2026 Undergrad Projects in the Hoffman Lab

The Hoffman Lab is looking for Harvard undergraduates to work on several research projects in 2026. Please email your CV to Prof. Hoffman.

Funding

Spring 2026 funding:
- HCRP deadline is Mon, Jan 12
  (funding has historically been in the range of ~$500-$1000/semester)
- Harvard Quantum Initiative (supplemental funding for students **with financial need**, since HCRP does not pay minimum wage). Submit the same application to HQI right after you submit it to HCRP.
- Physics 90r or Eng. Sci. 91r credit is also a possibility. Typically this receives a letter grade based on effort (reliable 10 hr/wk commitment) and organization (clear, readable lab notebook at the end of the semester).

Summer 2026 funding:
- Herschel Smith deadline Tues, Feb 3
- PRISE deadline Sun, Feb 1
- HCRP deadline Mon, March 16
- Summer room & board in a Harvard dorm (TBA) was available last year for $3150, which was taken out of the total HCRP stipend (leaving ~$2000 take-home)
- Harvard Quantum Initiative deadline TBD (mid March?)

See additional funding notes and other Hoffman lab resources.

Requirements

For most of these projects, no specific background knowledge is necessary. You will be trained and mentored by a graduate student or postdoc in the Hoffman lab. But you must work carefully, document well, and think creatively & independently to solve physics & engineering challenges.

Minimum term-time commitment: 10 hours/week
Typical summer commitment: 10 weeks, 40 hrs/wk

CV: In case you haven't made your CV before, here is an example.
Please include your relevant science & math coursework on your CV (or attach a transcript).

(1) Acoustic metamaterials to mimic quantum materials

We are looking for undergraduates to work on the development of acoustic metamaterials as a broad platform to simulate novel quantum materials. Electrons in quantum materials obey the Schrodinger equation, but we can learn a lot about their quantum behavior by studying the analogous acoustic wave equation in macroscopic metamaterials. This is a great on-ramp project for quantum materials, because it has both a simulation (finite element analysis) and a hands-on (3D-printing and acoustic measurements) component. To get an overview of this project, please look at our recent papers below (undergrad authors in bold).

(1) “Topological Phononic Logic”
Harris Pirie, **Shuvom Sadhuka**, **Jennifer Wang**, **Radu Andrei**, Jennifer Hoffman
Physical Review Letters 128, 015501 (2022) (full paper & press release)

(2) “van der Waals metamaterials”
William Dorrell, Harris Pirie, **Minhal Gardezi**, Nathan Drucker, Jennifer Hoffman
Physical Review B 101, 121103(R) (2020) (full paper)

(3) “Acoustic twisted bilayer graphene”
Minhal Gardezi, Harris Pirie, Stephen Carr, William Dorrell, Jennifer Hoffman
2D Materials 8, 031002 (2021) (full paper)

(4) “Quantum-inspired design of a tunable broadband high-Q acoustic resonator”
Jeffrey Shi, Benjamin H. November, Stephen Carr, Harris Pirie, Jennifer E. Hoffman
(preprint at arxiv:2412.20274)

