

2020 Undergraduate Research Fair

Introduction by Karsten Heeger & Nikhil Padmanabhan

Research Presentations:

Biophysics

Damon Clark (damon.clark@yale.edu) – slide

AMO

Jack Harris (jack.harris@yale.edu) – slide

Nuclear/Particle

Keith Baker (oliver.baker@yale.edu) – slide

David Moore (david.c.moore@yale.edu) – slide

Laura Newburgh (laura.newburgh@yale.edu) – slide

Astro

Daisuke Nagai (daisuke.nagai@yale.edu) – slide

Nikhil Padmanabhan (nikhil.padmanabhan@yale.edu) – slide

Theory

Particle: George Fleming (george.fleming@yale.edu) – no slide

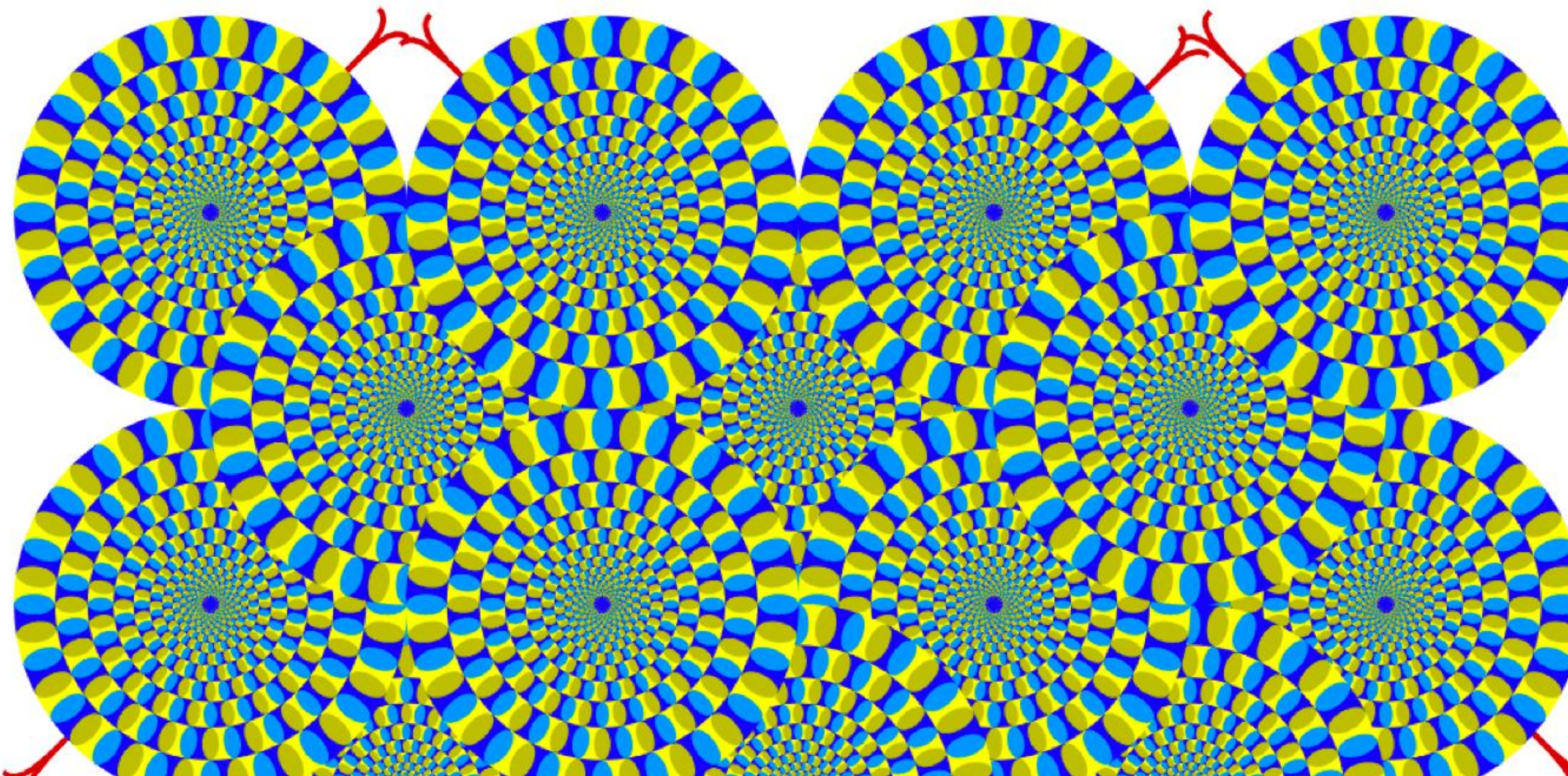
Condensed Matter: Steven Girvin (steven.girvin@yale.edu) - slides

Wright Lab research - slides (Karsten Heeger (karsten.heeger@yale.edu) presenting)

Wright Lab projects – slides (Victoria Misenti (victoria.misenti@yale.edu) presenting)

