

2018 NSF/DOE/AFOSR Quantum Science Summer School

Joe Checkelsky (MIT)
Natalia Drichko (JHU)
Liang Fu (MIT)
Kyle Shen (Cornell)
Jun Zhu (PSU)



U.S. DEPARTMENT OF
ENERGY

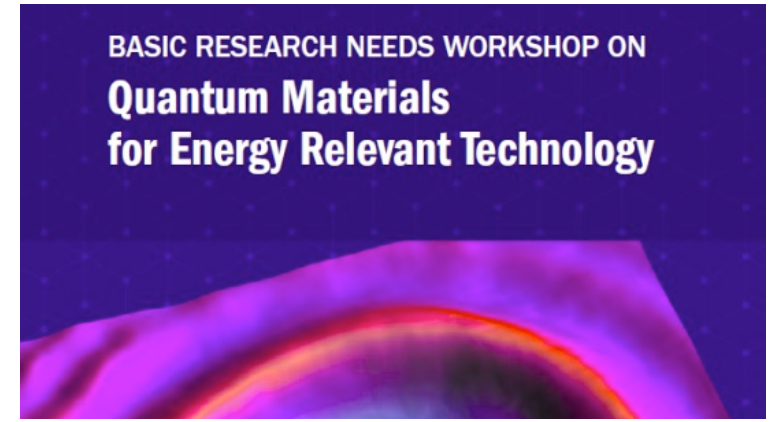
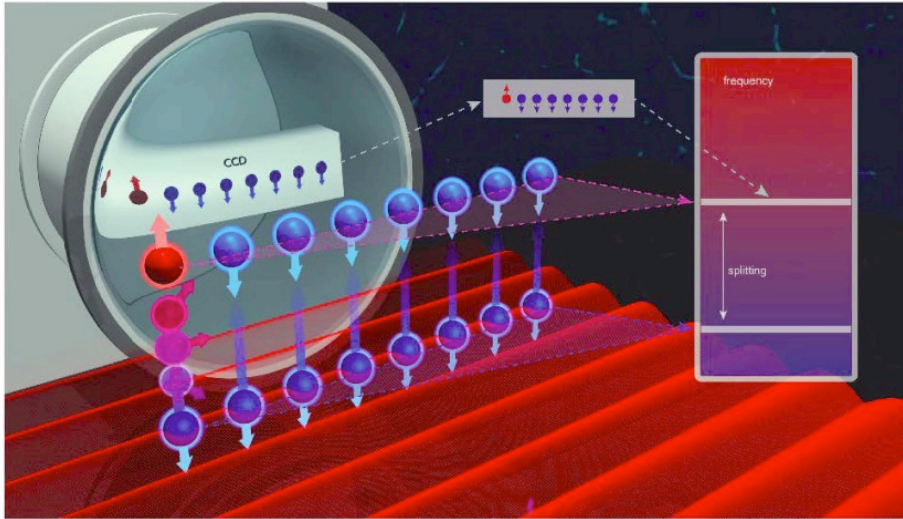
Office of
Science



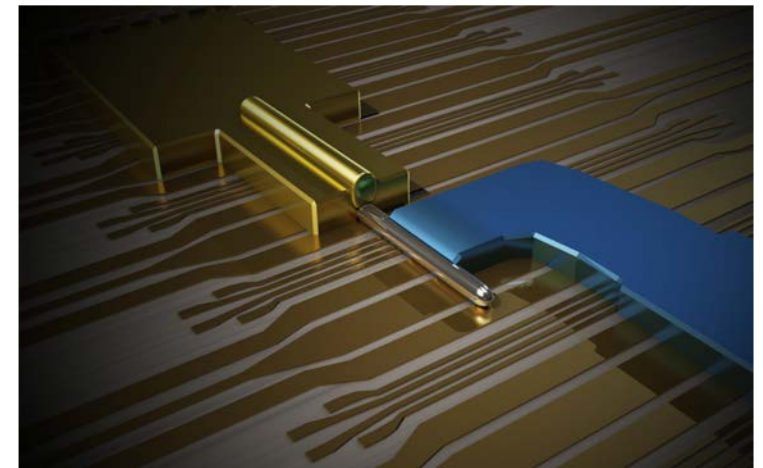
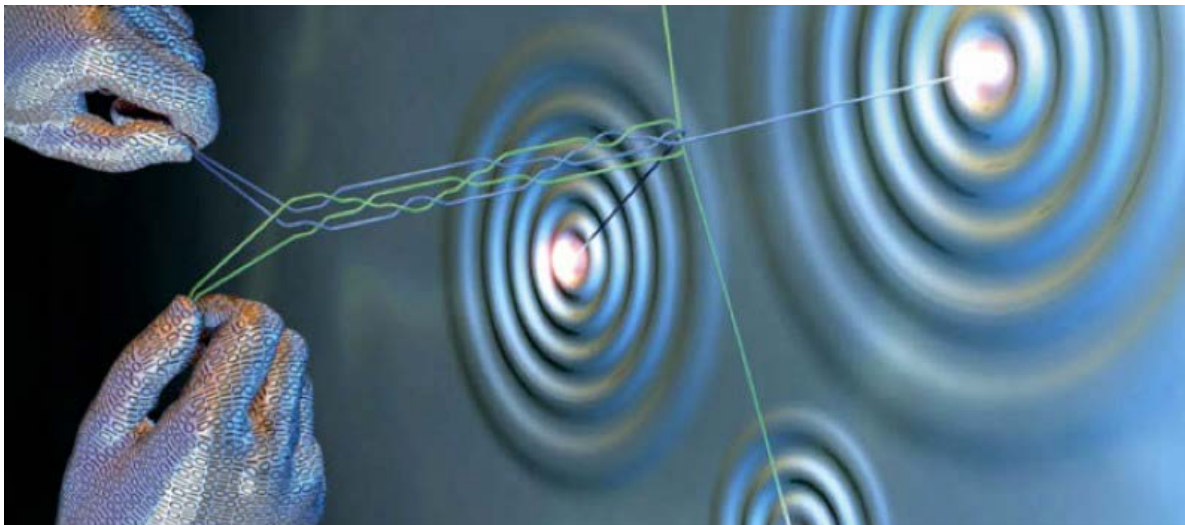
About QS³ : Quantum Computing, Quantum Materials, Quantum Devices