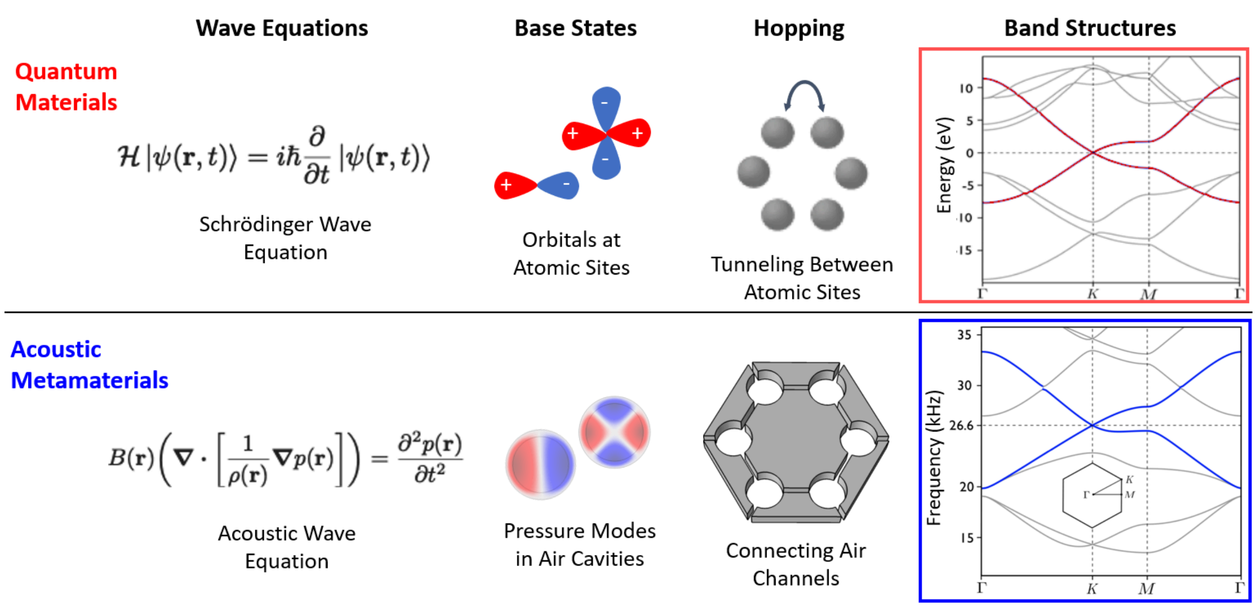

Figure 1: (a) The Schrodinger equation is analogous to the acoustic wave equation. **(b)** Atomic basis states are analogous to pressure modes in circular air cavities (similar to drum modes). **(c)** Electrons hop between atoms, analogous to pressure waves moving through air channels between cavities. **(d)** The electronic band structure (energy vs. momentum of the electrons) is analogous to the acoustic dispersion relation (frequency vs. wavevector of the sound).

Current & upcoming projects:
- simulating pseudo-magnetic fields in rippled metamaterial graphene
- simulating metamaterial twisted bilayer kagome lattices
- simulating nonlinear acoustic effects to mimic strongly correlated electrons

- 3D-printing & measuring metamaterial kagome lattices
- 3D-printing & measuring metamaterial twisted bilayer lattices
- acoustic quasicrystals

Background knowledge required (or learned by dedicated independent reading):
- physics 15c (wave mechanics)
- physics 143a (quantum mechanics)
- physics 195 (solid state physics)

Skills that can be learned on the job:
- finite element analysis modeling of acoustic waves using Comsol
- operation of microphone for acoustic measurement
- electronics (oscilloscope, lockin amplifier, spectrum analyzer, etc.)
- computer-instrument communication (labview)
- data analysis (python)
- literature search & review

How to apply: email your CV (including coursework) and a brief statement of interest to *both* Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and grad student Phil Shenk (philipshenk@g.harvard.edu).

(2) Surface acoustic wave metamaterials in $LiNbO_3$

Electrons in quantum materials obey the Schrodinger equation, but we can learn a lot about their quantum behavior by studying the analogous acoustic wave equation. We have developed several macroscopic acoustic metamaterials, e.g. centimeter-scale arrays of holes in a metal plate, as shown in Figure 1. Now we are working towards scaling down to smaller, faster devices, using GHz surface acoustic waves (SAWs) on the piezoelectric material $LiNbO_3$ (this is the same material and technology that is used to filter and transmit sound in your cell phone). We are using photolithography to create patterns on the surface of $LiNbO_3$ analogous to the atomic lattices of quantum material. We are developing a new microscopy technique to image the transmission of these waves at GHz frequencies.

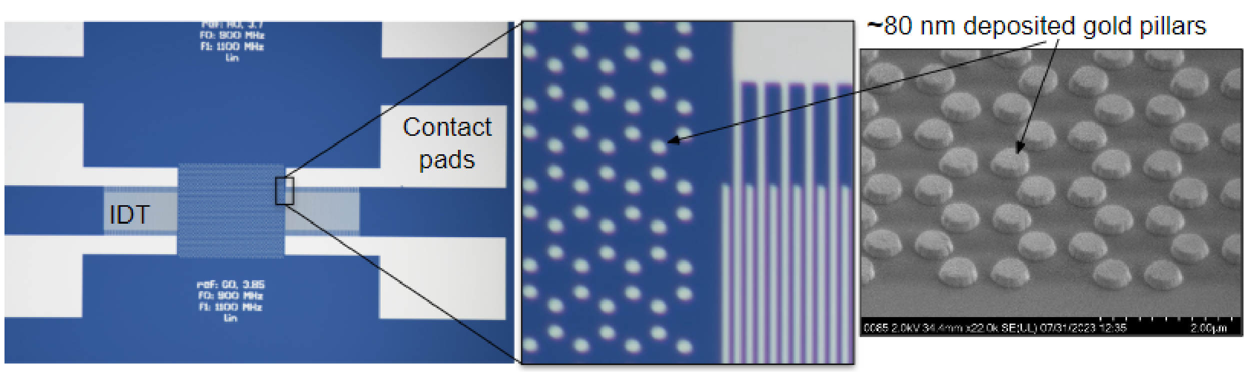

Figure 2: Fabricated contact pads and Au pillar “graphene” metamaterial on $LiNbO_3$.