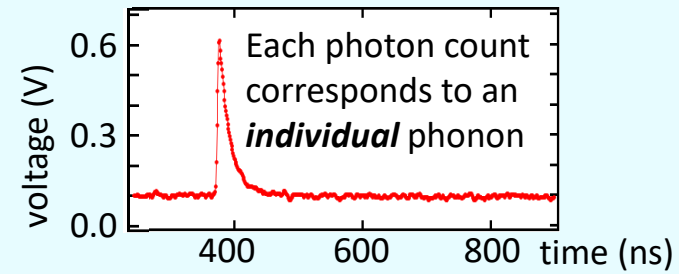
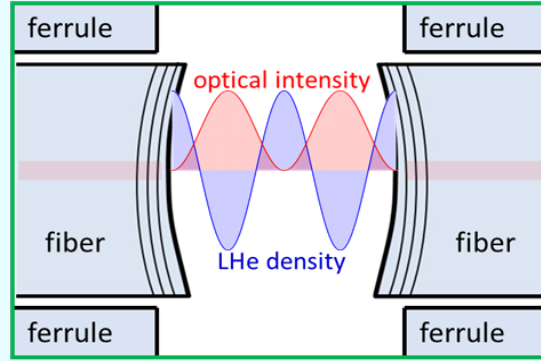
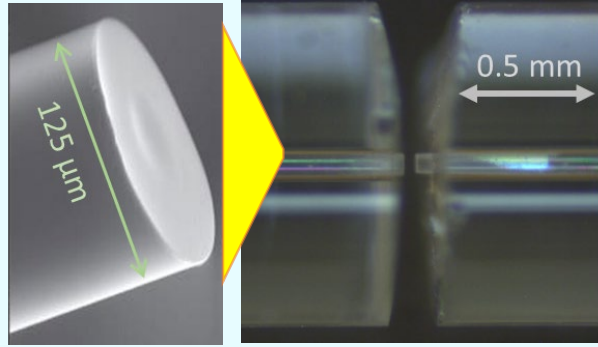
Web site - <https://physics.yale.edu/academics/undergraduate-studies/undergraduate-research-opportunities-2020-21>

How do visual systems work?

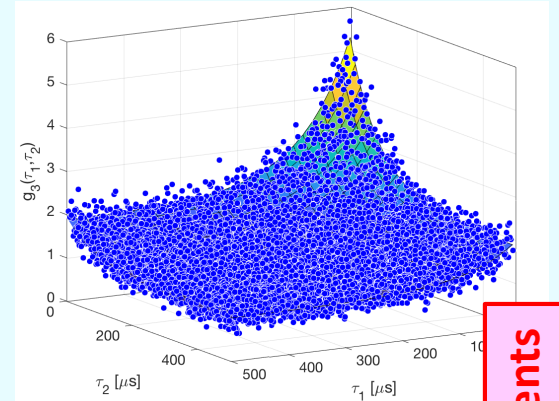


Jack Harris Lab: Experiments on macroscopic quantum phenomena and topological dynamics

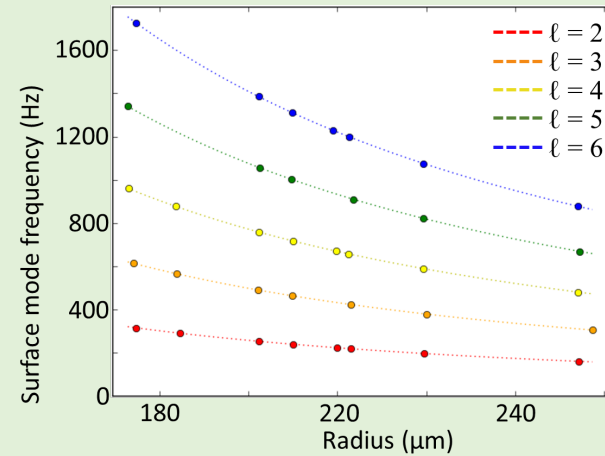
1. Superfluid-filled cavities



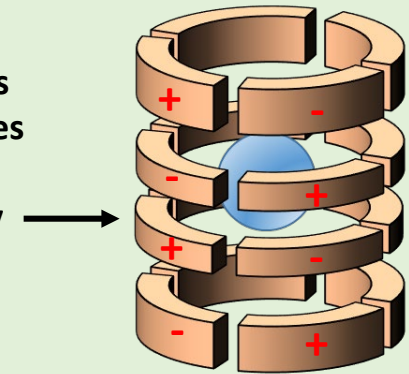
- New devices to enhance phonon lifetime
- Entangle multiple devices
- Trap electron bubbles in cavity



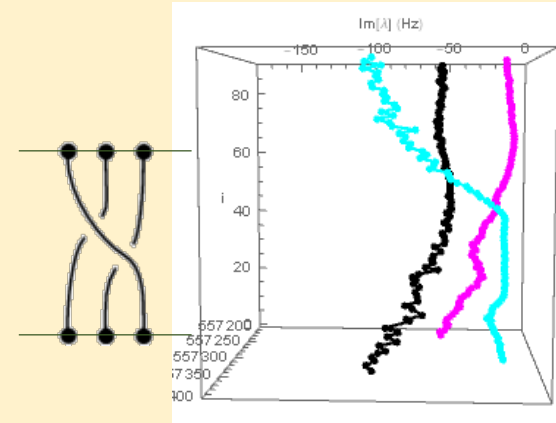
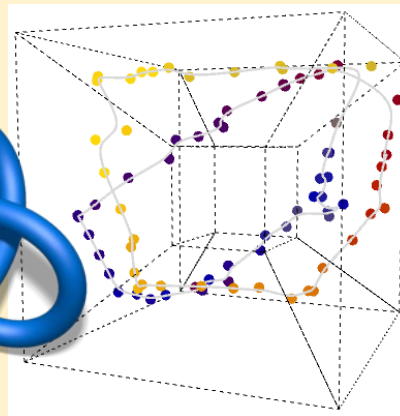
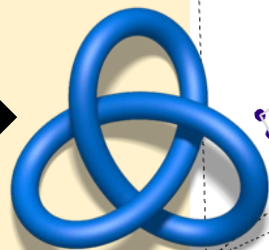
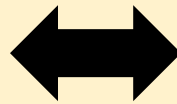
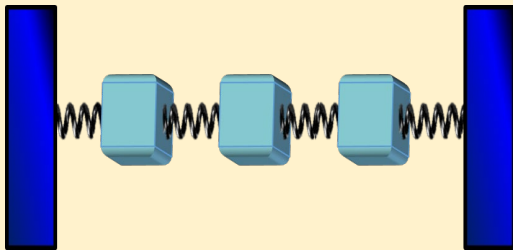
2. Magnetically levitated drops



