
Virtual Graduate Open House
March 13-14, 2020

Agenda

Friday March 13

4:00-5:30pm Faculty Overview/Question & Answer Session

Saturday March 14

8:30-11:30am Virtual Lab and Office Visits with Individual Groups

(separate list of meeting IDs will be sent via email)

12:00-1:15pm Grad Student Panel Discussion

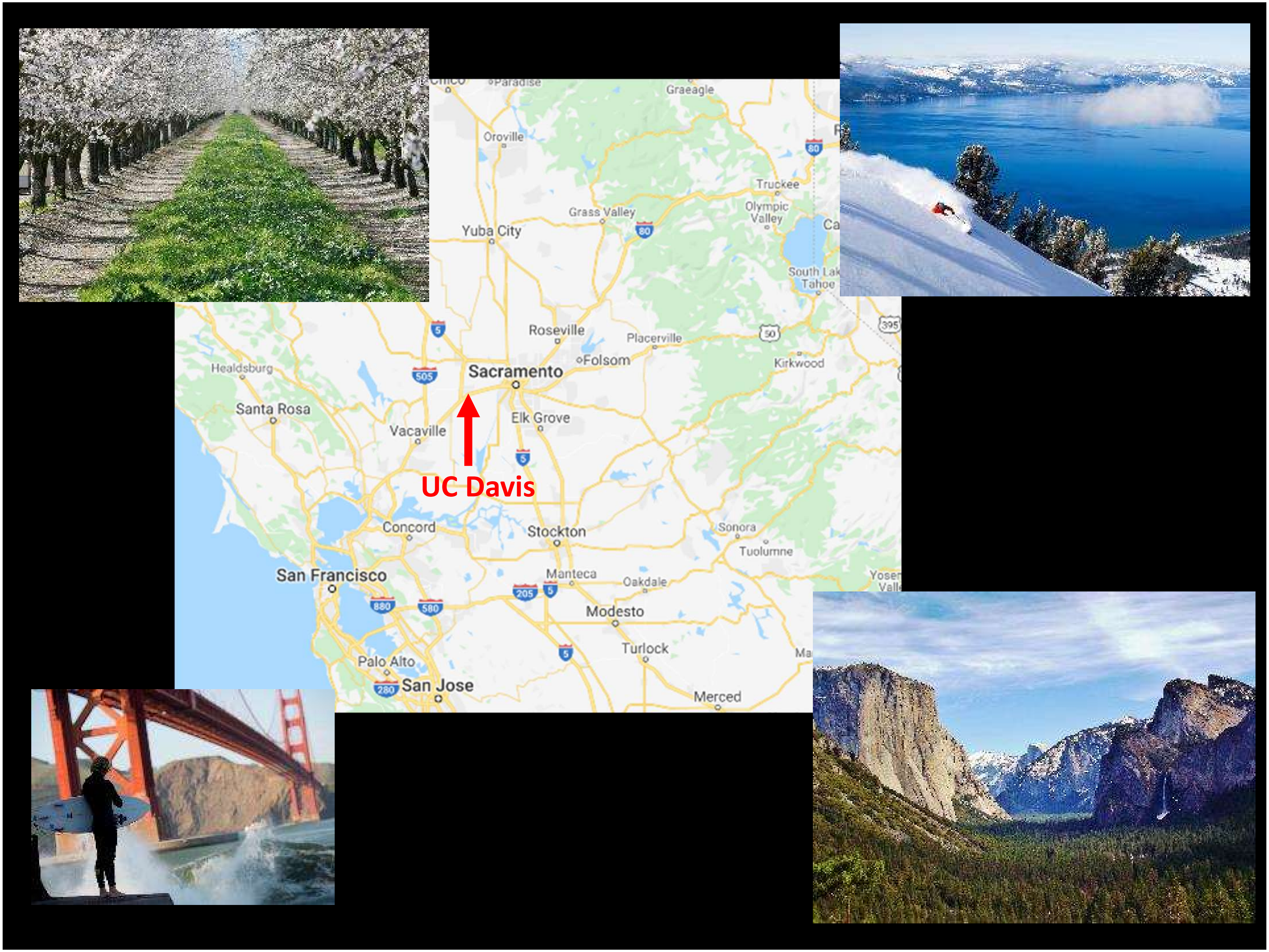
(same meeting ID as this one)