We are looking for a new undergraduate to partner with current undergrads Michelle Liu and Ethan Li to simulate materials, learn the photolithography skills to develop new quantum materials analogs, and to push forward on the new fast imaging technology.

Background knowledge required (or learned by dedicated independent reading):

- physics 15c (wave mechanics)
- physics 143a (quantum mechanics)
- physics 195 (solid state physics)

Skills that can be learned on the job:

- tools in the Center for Nanoscale Systems (CNS), likely including
    - Photolithography
    - Wet bench processes (acid etch, etc.)
    - Thermal evaporation metal deposition
    - Scanning electron microscopy
    - Atomic force microscopy
- electronics (oscilloscope, lockin amplifier, spectrum analyzer, etc.)
- RF (radiofrequency) electronics
- Wire-bonding & transport measurements
- computer-instrument communication (labview)
- finite element analysis modeling of acoustic waves using Comsol
- data analysis (python)
- Literature search & review

How to apply: email your CV (including coursework) and a brief statement of interest to Prof. Jenny Hoffman (jhoffman@g.harvard.edu).

(3) Acoustic topological insulator - museum demonstration

We are looking for an undergraduate to develop a pedagogical demonstration (for a classroom or a science museum) of a topological insulator in an acoustic system.

A topological insulator is a quantum material whose interior behaves as an electrical insulator while its surface behaves as an electrical conductor, meaning that electrons can move only along the surface of the material. Furthermore, the surface state electrons are “spin-momentum-locked” - e.g. right-moving electrons have spin up, while left-moving electrons have spin down. These properties imply that electrons can move without dissipation, and carry spin information that could be useful in spintronic or quantum computing applications.

We have designed an acoustic analog of a topological insulator, in which sound waves can move along specific edge channels, but not through the interior of a material (PRL 2022 & press release). Former Wellesley undergraduate Nicole Zhao submitted our design to the Max Planck - Harvard Quantum Initiative competition for science museum exhibits to demonstrate quantum phenomena, and was selected as a winner (full proposal)! Now we are looking for a new undergraduate to turn these ideas into reality, starting with simple waves on strings, and expanding to a honeycomb lattice of pillars that can transmit sound along specific switchable channels.