The Quantum Leap: Leading the Next Quantum Revolution

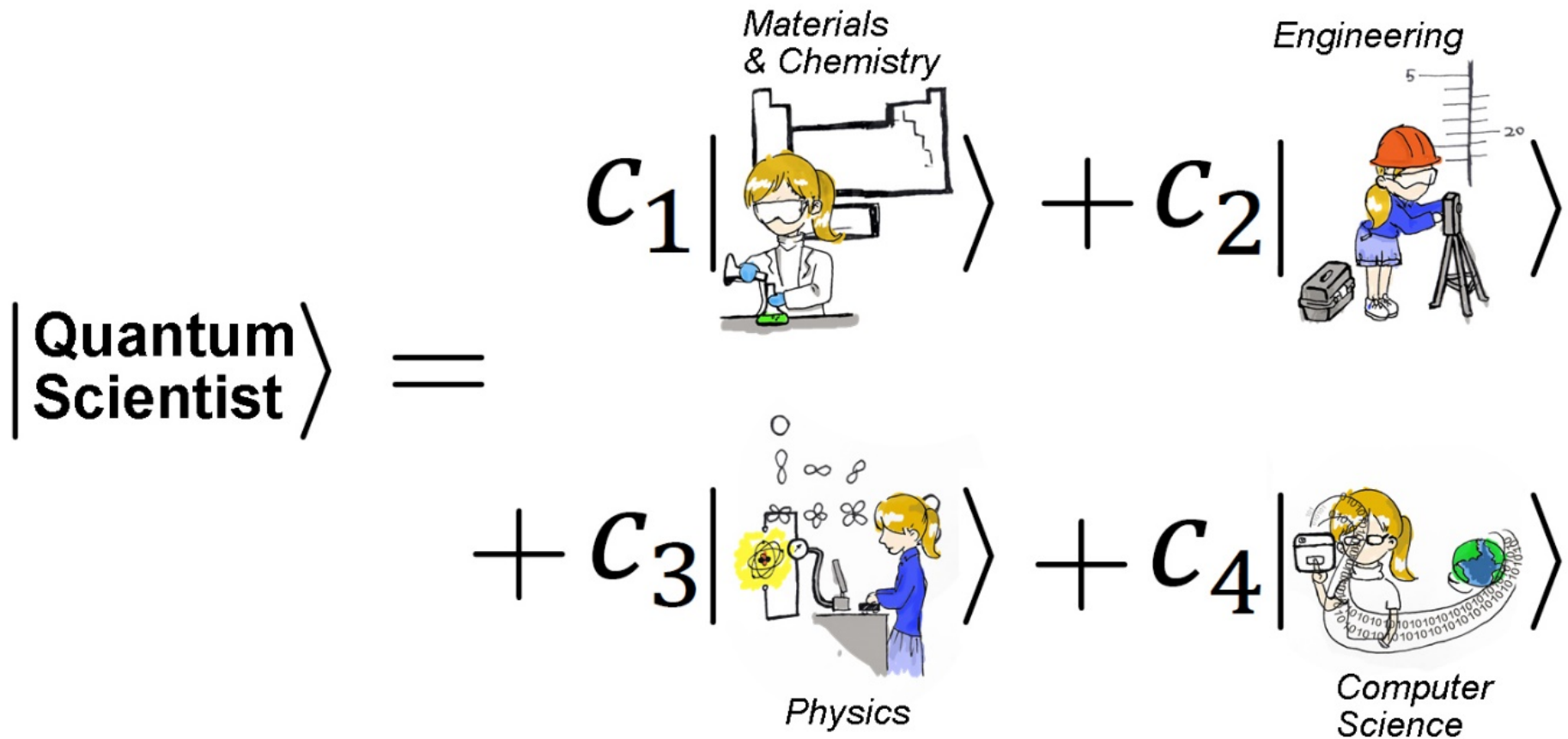


Quantum devices



Mourik et al, Science 336, 1003 (2012)

The QS³ is an annual summer school with the mission of training graduate students and postdocs in physics, chemistry, engineering, mathematics, materials science, computer science and related fields for the next "quantum revolution."

$$|\text{Quantum Scientist}\rangle = c_1 |\text{Materials \& Chemistry}\rangle + c_2 |\text{Engineering}\rangle + c_3 |\text{Physics}\rangle + c_4 |\text{Computer Science}\rangle$$


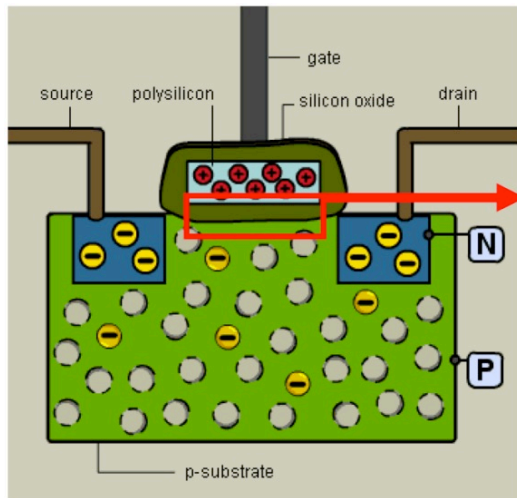
The diagram illustrates the concept of a quantum state superposition. On the left, the state $|\text{Quantum Scientist}\rangle$ is shown. This state is equal to a sum of four terms, each representing a different scientific field:

- $c_1 |\text{Materials \& Chemistry}\rangle$: A cartoon of a scientist in a lab coat working with a beaker and a graph.
- $c_2 |\text{Engineering}\rangle$: A cartoon of a scientist in a hard hat and safety glasses working with a tripod-mounted instrument and a scale.
- $c_3 |\text{Physics}\rangle$: A cartoon of a scientist working at a computer with a glowing atom symbol and mathematical symbols.
- $c_4 |\text{Computer Science}\rangle$: A cartoon of a scientist with a globe and binary code.