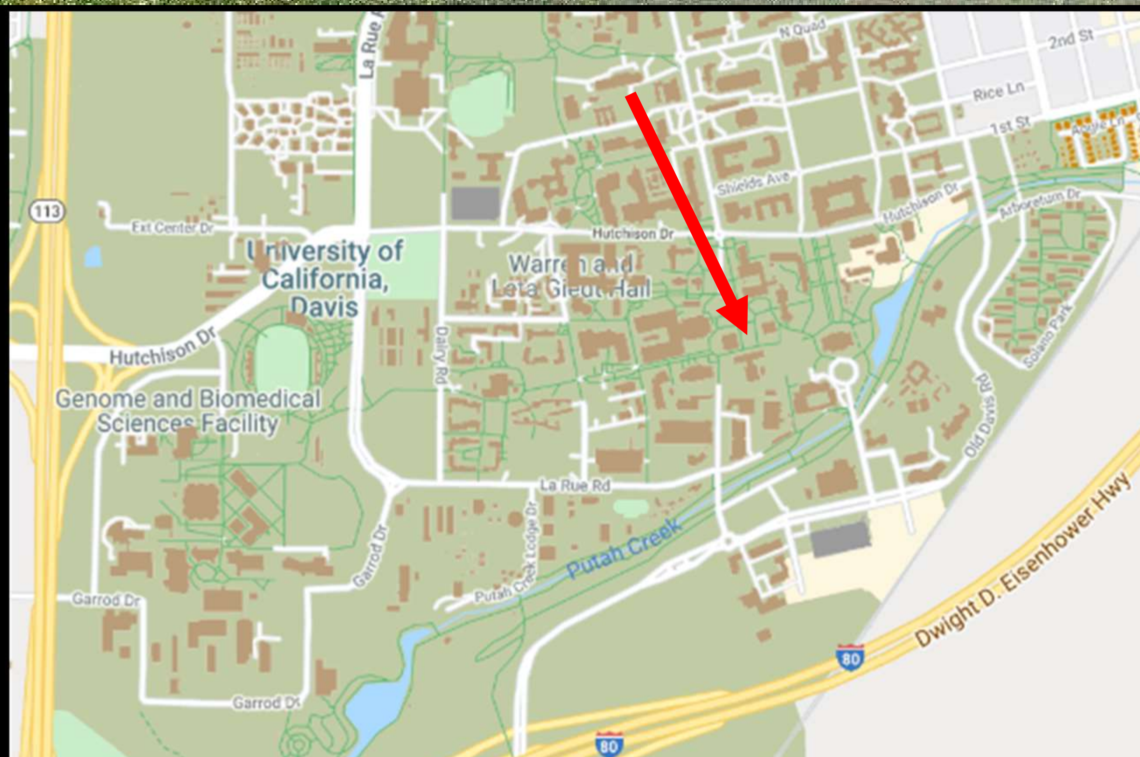
1:15-1:30pm Grad OPS