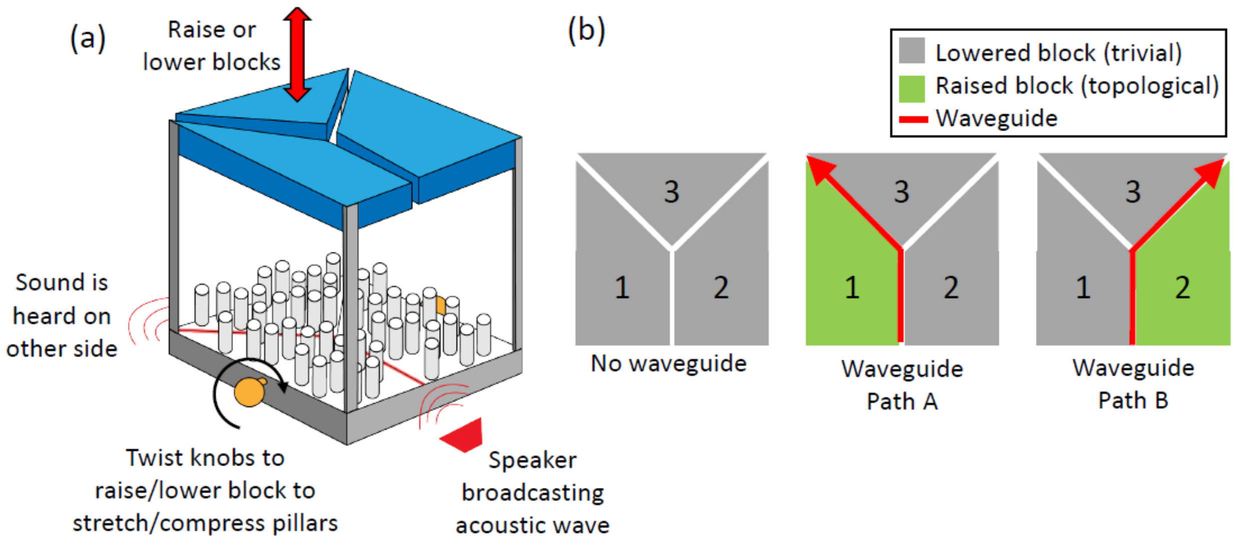

Figure 3: Exhibit of topological acoustic switch. **(a)** Three-section acoustic metamaterial system with compressible rubber pillars in an air-tight box. **(b)** By stretching or compressing the pillars to change the topological phases of the lattice segments, the system can block sound, or transmit sound along Path A or Path B.

Background knowledge required (or learned by dedicated independent reading):

- physics 15c (wave mechanics)
- physics 143a (quantum mechanics)
- physics 195 (solid state physics)

Skills that can be learned on the job:

- finite element analysis modeling of acoustic waves using Comsol
- operation of microphone for acoustic measurement
- electronics (oscilloscope, lockin amplifier, spectrum analyzer, etc.)
- computer-instrument communication (labview)
- data analysis (python)
- literature search & review

How to apply: email your CV (including coursework) and a brief statement of interest to *both* Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and grad student Phil Shenk (philipshenk@g.harvard.edu).

(4) Nanoscale patterning of high-Tc superconductivity (ON HOLD)

Nanoscale fabrication procedures are at the core of everyday technologies such as smartphones and laptops, as well as state-of-the-art research systems such as nano-SQUIDS and topological materials. However, nanoscale fabrication techniques for advanced materials such as superconductors and xenes (single atomic layers) lag far behind existing techniques for silicon-based electronics. Our research focuses on topological superconductors with potential utility in next-generation quantum computers.

We are looking for an undergraduate to develop a procedure to “write” patterns into the high-temperature superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$. The student will use fabrication tools including photolithography, wet bench etching, metal deposition, and scanning electron microscopy from the clean room facilities at the Harvard Center for Nanoscale Systems (CNS) to fabricate superconducting structures on a sub-micrometer length scale – down to 20 nm if the project progresses well. This is a great on-ramp project for a committed student because it will teach a large number of hands-on laboratory skills without requiring significant prior coursework. The student will be trained to use the fabrication equipment by CNS staff; and will begin work primarily in the clean room to fabricate and characterize the superconducting patterns. The student may continue to characterize the devices using even higher-resolution scanning probe microscopy techniques within the Hoffman lab.