Theory, Experiment, Simulation, Algorithm, Application

Example of Quantum Leap: Computing

<http://www.nobelprize.org/educational/physics/transistor/>



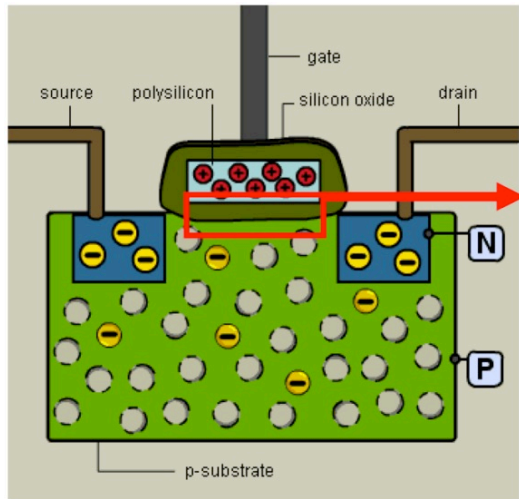
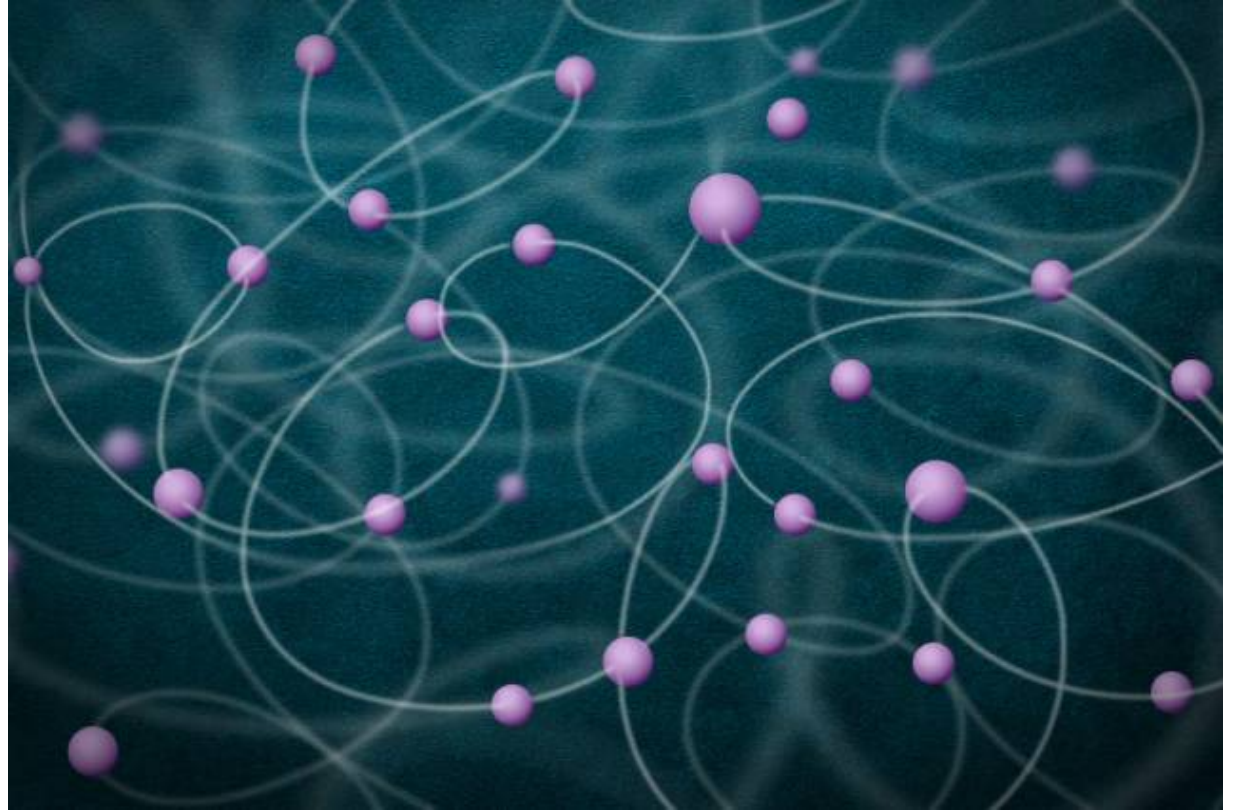
Modern Classical Computers:
Product of 20th Century Quantum Leap