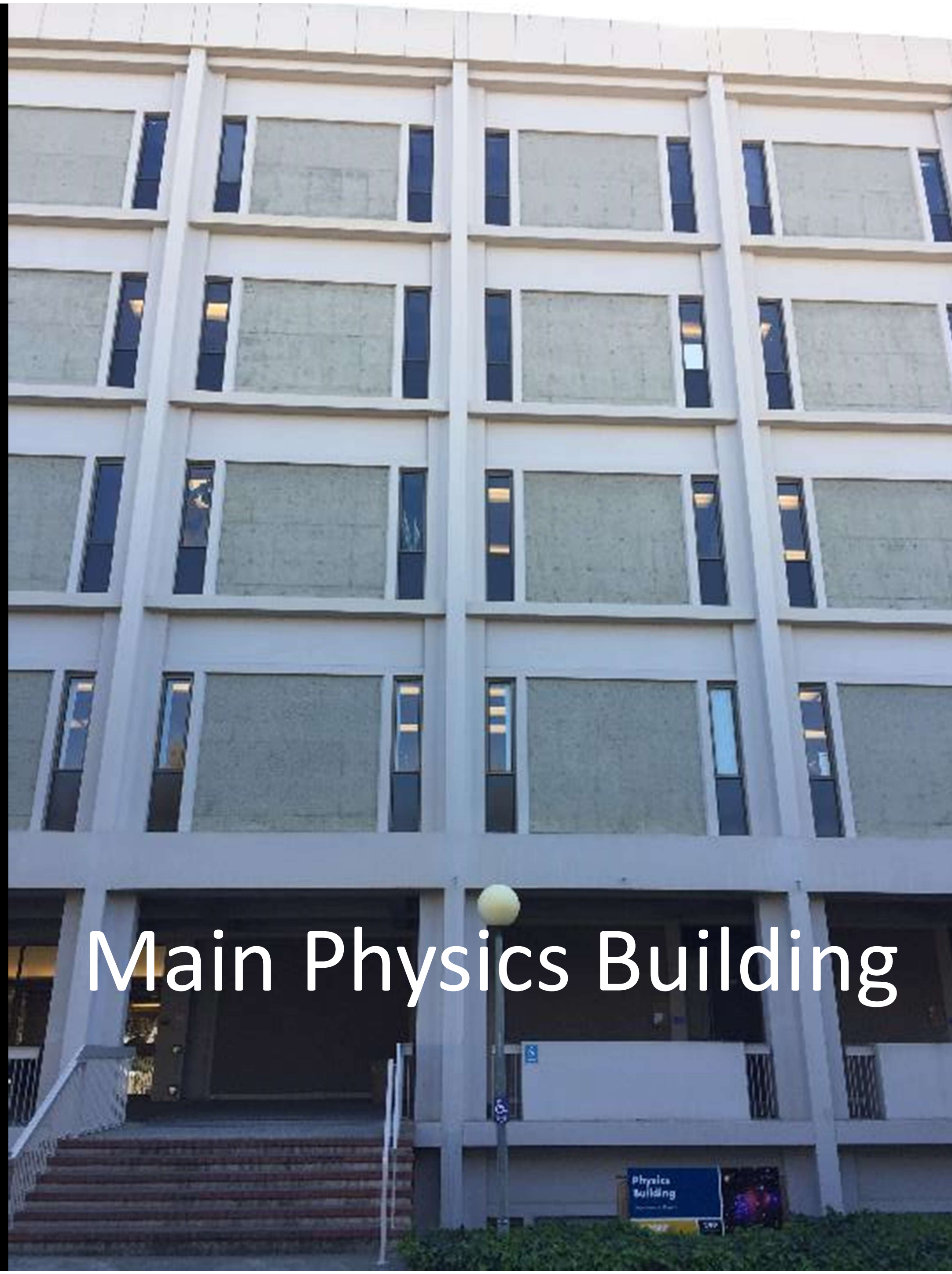
(same meeting ID as this one)