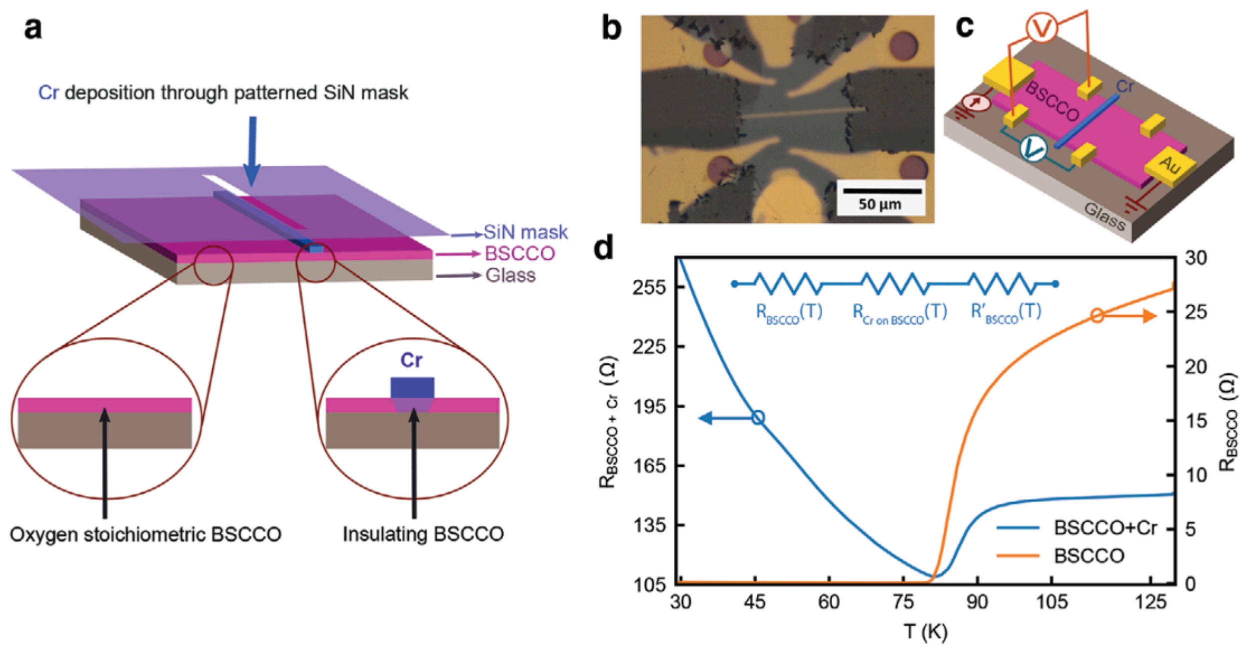

Figure 4: Superconducting devices made by patterning Cr on BSCCO.
Figure borrowed from: [Ghosh et al, Advanced Materials 32, 2002220 (2020)]

Background knowledge required:

- n/a, can be learned on the job

Skills that can be learned on the job:

- tools in the [Center for Nanoscale Systems] (CNS), likely including
    - Photolithography
    - Wet bench processes (acid etch, etc.)

    ○ Thermal evaporation metal deposition
    ○ Scanning electron microscopy
    ○ Atomic force microscopy
- Glove box procedures
- Mechanical exfoliation of atomically-thin 2D materials
- Transport measurements
- Literature search & review
- Long-term: E-beam lithography & scanning tunneling microscopy

How to apply: email your CV (including coursework) and a brief statement of interest to *both* Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and grad student Yidi Wang (yidi_wang@g.harvard.edu).

(5) Radiofrequency (RF) filter development (FILLED)

The study of fundamental quantum effects and the development of quantum computing platforms requires ultra-sensitive measurements that are susceptible to miniscule levels of noise. Cryogenic radiofrequency (RF) powder filters have been implemented in instruments but noise dissipation in these filters is not well understood.

We are looking for an undergraduate who will design and implement a variety of filter geometries, with different powders and capacitors, to better understand the dissipative mechanism and to design a superior filter based on their results.

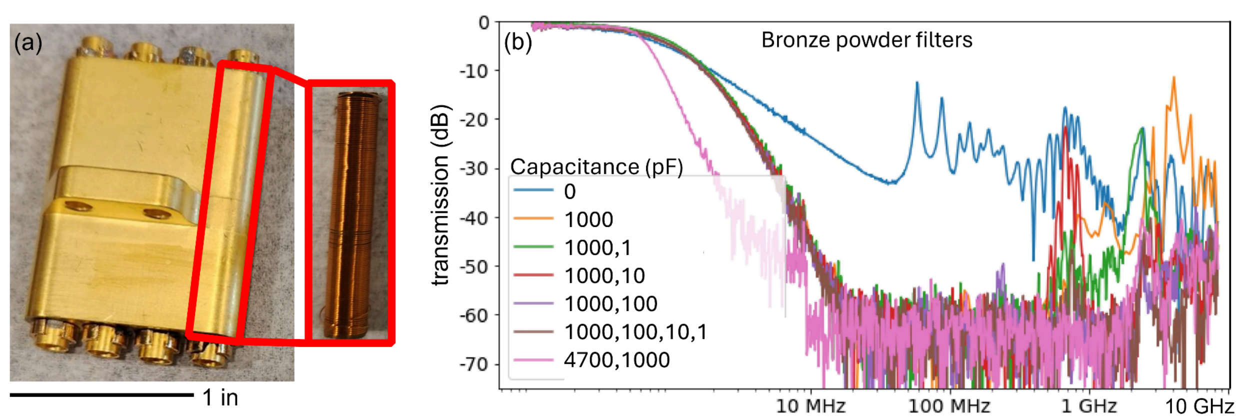

Figure: (a) Filter cartridge fabricated in the Hoffman lab, containing four bronze powder filters built using similar specifications to RSI 2020. **(b)** Our measured filter transmission using different capacitors.

Background knowledge required: Basic electronics, soldering. Completion or concurrent enrollment in Physics 113 or 123 (“Laboratory Electronics”) or equivalent. Experience with a vector network analyzer and/or circuit design software is a plus.