Example of Quantum Leap: Computing

<http://www.nobelprize.org/education/physics/transistor/>



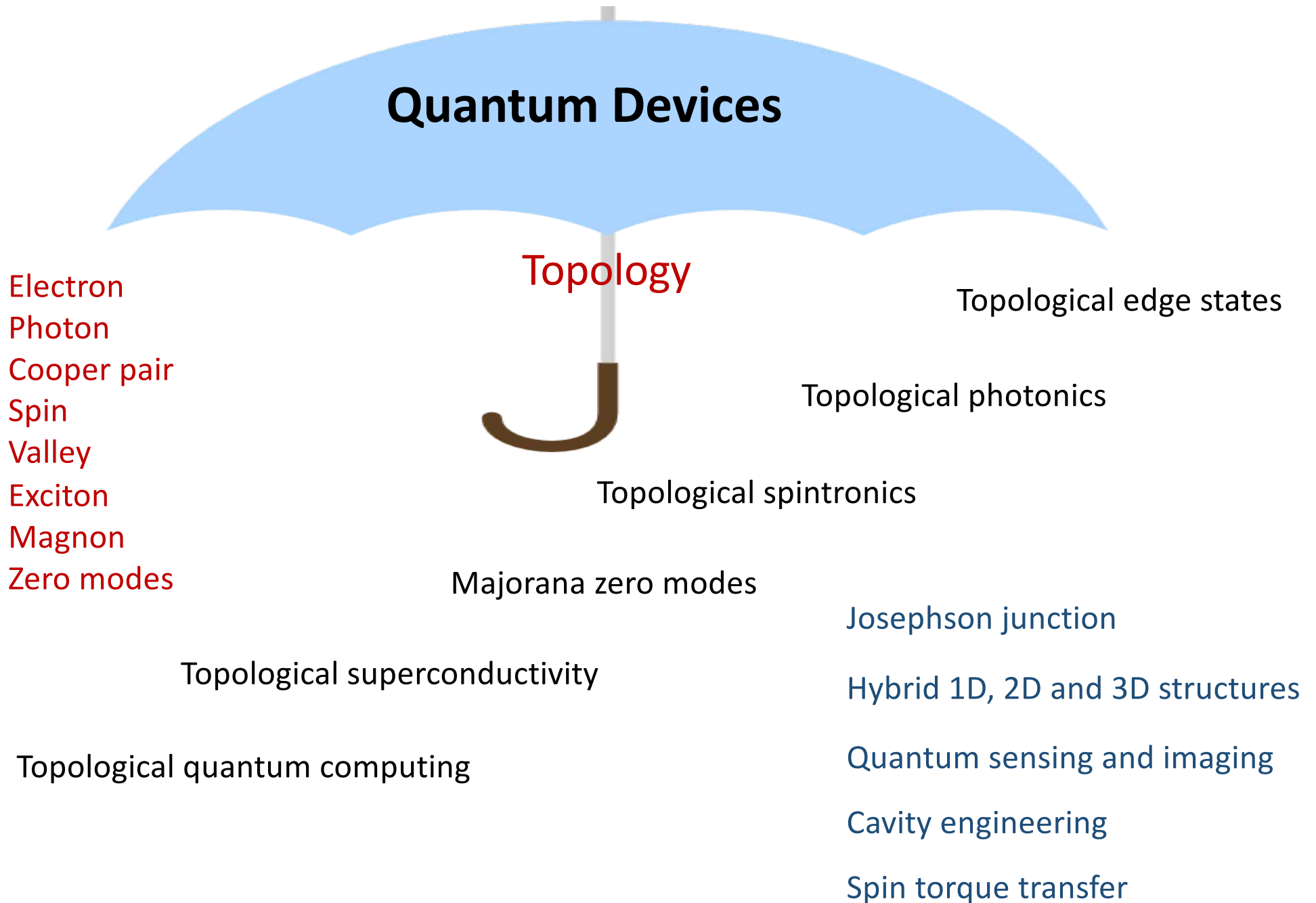
MIT news / Vuletic



Quantum Computation
Product of 21st Century Quantum Leap?

Modern Classical Computers:
Product of 20th Century Quantum Leap

Fundamentals and Applications of Quantum Devices



School Outline

QS3 2019 Penn State University, June 3-14 (2019)

	Monday 3	Tuesday 4	Wednesday 5	Thursday 6	Friday 7
8:40 AM	Opening				
9:00 AM	Van Harlingen 1	Van Harlingen 2	Rechtsman 2	Nowack 2	Hu 2
9:30 AM					
10:00 AM	Coffee Break				
10:30 AM	Coffee Break				
11:00 AM	Frolov 1	Frolov 2	Nowack 1	Hu 2	Samarth 2
11:30 AM					
12:00 PM	Lunch				
12:30 PM	Lunch				
1:00 PM	Lunch				
1:30 PM	Lunch				
2:00 PM	Crystal Modeling	Rechtsman 1	Samarth 1	Active Learning	Facility Tours
2:30 PM					
3:00 PM	Poster Talks	Open Lab Visits	Open Lab Visits		
3:30 PM					
4:00 PM	Introductions		Open Lab Visits		
4:30 PM					
Evening	Posters (5:00pm-6:30pm)				School BBQ (5:30pm-8:00pm)

	Monday 10	Tuesday 11	Wednesday 12	Thursday 13	Friday 14
9:00 AM	Sau 1	Sau 2	Crooker 1	Crooker 2	Jayich 2
9:30 AM					
10:00 AM	Coffee Break				
10:30 AM	Coffee Break				
11:00 AM	Hone 1	Hone 2	Vitale	Jayich 1	Zhu
11:30 AM					
12:00 PM	Lunch				
12:30 PM	Lunch				
1:00 PM	Lunch				
1:30 PM	Lunch				
2:00 PM	Facility Tours	Wang	Sun	Active Learning	
2:30 PM		Poster Talks	Industry Panel		
3:00 PM				Posters (4:30pm-6:00pm)	
3:30 PM					
4:00 PM					
4:30 PM					
Evening					

- 23 lectures (Willard 262)
- 1 virtual reality experience (crystal modeling)
- 2 poster sessions (with hors d'oeuvres)
- 2 visits to faculty labs (see participating list on website)
- 5 facility tour/hands-on activities (2D crystal growth consortium, material characterization facility, nanofabrication)
- 2 active learning sessions
- 1 panel discussion (**From Quantum Science to Quantum Technology**)
- 1 picnic in Sunset park