1:30-2:30pm Faculty Panel Discussion

(same meeting ID as this one)


Paradise
Graeagle
Oroville
Truckee
Olympic Valley
Grass Valley
Yuba City
Roseville
Placerville
Folsom
Kirkwood
Healdsburg
Sacramento
Santa Rosa
Elk Grove
Vacaville
UC Davis
Concord
Stockton
Sonora
Tuolumne
San Francisco
Manteca
Oakdale
Modesto
Turlock
Palo Alto
San Jose
Merced


University of California, Davis
Warren and Leta Giedt Hall
Genome and Biomedical Sciences Facility
Hutchison Dr
La Rue Rd
Putah Creek
Dwight D. Eisenhower Hwy
Garrod Dr
Dairy Rd
Old Davis Rd
Arboretum Dr
Shields Ave
Rice Ln
1st St
2nd St
N Quad
Ext Center Dr
Solano Park
113
80



Cosmology

Theory

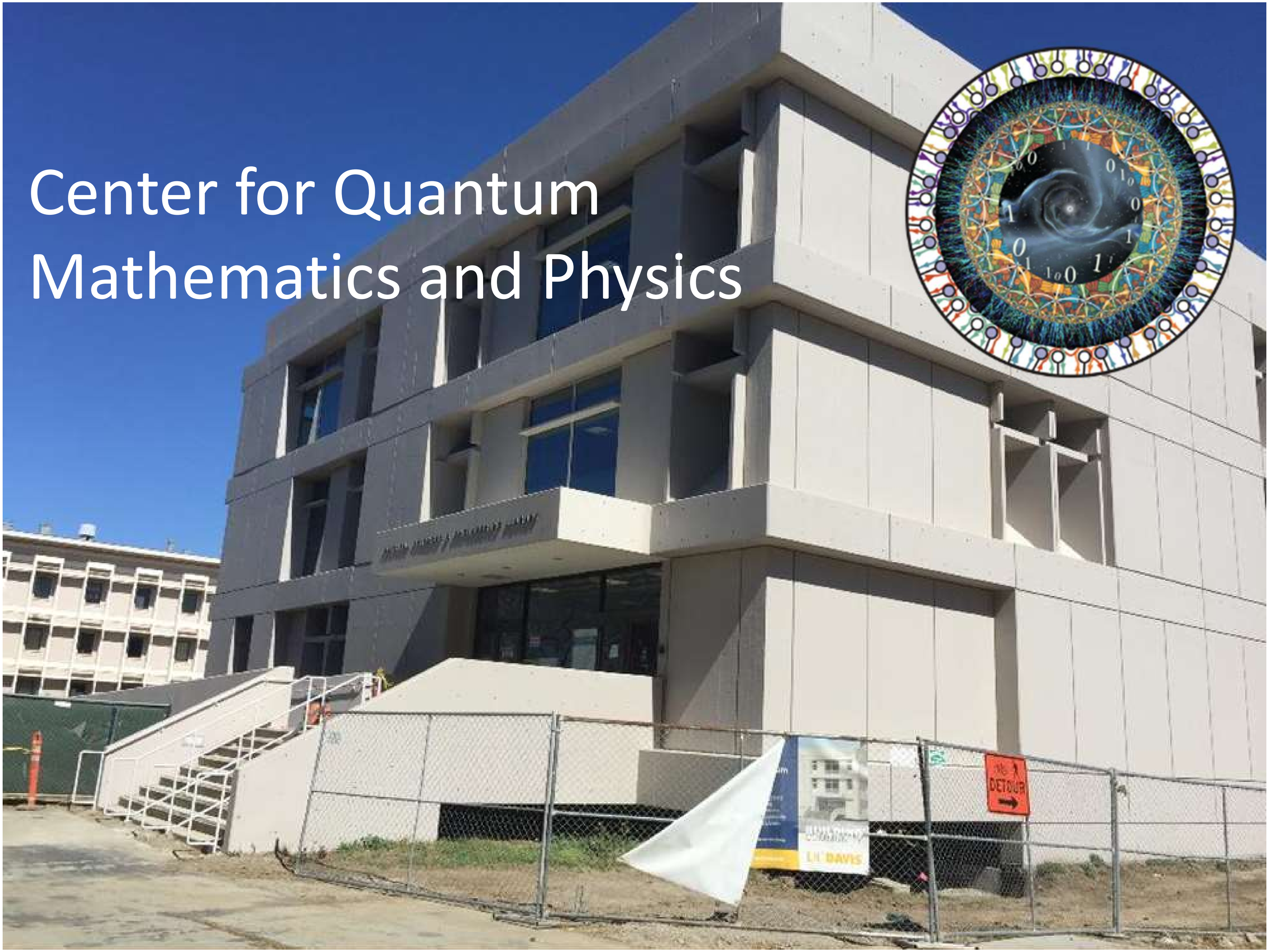
High Energy Expt

Condensed Matter Expt

Administration, Classrooms, Complexity

CME and HE Laboratories

Center for Quantum Mathematics and Physics



Roessler Hall – Lectures, Teaching Laboratories


JOHN A. JUNGERMAN HALL
Crocker Nuclear
Laboratory

Friday evening agenda

- Chair's Welcome — Zieve
- Grad Program Overview — *Singh*

5 short talks on research opportunities:

- Condensed Matter — *Taufour*
- Cosmology — *Valenti*
- Complexity Science — *Singh*
- High Energy — *Pantic*
- High Energy/Cosmology Theory — *Luty*

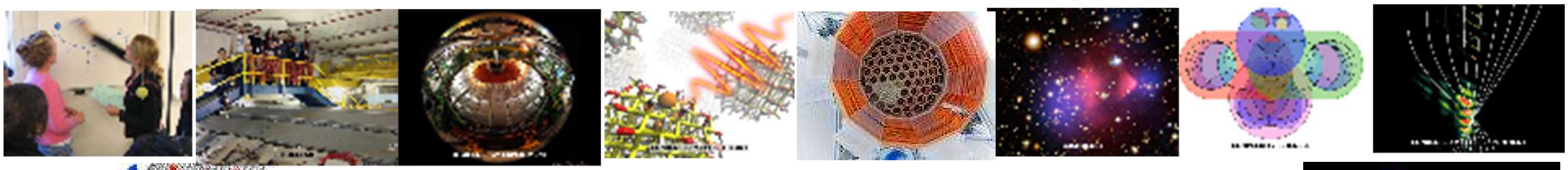
Helium Recycling Center –
One of several labs recently renovated ($8.5M, 5000 square feet)