- Access drop's optical whispering gallery modes
- Rotational motion & vortices
- Drops of ^3He
- Tests of electrical neutrality



3. Topological dynamics

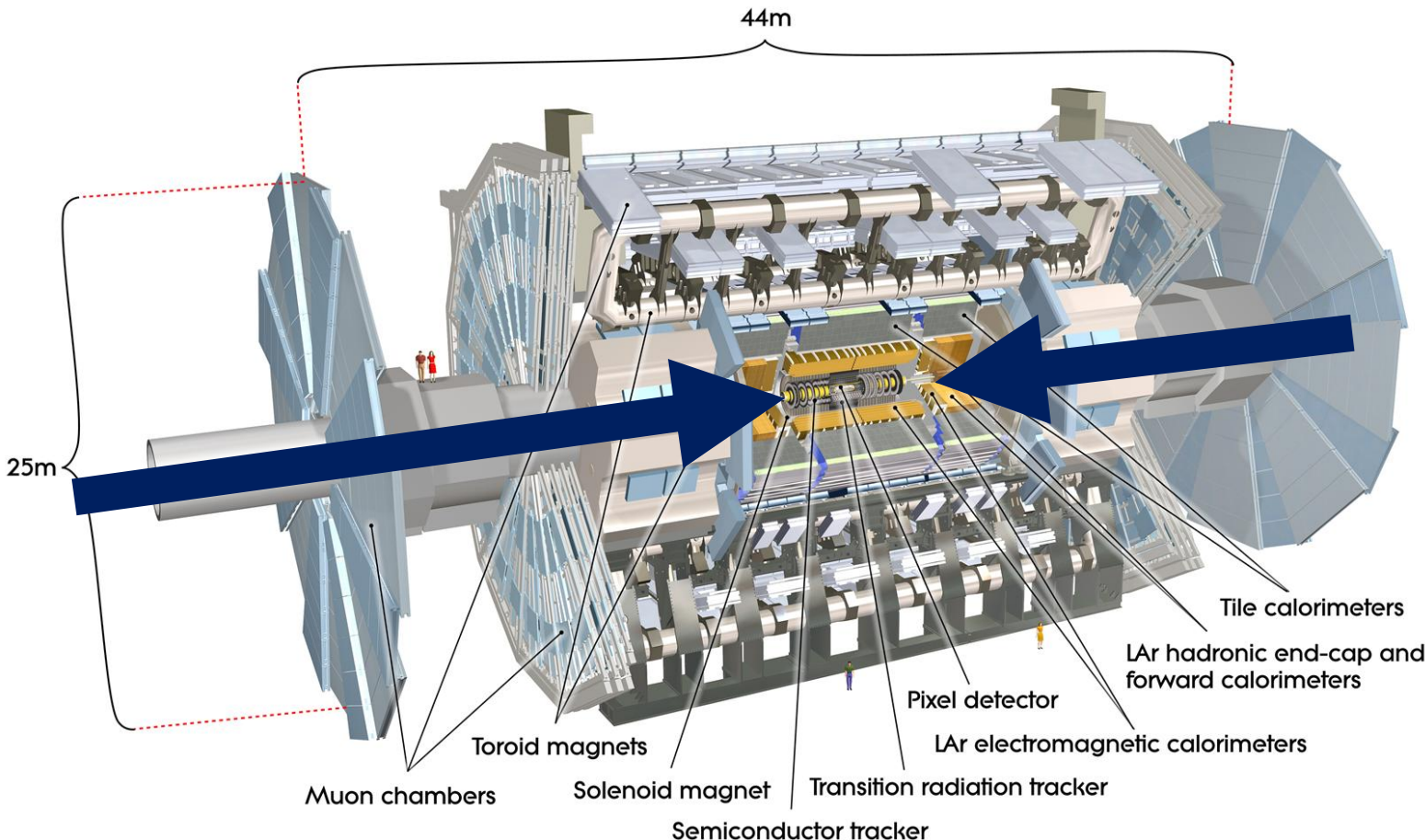


- Knot structures
- Braiding operations
- Topological phases
- Extend to nonlinear oscillators