Skills that can be learned on the job:

- Vector network analyzer operation
- Vacuum oven operation

How to apply: email your CV (including coursework) and a brief statement of interest to both Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and grad student Henry Bowman (hbowman@g.harvard.edu).

References

1. Mueller *et al*, "Printed circuit board metal powder filters for low electron temperatures" Review of Scientific Instruments 84, 044706 (2013) https://doi.org/10.1063/1.4802875
2. Lukashenko & Ustinov, "Improved powder filters for qubit measurements" Review of Scientific Instruments 79, 014701 (2008) https://doi.org/10.1063/1.2827515
3. Schwenk *et al*, "Achieving μeV tunneling resolution in an in-operando scanning tunneling microscopy, atomic force microscopy, and magnetotransport system for quantum materials research" Review of Scientific Instruments 91, 071101 (2020) https://doi.org/10.1063/5.0005320

(6) Magnetic tip coating FILLED

Quantum computing promises an exponential advantage over traditional binary transistor methods for solving complex computational problems. However, the development of quantum computers faces a significant obstacle due to environmental disturbances that can disrupt their delicate building blocks, known as qubits. One possible solution would leverage excitations called Majoranas, found in topological superconductors, to build more robust qubits. We have proposed a method to braid Majoranas and perform topological quantum computing operations using a magnetic force microscope (MFM) tip to manipulate magnetic vortices in a topological superconductor $FeTe_{0.55}Se_{0.45}$ (arxiv:1905.09792).

We are looking for an undergraduate to develop techniques for applying a magnetic coating to microcantilevers to be used in the magnetic force microscopy manipulations of Majoranas (e.g. see Deng *et al*, Applied Physics Letters 2004).

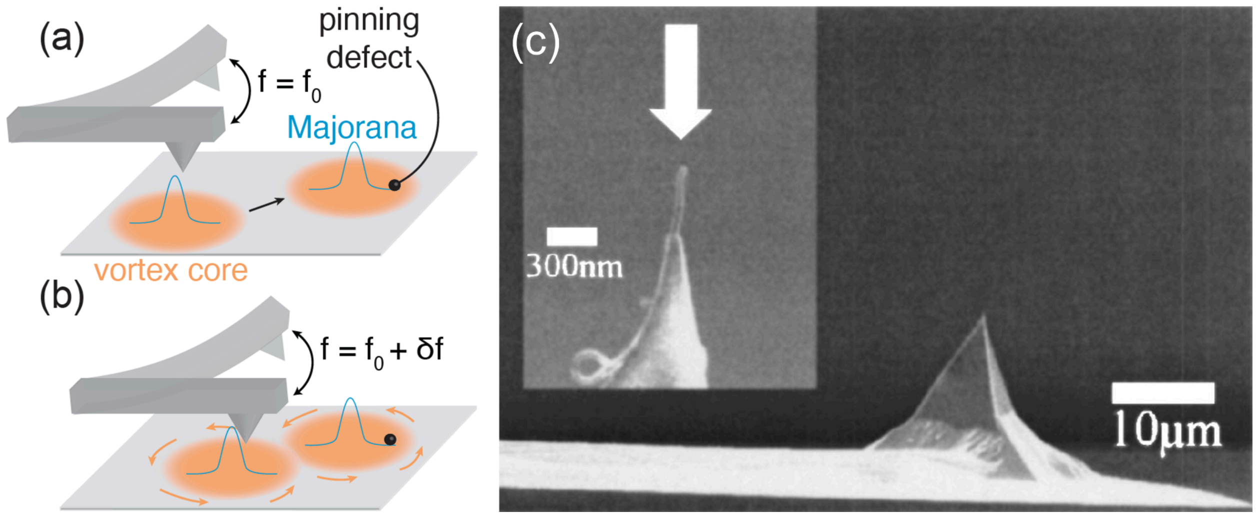

Figure: (a-b) The force from a magnetic-tipped microcantilever will be used to drag individual magnetic vortices in a topological superconductor. Each vortex consists of a swirling electrical current, with a Majorana excitation trapped in its center. Image adapted from arxiv:1905.09792. **(c)** Microcantilevers may be purchased commercially, e.g. from Nanosensors. We will use thermal evaporation to coat the tip with a magnetic material such as cobalt. We may also explore methods to attach nanotubes to tips. Image adapted from APL 2004)

Background knowledge required:
None; just a desire to learn, and motivation to work ***carefully*** and ***diligently***.