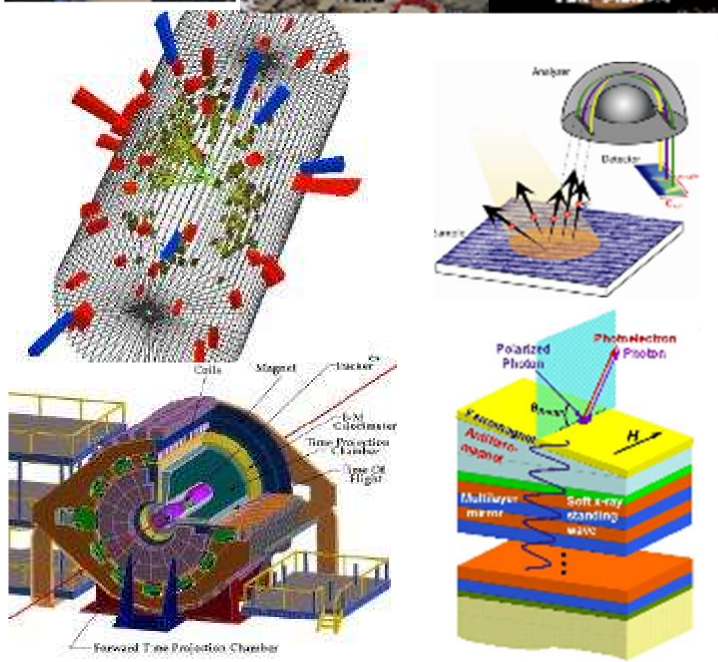
Synthesis Laboratories on Second Floor

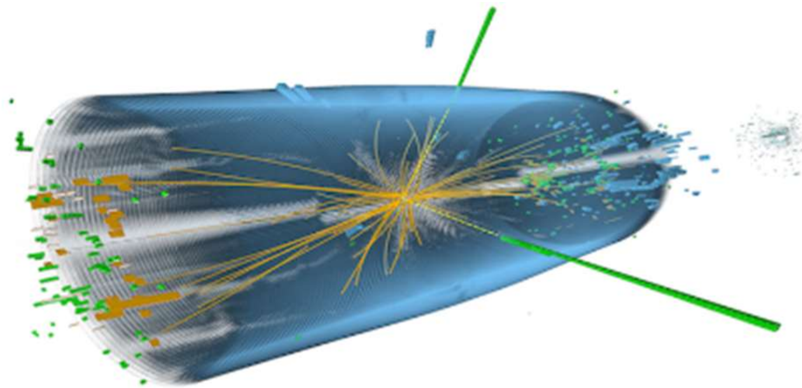
ARPES and Ultrafast Laboratories in Basement