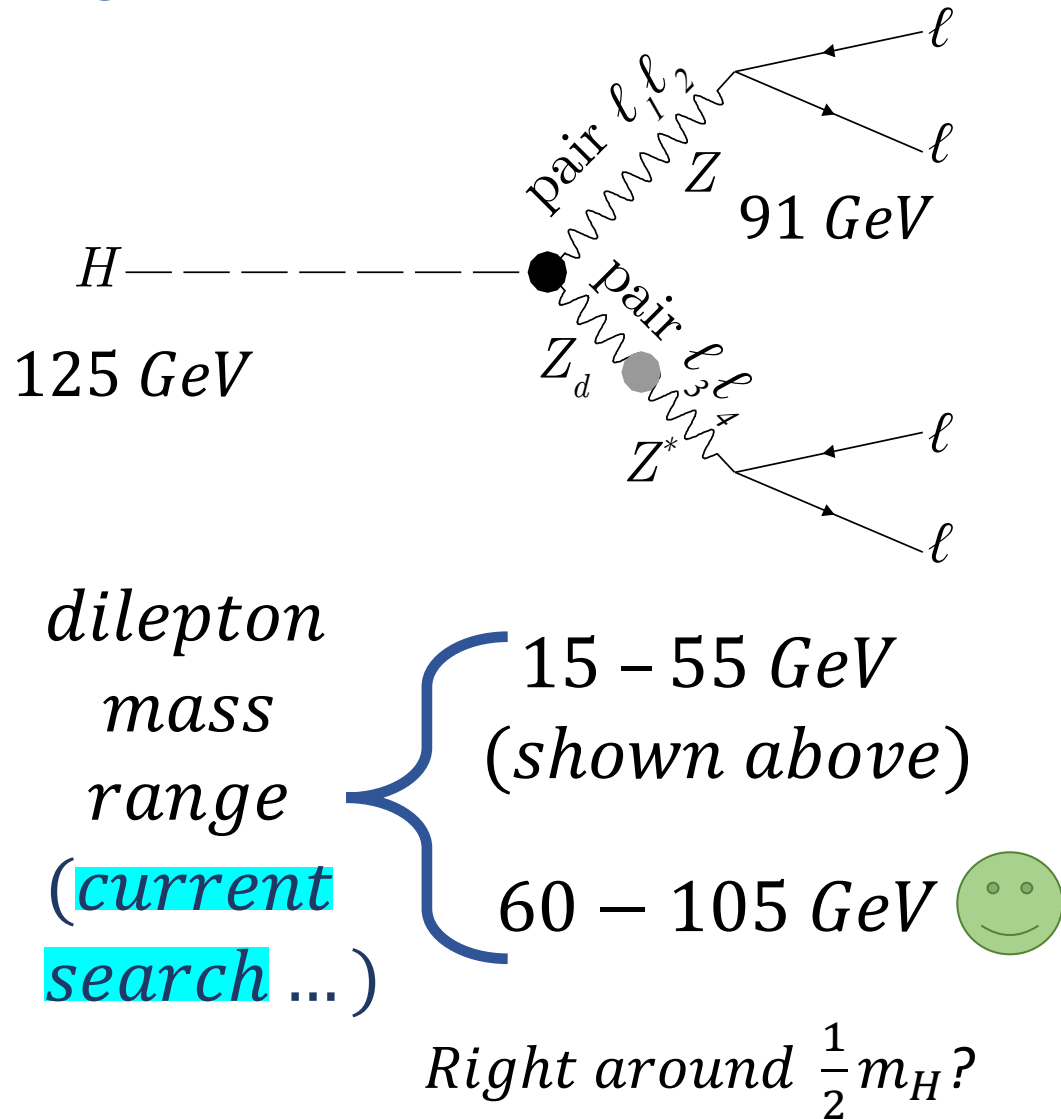
Welcome undergraduate students
for all projects

The ATLAS Detector (A Toroidal LHC Apparatus)

- The largest, general-purpose particle detector experiment at the Large Hadron Collider
- Weighs similar to the weight of the Eiffel Tower
- Beam of 7 TeV each ($\sim 10^{12}$ eV, or speeds up to 99.999999% that of light)
- Located at Geneva, Switzerland



Beyond SM Z_d ?



- Why Higgs? Coupling to mass -- preferred “portal” by the hidden sector particles?
- Which model? $U(1)_d$ symmetry breaking
Narrow $\Gamma \Rightarrow$ Sizable new decay modes
(even though $\text{BR} \approx 15\%$ at 95% CL)
- BSM signal? For $H \rightarrow ZZ_d$, a resonance in the dilepton invariant mass spectrum
- Parameter space? Kinetic mixing
“prompt”) and m_{Z_d}

Experimental Neutrino and Particle Physics at the precision frontier

Prof. David Moore, david.c.moore@yale.edu

Our group is developing new technologies aimed at answering some of the major outstanding questions in nuclear and particle physics:

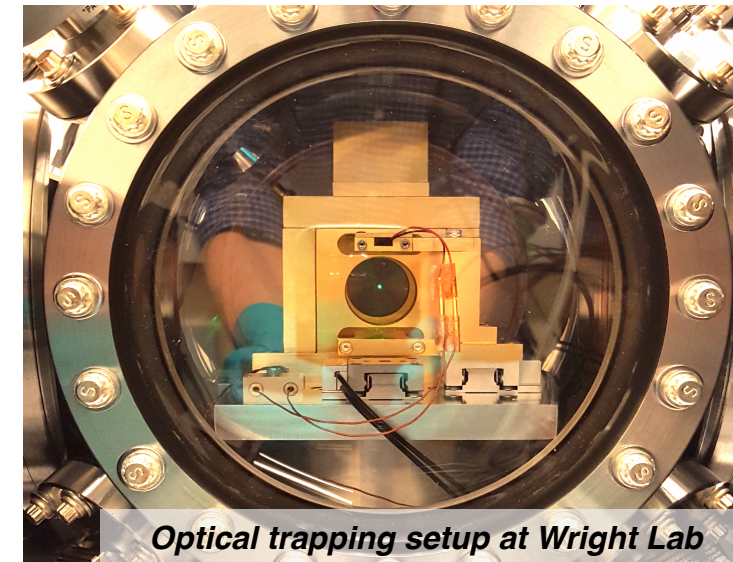
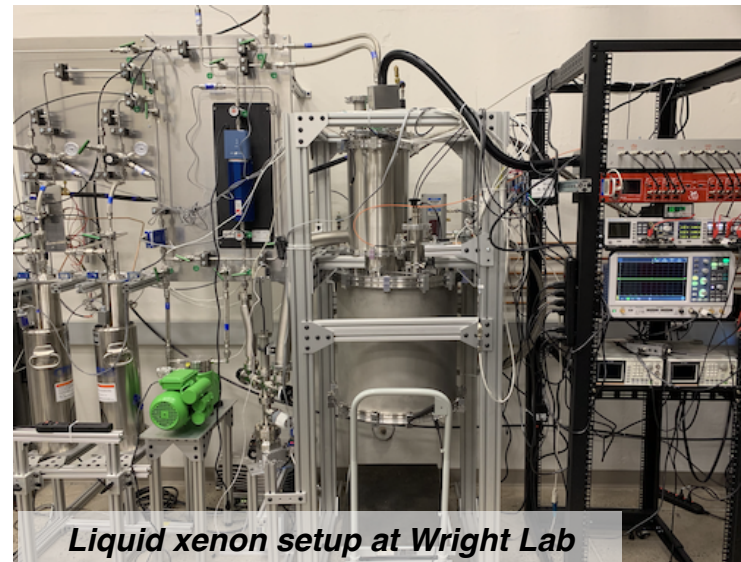
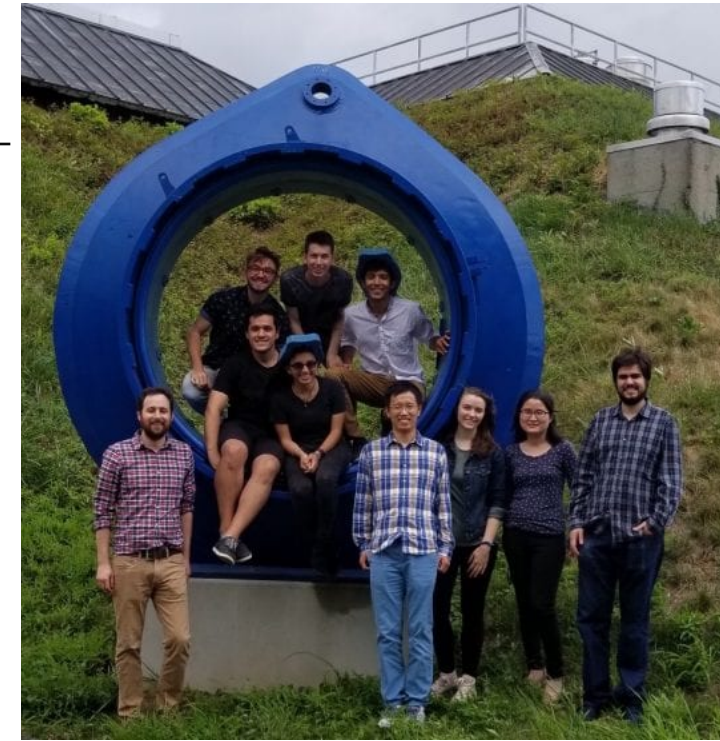
- What are the fundamental properties of neutrinos?
- What is the nature of dark matter and dark energy?
- Are there deviations from gravity that can be observed at microscopic distances?

Answering these questions requires applying cutting-edge techniques from particle, nuclear, atomic, and optical physics.

See <http://campuspress.yale.edu/moorelab/> for more details

Recent undergraduate researchers in our group:

Ilana Kaufman (YC17), Adam Fine (YC19), Cady van Assendelft (YC19), Alec Emser (YC19), Michael Mossman (YC19), Sam Day-Weiss (YC20), Shoumik Chowdhury (YC21), Charlotte Kavalier (YC21), Sam Borden (YC20), Alex Lathem (YC21), Trey Borden (YC23), Ryan Flynn (YC22), Sukhman Singh (YC21)





Cosmic Microwave Background Measurements with the Simons Observatory (and CMB-S4)

Simons Observatory: 4 new telescopes in Chile starting 2021
CMB-S4: 19 telescopes starting 2027



I lead 'DAQ' : all acquisition and control software, timing, live monitoring

21cm Measurements of Dark Energy with CHIME and HIRAX

CHIME telescope : DRAO, British Columbia, Canada
On sky and taking data

I work on calibration — instrumentation and analysis



(Sanah working with low temperature thermometry)



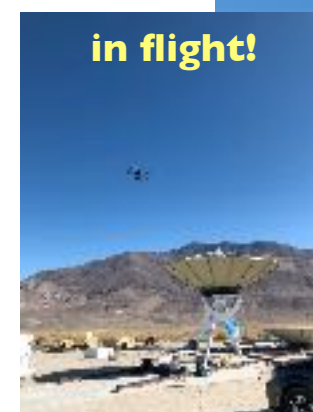
(Holographic measurements at CHIME)



