matter detection using atom interferometry (MAGIS-100)*. Midwest Cold Atom Workshop, Purdue University.

# **Contributed talks**

**2023**: T. Deshpande, K. DeRose, J. Glick, K. Jiang, N. Sachdeva, S. Saraf, Y. Wang, T. Kovachy. *Progress toward tests of gravity and quantum mechanics using atom interferometry with Strontium*. American Physical Society (APS) Division of Atomic, Molecular and Optical Physics (DAMOP) meeting.

**2023**: T. Deshpande, A. Ionescu, N. Miller, M. Nguyen, P. Parshi, R. Desalvo, T. Kovachy, A. Geraci, and G. Gabrielse. *Progress toward detection of ultralight dark matter with cryogenic optical cavities*. APS April meeting.

**2022**: T. Deshpande, A. Ionescu, N. Miller, R. Desalvo, T. Kovachy, B. Odom, A. Geraci, G. Gabrielse. *Progress toward detection of ultralight dark matter with cryogenic optical cavities*. APS DAMOP meeting.

**2021**: T. Deshpande on behalf of the MAGIS-100 collaboration. *Detection of gravitational waves and dark matter using atom interferometry (MAGIS-100)*. APS March meeting.

**2021**: T. Deshpande, K. DeRose, J. Glick, T. Kovachy. *Development of laser system for atom interferometric detection of gravitational waves and dark matter*. APS DAMOP meeting.

**2021**: T. Deshpande, Y. Wang, N. Sachdeva, G. Louie, J. Kangara, J. Glick, K. Fonseka, K. DeRose, T. Kovachy. *Progress toward development of a Strontium atom interferometer for performing short-distance tests of gravity*. APS DAMOP meeting.

**2020**: T. Deshpande, J. Kangara, J. Glick, K. DeRose, N. Sachdeva, Y. Wang, T. Kovachy. *Tests of gravity using a Strontium atom interferometer over 10 cm to 1 m length scales*. APS DAMOP meeting.

**2018**: T. Deshpande, J. Harter, K. Frohna, W. Peng, B. Barker, J. Neaton, S. G. Louie, O. M. Bakr, D. Hsieh, and M. Bernardi (2018). *Inversion symmetry in methylammonium lead iodide single crystals probed by second harmonic optical anisotropy*. APS March meeting.

**2016**: T. Deshpande, J. Harter, A. Fedorov, and D. Hsieh (2016). *Towards laser-based angle-resolved photoemission spectroscopy at ultralow temperatures*. APS March meeting.

**2014**: T. Deshpande, D. Torchinsky, L. Zhao, X. Ni, T. Qi, G. Cao, and D. Hsieh (2014). *A time- and wavelength-resolved optical pump-probe reflectivity study of the metal-to-insulator transition in*  $Sr_2IrO_4$ . APS March meeting.

## **Posters**

2022: T. Deshpande. *Towards measurement of gravity from suspended or levitated masses using ultracold atoms*. LeviNet conference.
2021: T. Deshpande, N. Sachdeva, G. Louie, J. Jachinowski, J. Kangara, J. Glick, K. Jiang, K. DeRose, S. Saraf, Y. Wang, Z. Chen, and T. Kovachy. *Tests of gravity using a Strontium atom interferometer over 10 cm to 1 m length scales*. Midwest Cold Atom Workshop.
2011: T. Deshpande, S. A. Imam, A. Guermoune, M. Siaj, and T. Szkopek. *Charge transfer in large area graphene on silicon nitride dielectrics*. Canadian Institute for Advanced Research meeting.

## Awards

2018: R. K. Kar Award for Research in Physics, Caltech

2014-2016: Natural Sciences and Engineering Research Council of Canada (NSERC) graduate fellowship, Caltech

2010: NSERC Undergraduate Summer Research Award (USRA), McGill University

2009-2010: J. B. Woodyatt Scholarship, McGill University

2009: NSERC USRA, McGill University

2008-2009: Collins and Gilmour and McConnell Scholarships, McGill University

2007-2008: Dean's Honor List, McGill University