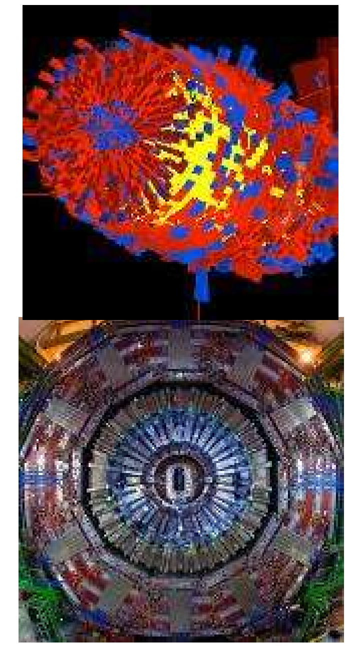

STM Laboratories in Basement

Graduate Program in Physics at UC Davis

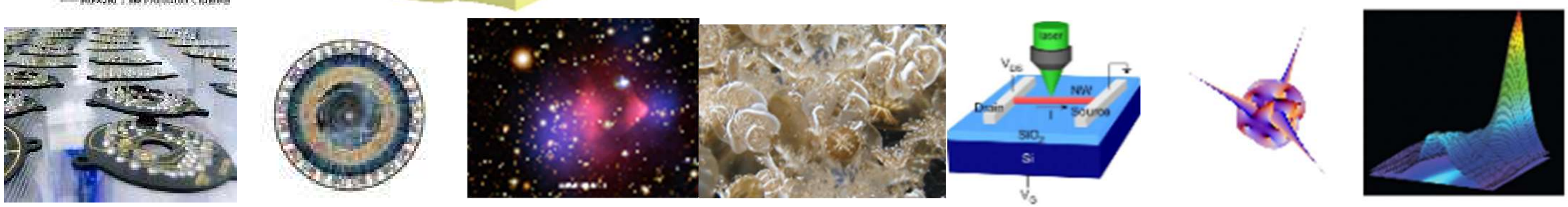




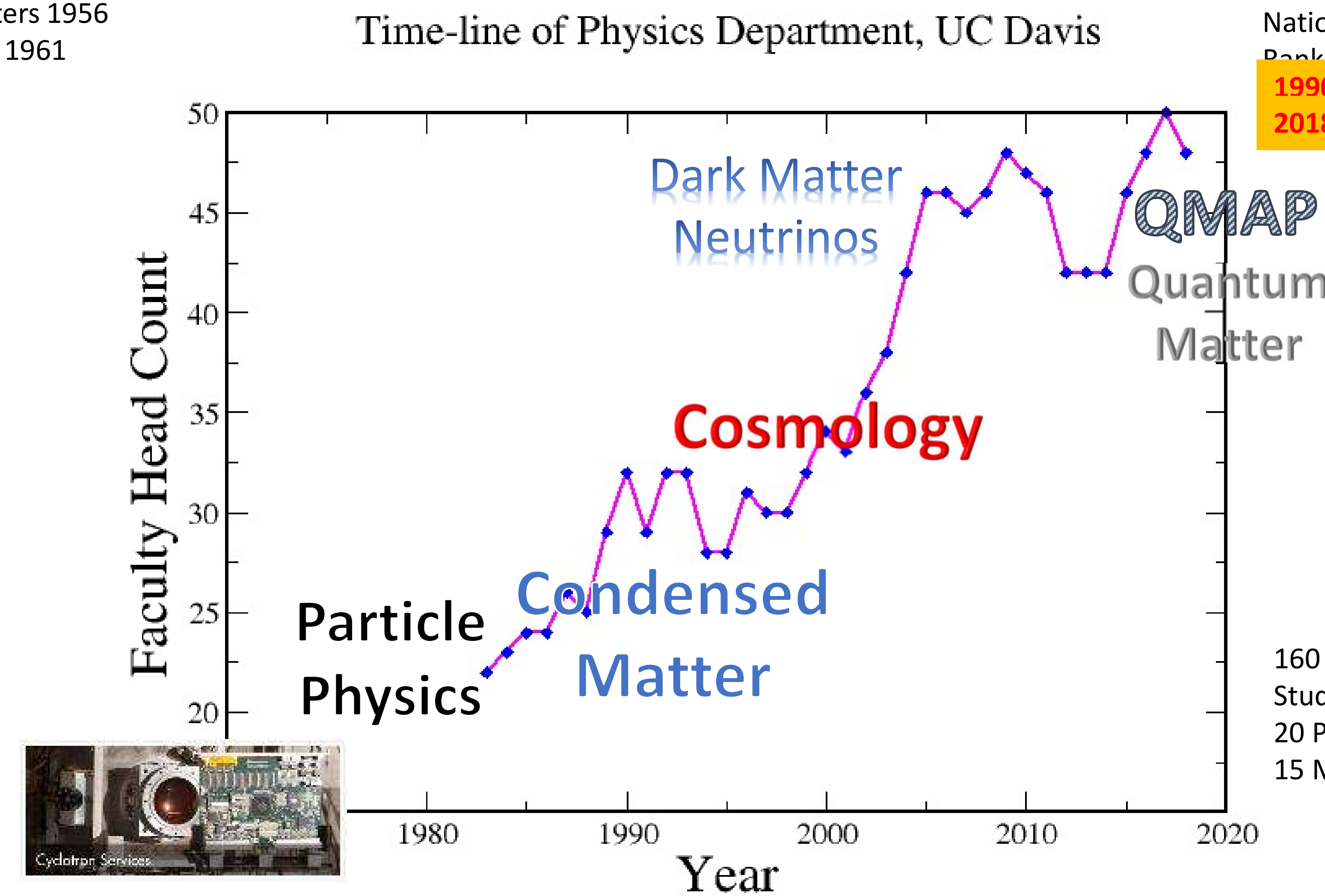




Physics Research at UC Davis



Masters 1956
PhD 1961



National Ranking:
1990 66
2018 29

160 Grad Students
20 Ph.D./Year
15 Masters/Year

Recently Hired Faculty












IUPAP Young Scientist Prize in Particle Physics
Fellow International Society on Gen. Rel. and Gravitation
Chancellor’s Fellow