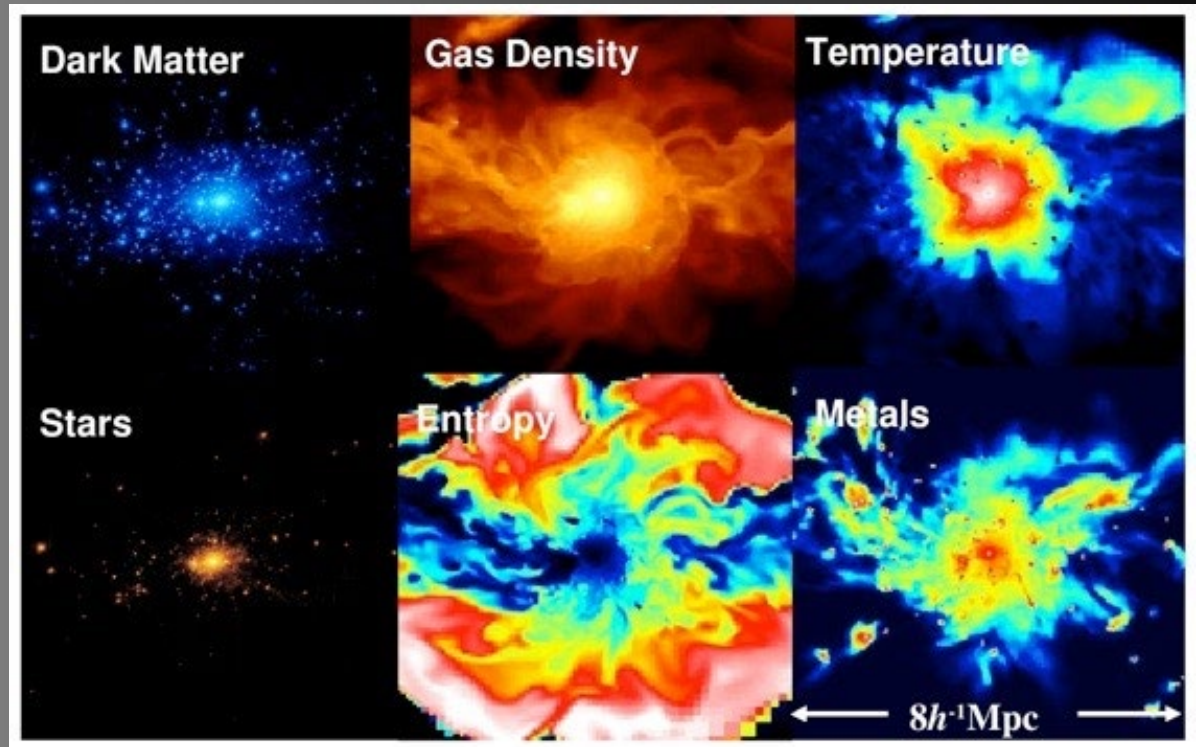
(Emily working on a testbed for noise characterization in lab)

(Drone test flight at Owens Valley Radio Observatory)

in flight!



Computational Cosmology @ Yale



Daisuke Nagai

Associate Professor in Physics & Astronomy

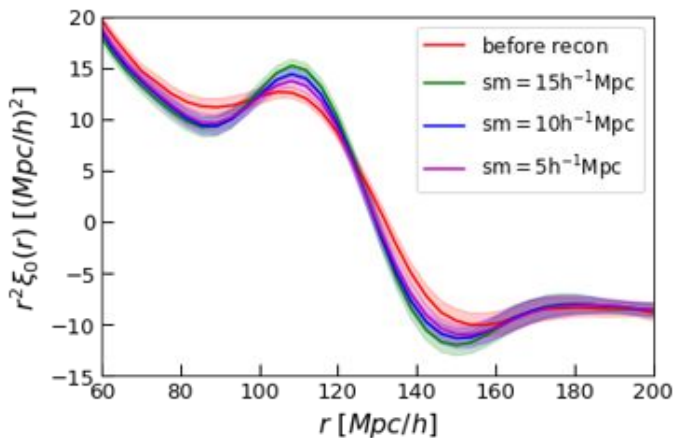
Research Interests – Computational Cosmology: Dark Matter, Dark Energy, Galaxy Clusters, Galaxy Formation, Cosmological Simulations, & Data Science

Current Projects

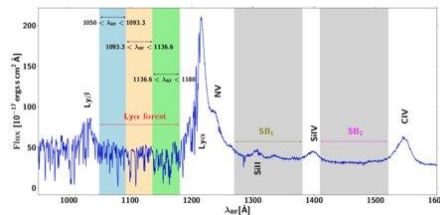
- Cluster image emulation with Auto-encoder
- Galaxy classification with Random Forest
- Analytical model of dark matter filaments

Cosmology with Galaxy Surveys

Naim and Xinyi at recent DESI observing runs

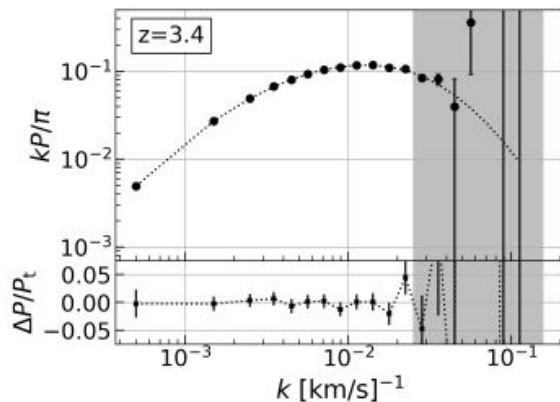


Reconstructing the BAO feature

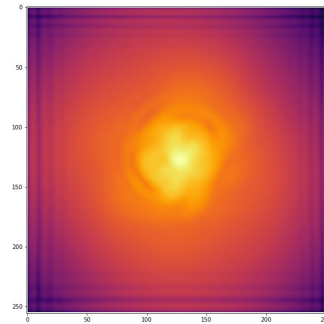
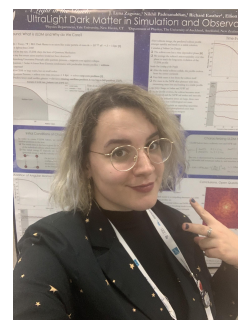
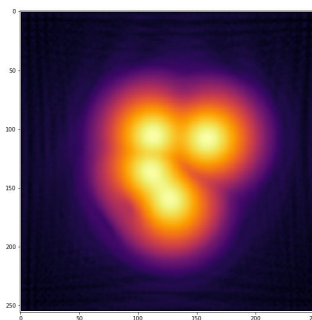


A simulation of how well DESI will measure the Ly-alpha P(k) (real data to follow soon)