Skills that can be learned on the job:

- tools in the Center for Nanoscale Systems (CNS), likely including
    - Scanning electron microscopy
    - Atomic / magnetic force microscopy
- Glove box procedures
- Thermal evaporation
- Literature search & review; scientific communication in presentation & writing

How to apply: email your CV (including coursework) and a brief statement of interest to both Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and postdoc Dr. Subhamita Sengupta (subhamita_sengupta@g.harvard.edu).

(7) Liquid helium experiment development FILLED

We are looking for an incoming first-year undergraduate to commit 10 hrs/wk to help design, construct, and test a "cryostat" - a fancy refrigerator that uses liquid helium instead of freon to reduce the temperature of our experiment to 1 Kelvin, just a degree above absolute zero (this is -457°F). We operate a scanning tunneling microscope at this very low temperature in order to improve our energy resolution for atomic-scale imaging of electrons in quantum materials. The undergraduate will work closely with a graduate student to design parts in Fusion360 (a computer-aided design, or CAD software), to machine and assemble parts, and to leak test for vacuum tightness.

A key challenge in quantum technology development is to understand the link between the atomic-scale building blocks or "quanta" of materials (the charges and spins of electrons) and the motion of these building blocks that give a device its function. To address this challenge, we are developing a versatile scanning 4-probe microscope (S4PM). The new microscope independently scans four switchable probes across a material or device: individual probes can image static atoms, charges, and spins, while two or more probes together can detect the motion of these charges and spins from 10s of nanometers to 100s of micrometers in length. Using a novel geometry in polar rather than cartesian coordinates, the microscope is much more compact than related commercial products, so it can operate in a high magnetic field (up to 9 Tesla) and liquid helium temperature (down to 1 Kelvin) - thus allowing access to a new regime of quantum phenomena. Projects enabled by this microscope include screening of new inhomogeneous materials, mapping the flow of electrons around single atom defects, developing nanostructured materials such as braided polymer cables, assembling complex sensors from individual atoms, and searching for emergent particles that can become the building blocks of new technologies.

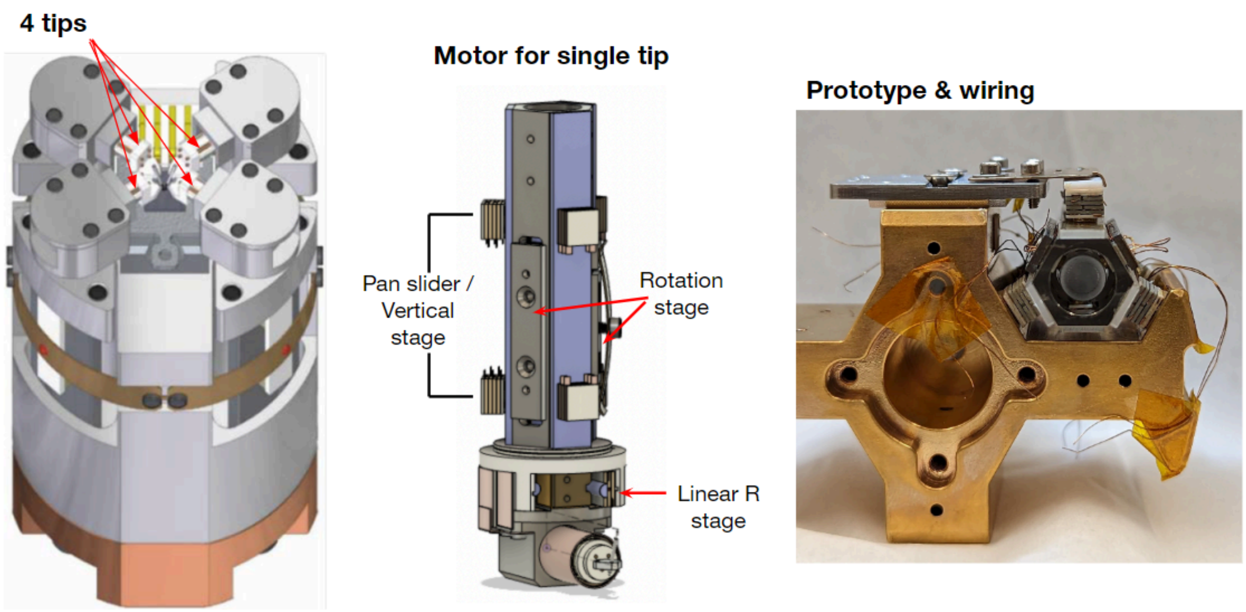

Figure 8: CAD sketch of full S4PM, zoom on the nanoscale-precision motor design to control one of the 4 tips, and beginning assembly & wiring of one motor. Assembly requires careful alignment on the micrometer scale. (This work is funded by NSF MRI award 1828569.)