Sloan Fellowship
NSF Career Award
DOE Career Award

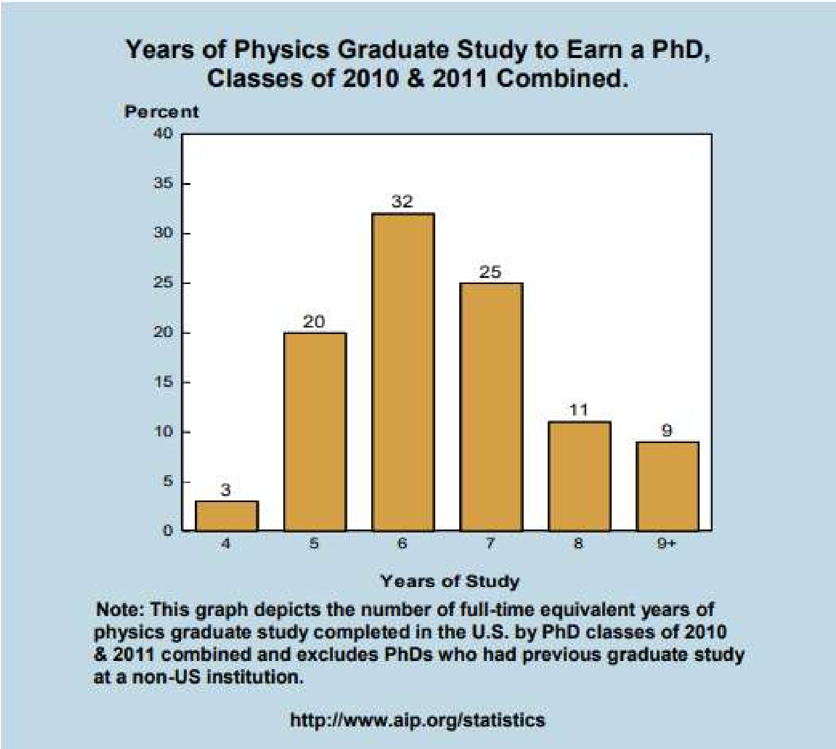
New Members of the **Graduate Group**

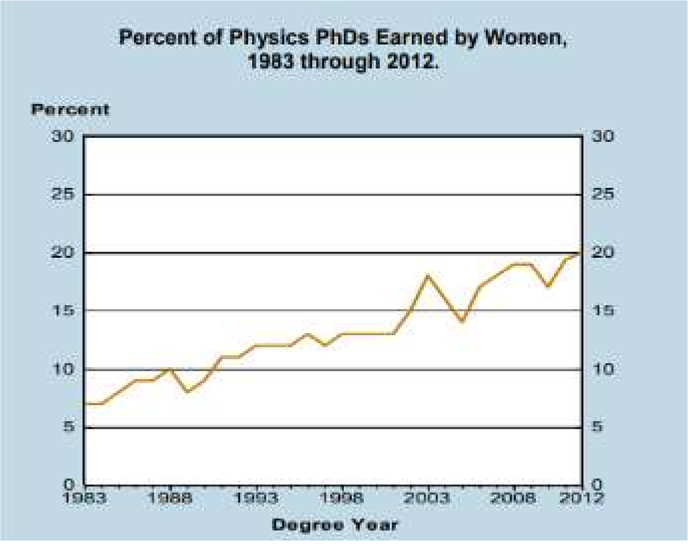
Raissa Dsouza, Network/ Computer Science
Thilo Gross, Network/ Computer Science
Mark Goldman, Neuroscience
Marina Radulaski, Electrical and Computer Engineering

Some Data on the Graduate Program

Year	Applications	Admits	Enrollment			Degrees Conferred			% Applicants Admitted	% Admits Enrolled
			New	Continuing	Total	Master's	PhD	Total		
2007-2008	314	94	34	97	131	7	14	21	29.9%	36.2%
2008-2009	273	58	15	111	126	15	9	24	21.2%	25.9%
2009-2010	273	79	29	116	145	14	11	25	28.9%	36.7%
2010-2011	252	66	17	122	139	23	16	39	26.2%	25.8%
2011-2012	332	69	23	107	130	14	26	40	20.8%	33.3%
2012-2013	334	94	20	113	133	19	19	38	28.1%	21.3%
2013-2014	366	106	38	106	144	12	20	32	29.0%	35.8%
2014-2015	440	101	26	125	151	10	22	32	23.0%	25.7%
2015-2016	363	73	30	127	157	16	18	34	20.1%	41.1%
2016-2017	428	79	26	135	161				18.5%	32.9%

Doctoral 6- & 8-Year Completion Rates			
Cohort Entry Year	Cohort Size	6 Year Completion Rate	8 Year Completion Rate
2001	22	45.5%	55%
2002	19	47.4%	47%
2003	26	30.8%	50%
2004	38	18.4%	55%
2005	31	35.5%	77%
2006	13	46.2%	62%
2007	34	55.9%	82%
2008	15	20.0%	73%
2009	29	37.9%	
2010	17	35.3%	





UCD Numbers: 6 18 32 23 14 7 **18 %**

Student Support

	Teaching	GSR	Dept fellowship	Other fellowship	Self-support
quarters	268.5	142.5	32	18	10
percentage	57	30	7	4	2

Departmental Endowed Fellowships:
Paul Brady-Charles Soderquist Fellowship
John Jungerman-Charles Soderquist Fellowship
John Jungerman Fellowship
Ling-Lie Chau Fellowship
Paul Brady Fellowship
Ching Fong Fellowship
James David Cone Fellowship