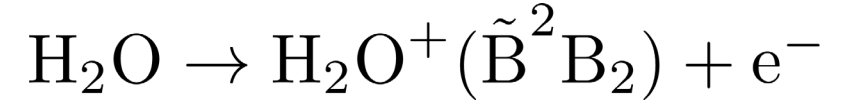
Nikhil Padmanabhan



Luna colliding fuzzy dark matter halos



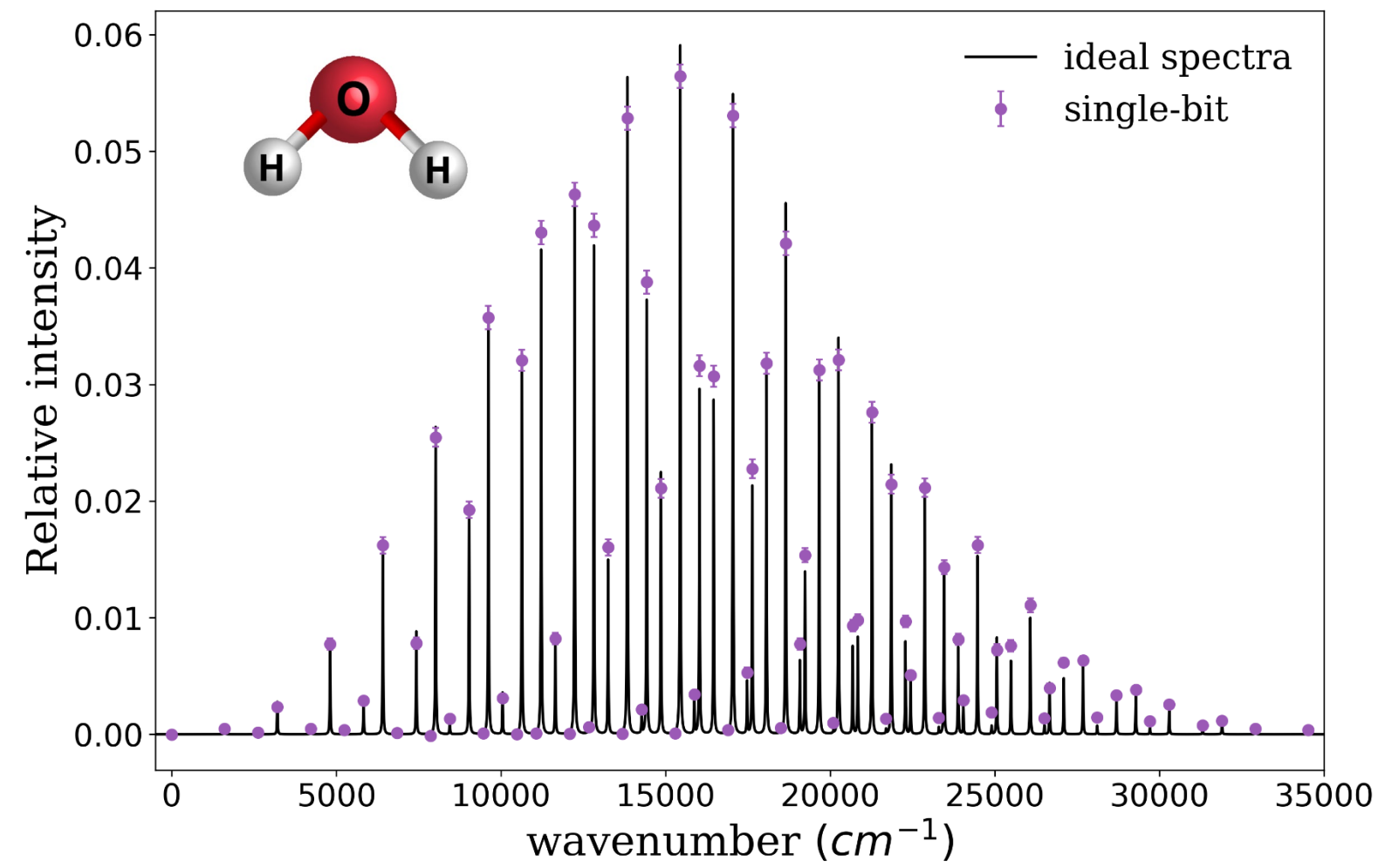
Experimentally simulated photoelectron processes using a quantum computer constructed in the Schoelkopf group



$|\psi_0\rangle = |0, 0\rangle$

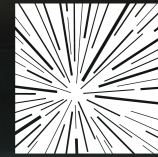
$$D = \frac{1}{2} \sum_{i,j} |p_{ij} - q_{ij}|$$

$$D_{\text{single-bit}} = 0.049$$



Wright Lab

Yale



Wright Laboratory

Exploring the Invisible Universe

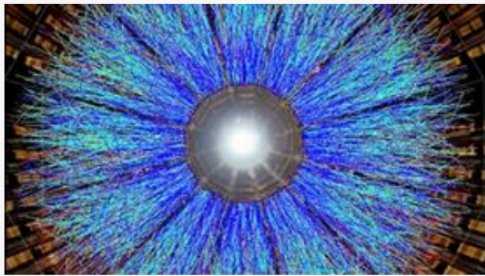
wlab.yale.edu

Research

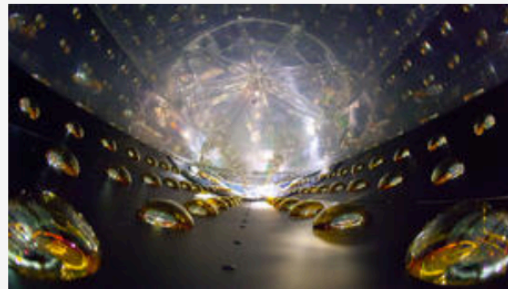


Explore a wide range of research areas in nuclear, particle and astrophysics, from the smallest particle to the evolution of the Universe.