Background knowledge suggested: Some interest / experience with mechanical equipment (e.g. fixing a bike or appliance, home handy projects, etc.)

Skills that can be learned on the job:
- Computer-aided design (CAD) software
- Basic vacuum, machining, soldering, and/or electronics skills

How to apply: email your CV (including relevant high school coursework, and planned fall Harvard courses) and a brief statement of interest to both Prof. Jenny Hoffman (jhoffman@g.harvard.edu) and grad student Sarah Ziegler (sziegler@g.harvard.edu).

(8) Vortex manipulation circuitry development FILLED

Quantum computing represents a groundbreaking frontier in computing technology, offering the promise of an exponential advantage over traditional computers in solving complex computational problems. However, the development of quantum computers faces a significant obstacle due to environmental disturbances that can disrupt the delicate building blocks of quantum computers, known as qubits. One innovative solution being pursued involves leveraging particles called Majoranas found in the vortices of topological superconductors to build more robust qubits. We are looking for an undergraduate to develop exfoliation techniques for placing these topological superconductors on top of circuitry described in Nano Lett. 2023.

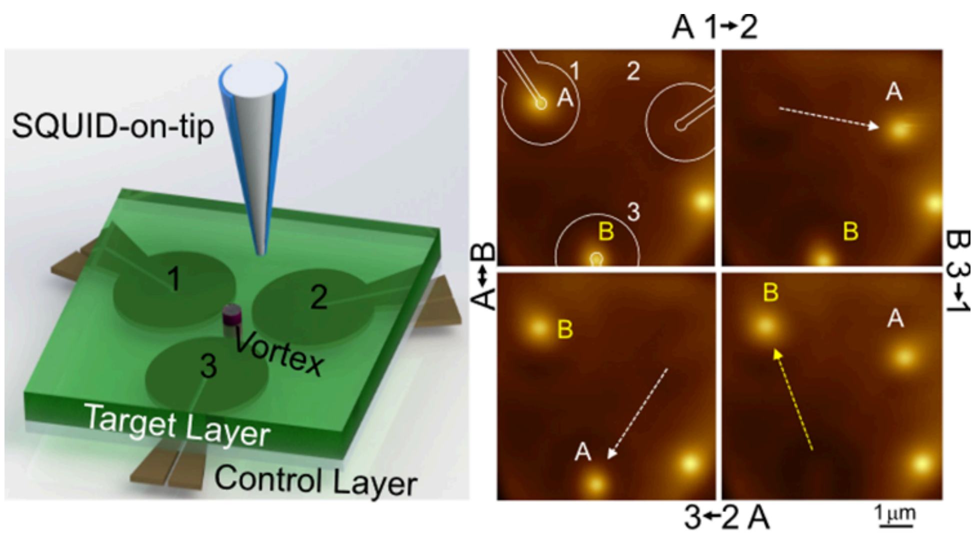

Figure 6: Superconducting circuits used for manipulating vortices in NbSe.
Figure borrowed from: Keren *et. al.* Nano Lett. (2023).

Background knowledge required:
None; just a desire to learn, and motivation to work ***carefully*** and ***diligently***.

Skills that can be learned on the job:

- tools in the Center for Nanoscale Systems (CNS), likely including
  - Scanning electron microscopy
  - Atomic force microscopy
- Glove box procedures
- Mechanical exfoliation
- Literature search & review; scientific communication in presentation & writing

How to apply: email your CV (including coursework) and a brief statement of interest to Prof. Jenny Hoffman (jhoffman@g.harvard.edu). (Possible mentors: Subhamita Sengupta, Henry Bowman)

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document under construction as of Dec 2025… stay tuned…

(For references here are old projects from 2025 and 2024 and 2023 and 2022.)

Fall 2026 funding:

- HCRP (deadline TBA, typically ~ Sept 8)
- Harvard Quantum Initiative deadline - typically 1 week after HCRP
- Physics 90r or Eng. Sci. 91r credit is also a possibility. Typically this receives a letter grade based on effort (reliable 10 hr/wk commitment) and organization (clear, readable lab notebook at the end of the semester).