http://qs3.mit.edu/images/pdf/QS3_2019_Summary_Schedule_v04.pdf

Millennium Science Complex

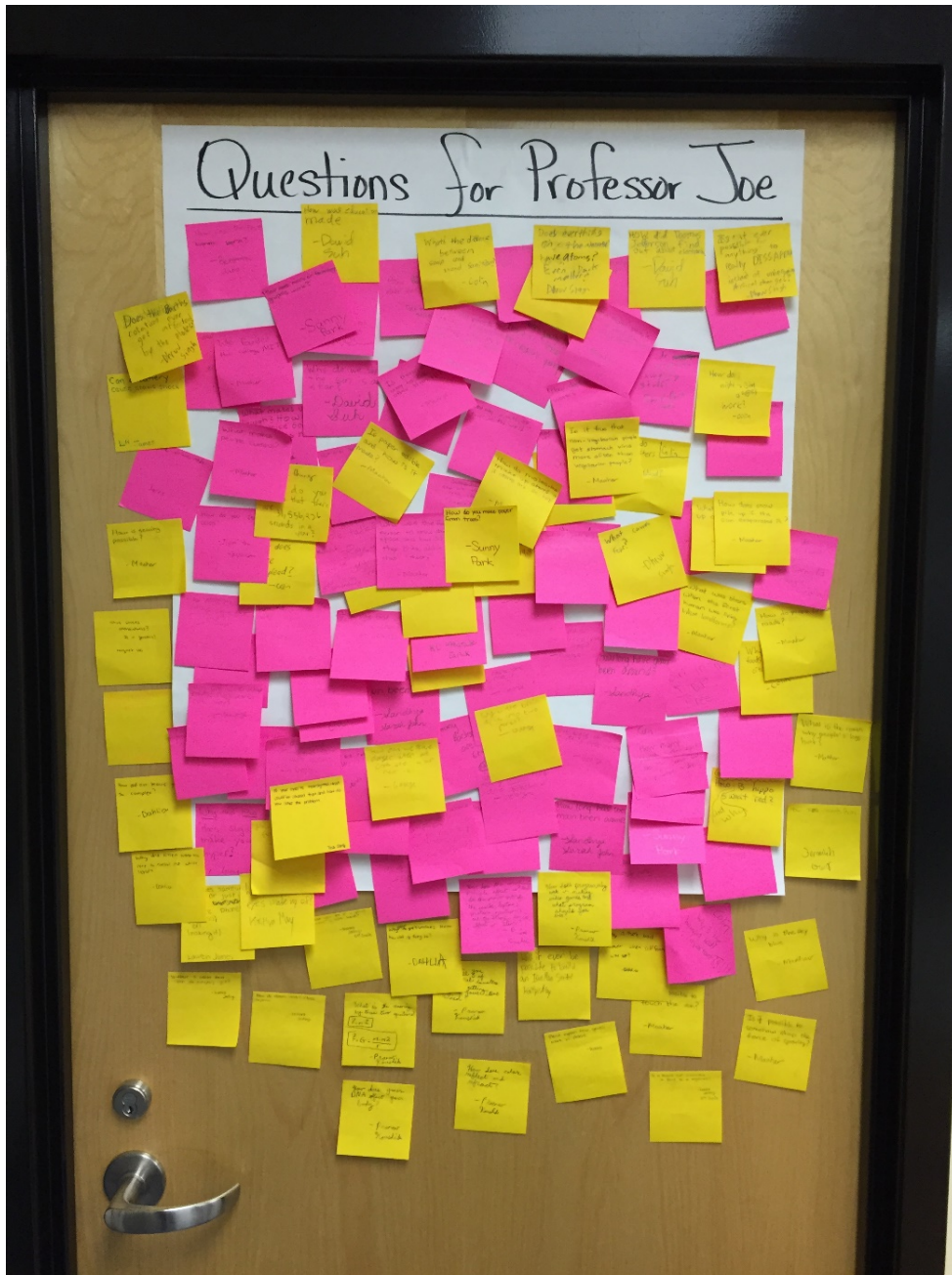


Materials Research Institute

Huck Institute of Life Science

- Hands-on activities (June 7 and 10, see schedule, grouping and meeting place on website)
- Poster sessions (June 4 and 11, MSC commons, 3rd floor)
- Group photo (June 6, MSC garden, with your QS³ T-shirts)