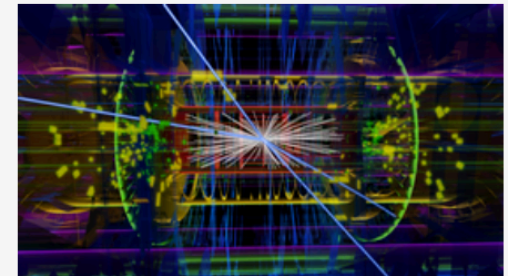
Research Areas



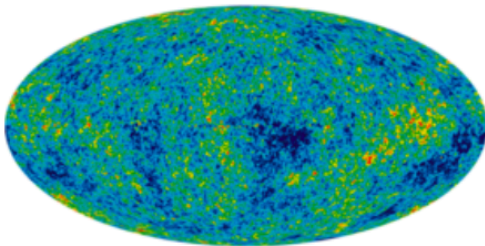
[Relativistic Heavy Ions](#)



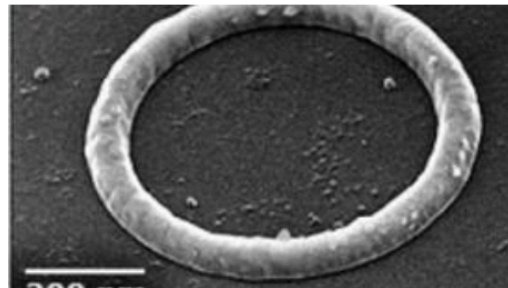
[Neutrinos & Fundamental Symmetries](#)



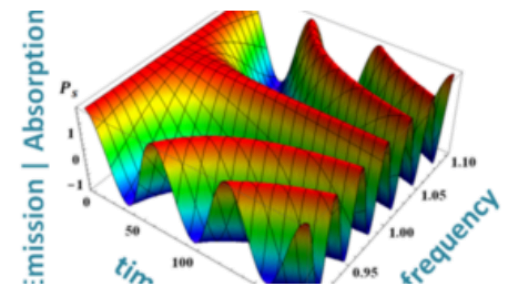
[Elementary Particles](#)



[Astrophysics & Cosmology](#)



[Quantum Physics & Devices](#)



[Beam Physics](#)

Facilities



Using resources at Wright Lab, develop and fabricate innovative research instrumentation for fundamental physics experiments around the world.

- **Wright Lab shops**

- Advanced Prototyping Center
- J.W. Gibbs Professional Shop
- Research Support Shop
- Teaching Shop



- **Other research facilities at Wright Lab**

- CAD and Remote Operations Room
- Clean Rooms
- Cryogenic Laboratories
- High-bays
- Low Background Facility
- Laser rooms and optical laboratories
- RF-Shielded Room

- **Wright Lab and YCRC Computing**



Teaching Shop



- Mills, lathes, welding, other tools
- Hours: 9am-3pm

(reduced hours to allow for cleaning; normal hours 8-4:30pm)

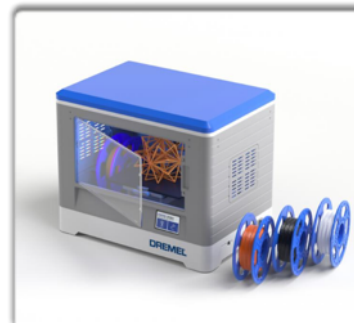
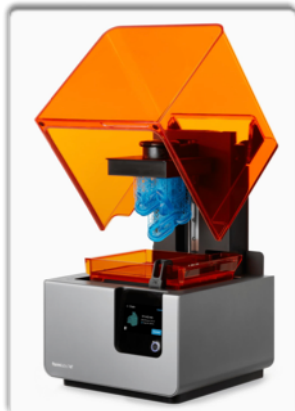
- Qualified users
 - General EHS shop training
 - PI authorization
 - CHEM 562L, PHYS 762 or equivalent
 - Checkout with supervisors
- Social distancing/Pandemic safety measures
 - Currently shop number limits
 - Please schedule in advance to avoid overcrowding
 - No after hours access to the shops
- More information: Dave Johnson (dave.w.johnson@yale.edu)



Advanced Prototyping Center (APC)



- CNC Abrasive Water Jet
- CNC Laser Cutter
- Three 3D printers
- Small electronics development bench
- Organize training and workshops
- Develop instrumentation and cool stuff for groups across campus
- More info: advancedprototyping@elilists.yale.edu



Events - Seminars



NPA: Brian Koopman, Mike Sas, Pranava Teja Surukuchi
admin: Paula Farnsworth

WIDG: Ako Jamil, Giacomo Scanavini, Tong Liu
admin: Lillian Vinston

YPPDO: Emma Castiglia, TBD
admin: Kimberly Tighe

DMDG: Reina Maruyama, Priyamvada Natarajan
admin: Paula Farnsworth

Instrumentation Lunch: Karsten Heeger, James Nikkel
admin: Paula Farnsworth

Contact: wlab-seminars@mailman.yale.edu

Calendar: <https://wlab.yale.edu/calendar>

Seminar descriptions: <https://wlab.yale.edu/seminars>



Events & Outreach



- **Collaboration meetings** and site visits
- **Conferences, symposia, workshops**
- Summer **undergraduate research symposium**
- **All-hands meetings** – weekly on **Mondays at 9:30 a.m.**
- Technical and computing **workshops**; EHS Orientations
- **Yale Day of Instrumentation**
- **Pitch your research** events (3MT competition, other)
- **Granville Academy**
- Outreach: **Tours** of WL, including Alumni Weekend, SPS
- Outreach: **Pathways to Science** at WL (Spring & Summer)
- Outreach: **Peabody Museum summer camp** "Hidden Worlds"
- **Artist-in-Residence** – Emily Coates
- **Visualize Science competition**
- **Community:** social activities & events

Get involved: victoria.misenti@yale.edu



Join our Community!