Questions, Exchanges and Feedback

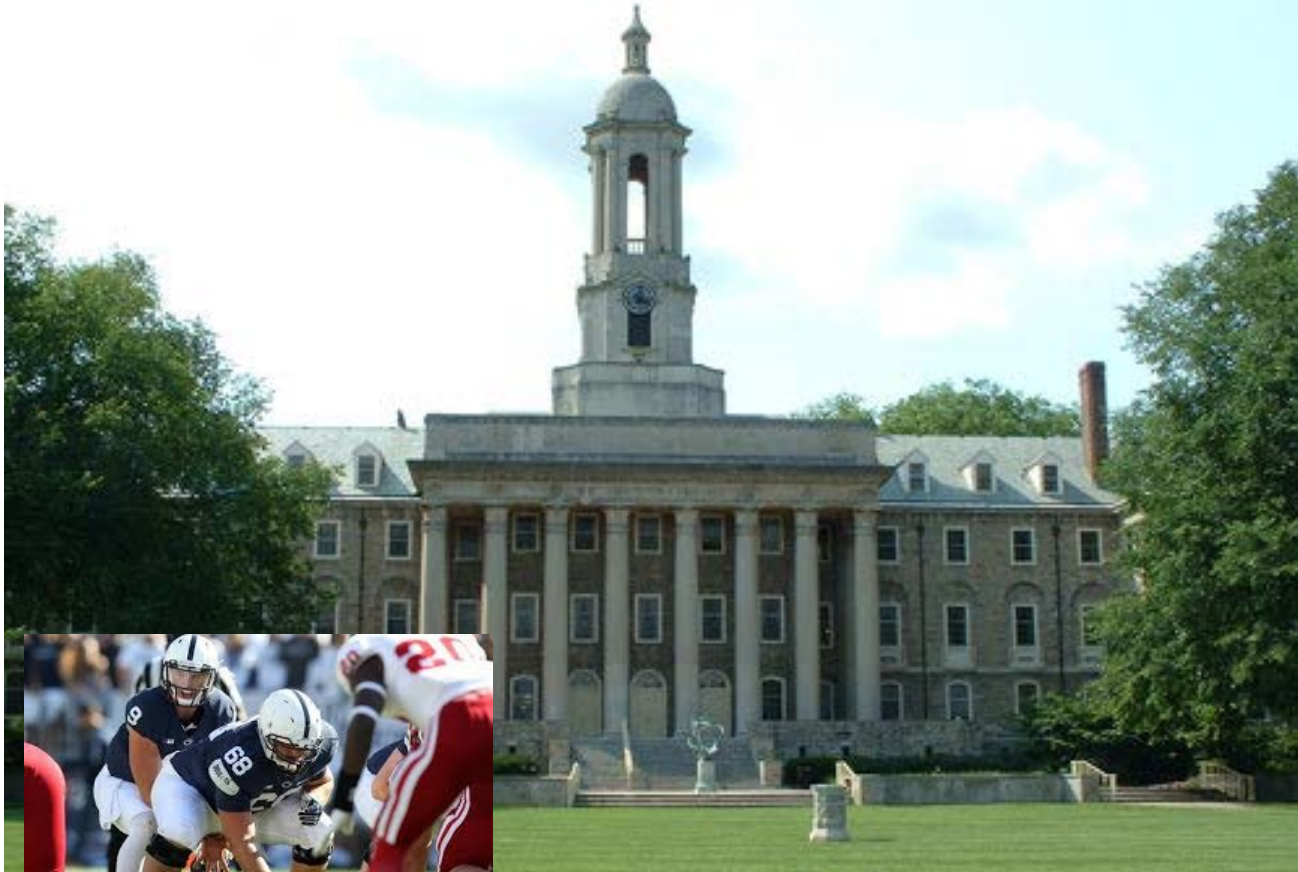


Ask questions throughout lectures and the entire school

- Active Learning Sessions (Thursday afternoons)
 - Informal discussions
 - Recap lecture points
 - Go deeper in your thinking
 - Stimulate connections between subjects
- Panel discussions on Wednesday June 12
 - Submit questions to our (mostly) industry panelists before Tuesday night.
- Feedback and input for the future
 - Fill out the questionnaire

Location

Penn State University, State College, PA



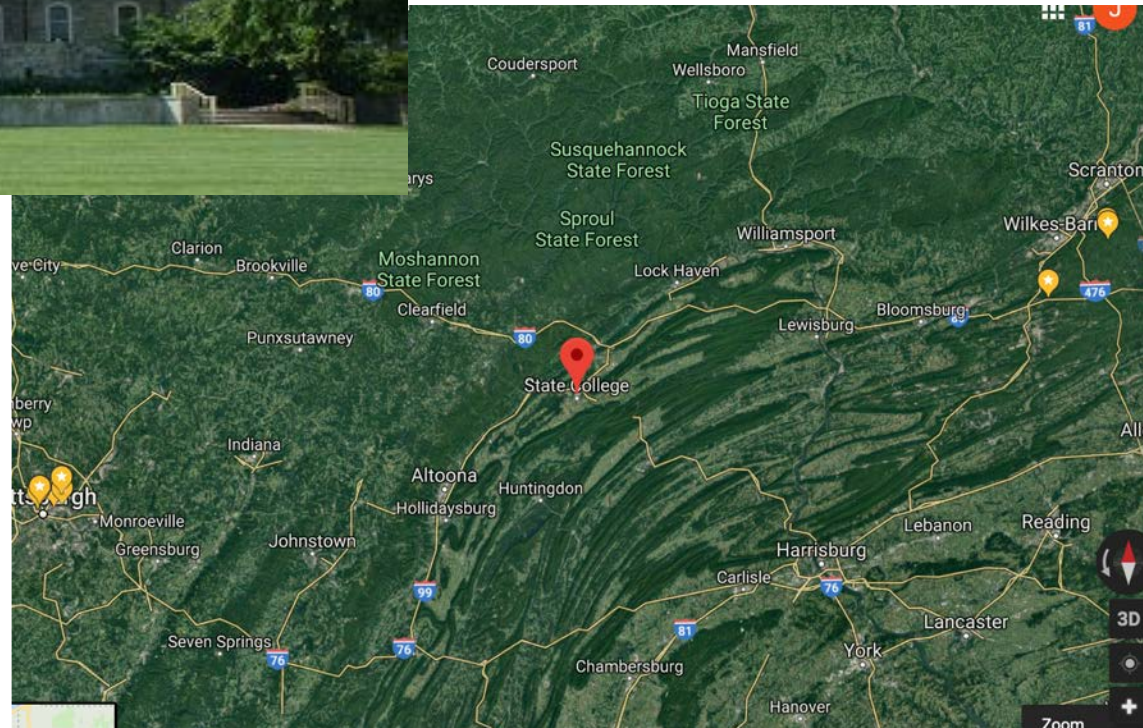
PennState

- Established 1855
- Land-grant state flagship
- 24 campuses
- 99,000 students total



Advancing materials. Improving the quality of life.

Founded at Penn State in 1973

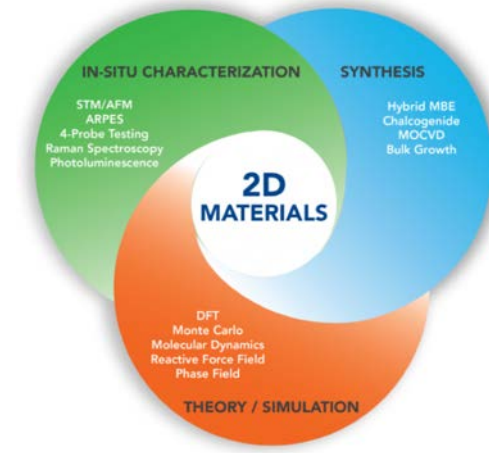


MATERIALS RESEARCH INSTITUTE

Research Centers and Facilities



2D Crystal Consortium
NSF Materials Innovation Platform



ATOMIC
Center for Atomically Thin
Multifunctional Coatings



Materials Characterization Lab
Nanofabrication Lab
Materials Computation Center

Center for Nanoscale Science

MRSEC



Materials Research Science
& Engineering Centers

Quantum Devices at Penn State Physics

PHYSICS
Eberly College of Science

Nitin Samarth



Topological insulator
Spintronics

Mikael Rechtsman



Topological photonics

Jun Zhu



Quantum valley Hall effect
Topological valleytronics

Ying Liu



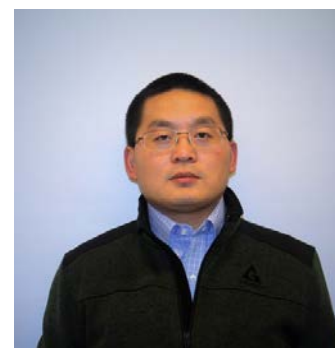
Superconductivity

Qi Li



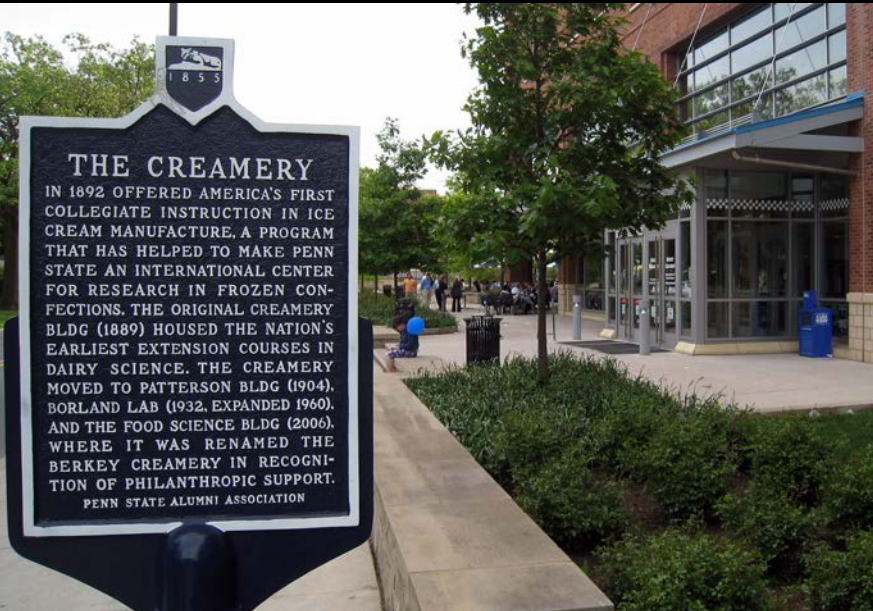
Multiferroics
Tunnel junctions

Cui-Zu Chang

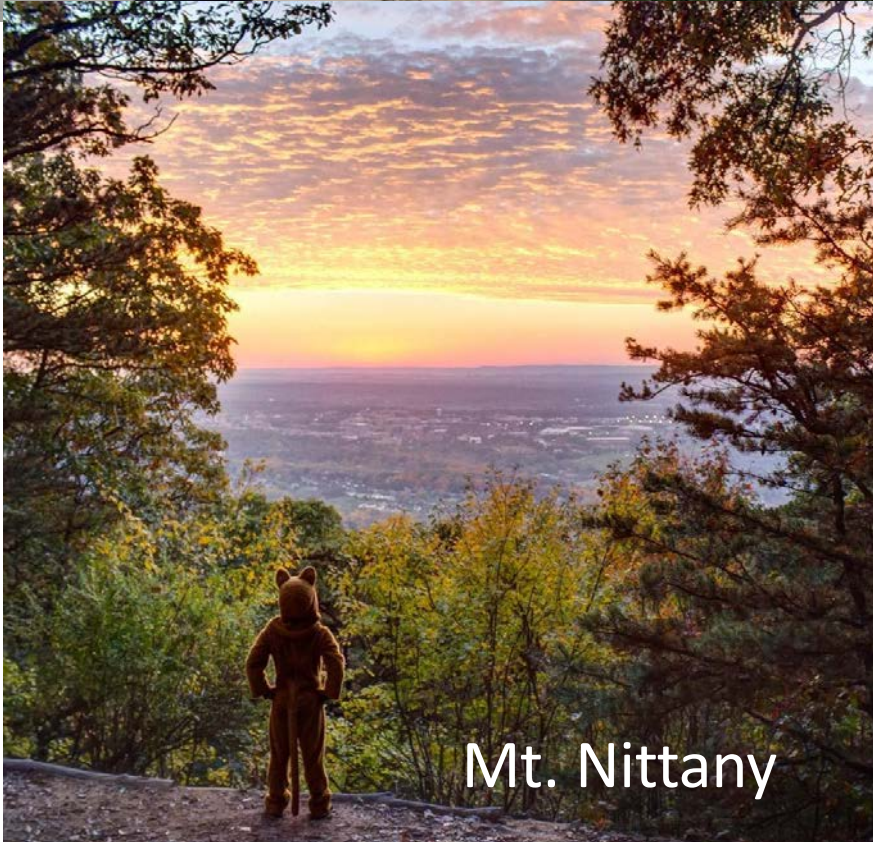


Quantum anomalous Hall effect

Where to go over the weekend



The Arboretum at Penn State



Bald Eagle State Park





Ania Bleszynski Jayich



Scott Crooker



Sergey Frolov



James Hone



Evelyn Hu



Katja Nowack



Mikael Rechtsman



Nitin Samarth



Jay Sau



Jonathan Sun
(IBM)



Dale Van Harlingen



Steven A. Vitale
(Lincoln Lab)



Zhengnan Wang
(Microsoft)



Joseph Broz
(SRI)



Susan Trolrier-McKinstry

Questions?

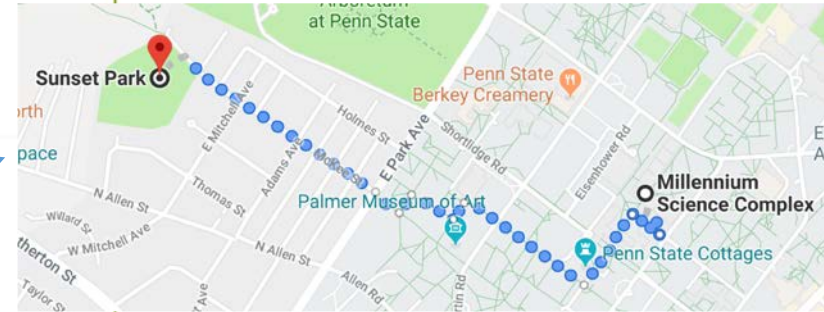
qs3.mit.edu

Organizers

- Joe Checkelsky (MIT)
- Natalia Drichko (JHU)
- Liang Fu (MIT)
- Kyle Shen (Cornell)
- Jun Zhu (PSU)

QS3 SCHOOL 2019

- On-Site Information
- Detailed Schedule
- Summary Schedule
- 2019 Posters
- Lecture Materials



2019 Lecture Materials

Open Lab Visit Information

Lab Descriptions

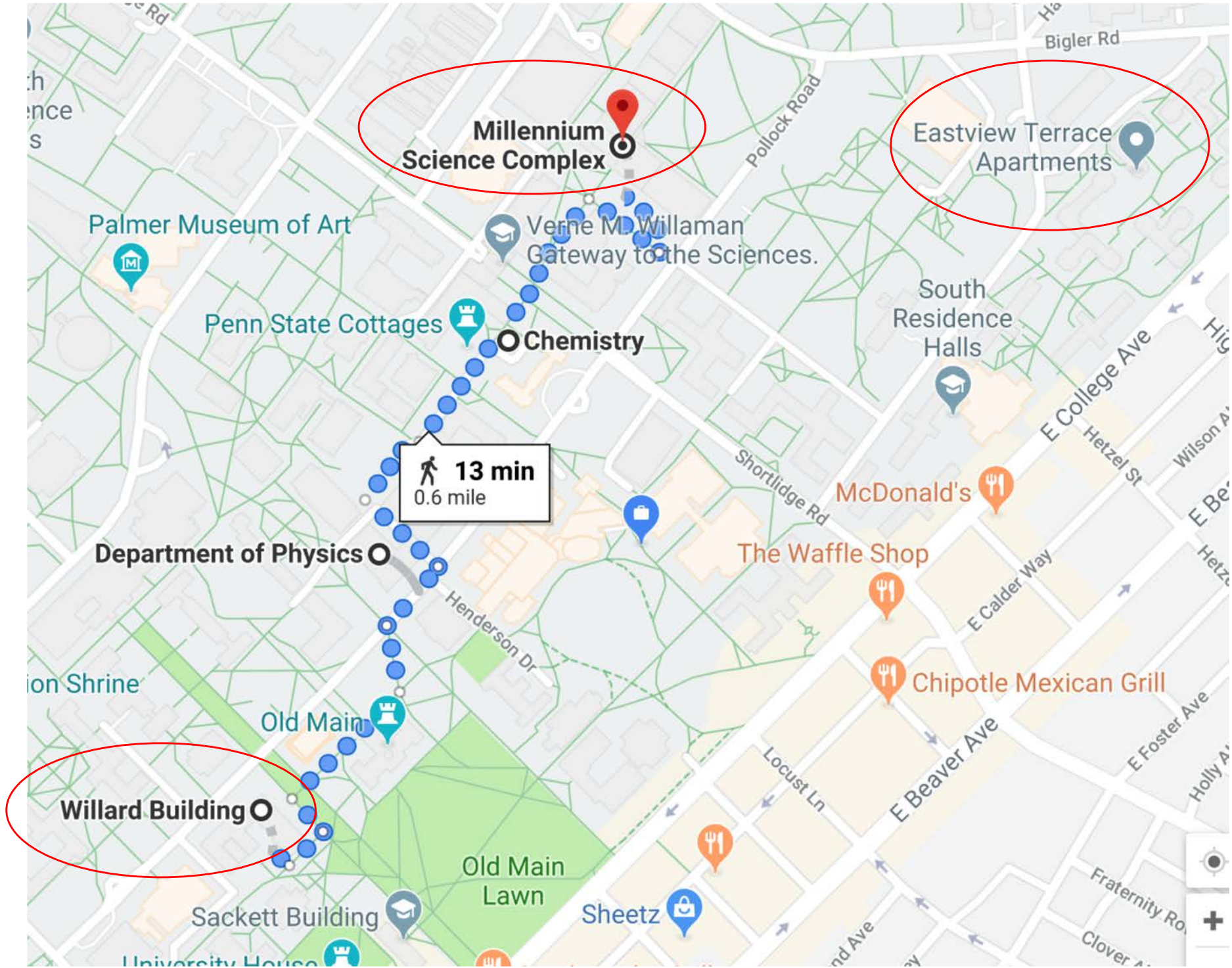
Hands-on Schedule

Questions to qs3@mit.edu

Questions about Reimbursements:

Donna Lucus

dzm4@psu.edu



Millennium Science Complex

Eastview Terrace Apartments

13 min
0.6 mile

Willard Building

Department of Physics

Chemistry

Verne M. Willaman Gateway to the Sciences.

Palmer Museum of Art

Penn State Cottages

South Residence Halls

McDonald's

The Waffle Shop

Chipotle Mexican Grill

Old Main

Old Main Lawn

Sackett Building

Sheetz

Bigler Rd

Pollock Road

Shortlidge Rd

Henderson Dr

Locust Ln

E Beaver Ave

E Calder Way

E College Ave

Hetzel St

E Foster Ave

Fraternity Ro

Clover Av



Software to Install

VESTA : jp-minerals.org/vesta/en/download.html

During coffee break, make sure you can connect to “attwifi”

→ Need this from 2pm for crystal modeling

→ If there are any issues, ask organizer during coffee or lunch

If you need a computer and haven't contacted us, let us know during coffee



Ania Bleszynski Jayich



Scott Crooker



Sergey Frolov



James Hone



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