Ryan Couch Travel Fellowship
Katherine Fadley-Pusateri Travel Fellowship

Also: NSF, DOE, Livermore, UC MEXUS, UC Davis Dissertation Fellowships

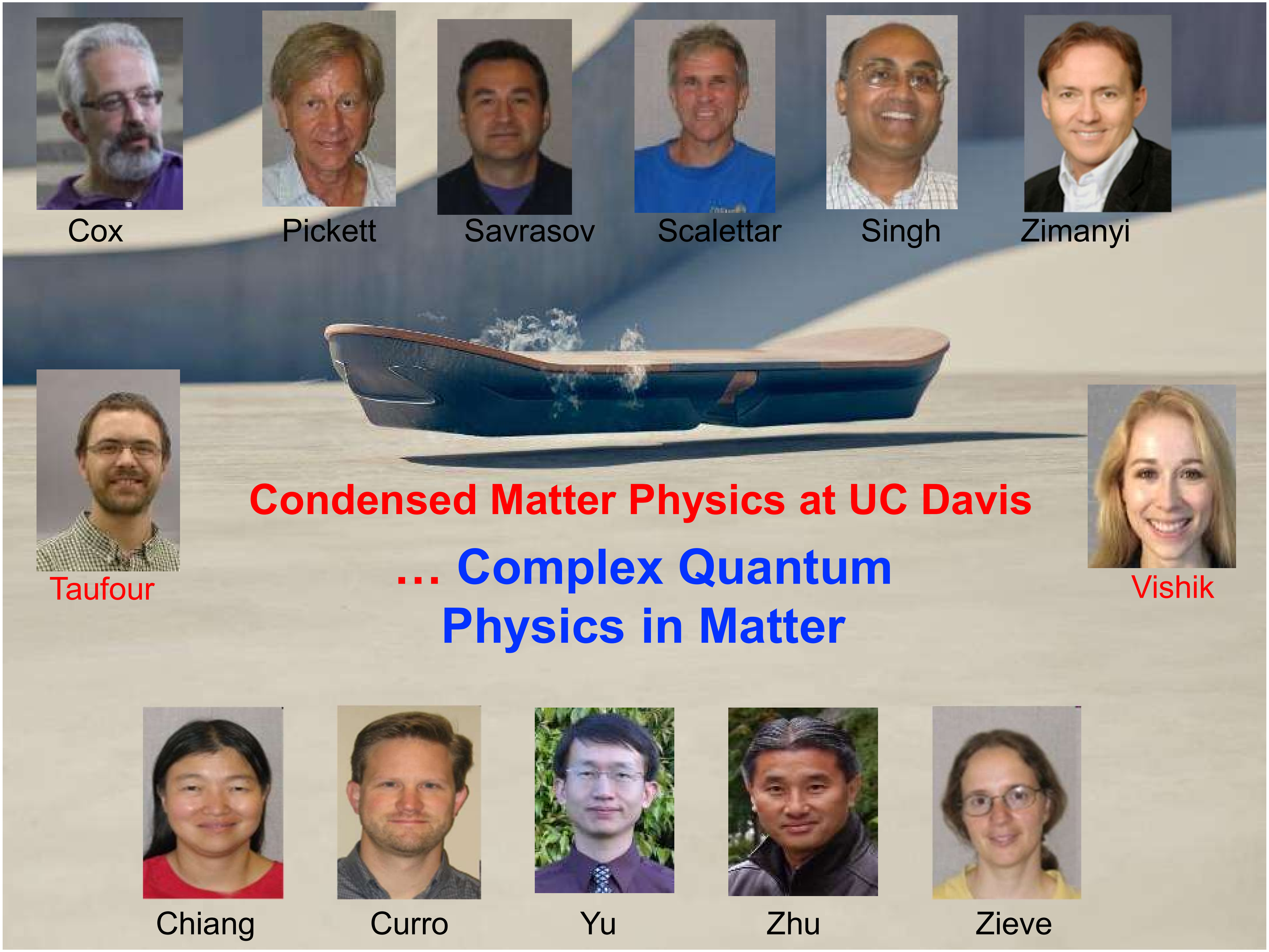
Employment after graduation

UC Davis (Physics)

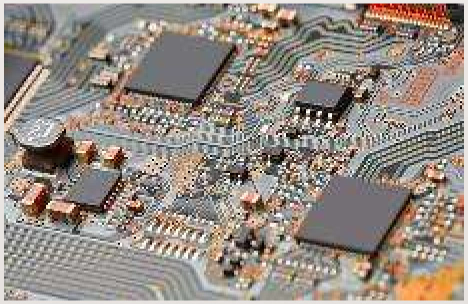
employer type	position type	number	%
Universities		**60**	44
	faculty	26	
	(permanent) research	12	
	postdoc	20	
	student	1	
	other	1	
Industry		**61**	45
	technology	16	
	programming or data science	42	
	finance	1	
	other	2	
National labs		**11**	8
	staff	8	
	postdoc	3	
Other government		**4**	3

National Numbers (American Institute of Physics):
Private Sector 438 (38 %)
Government Labs 190 (16 %)
Academia 533 (46 %)

Stanford University (Natural Sciences):
Academia 131 (55 %)
BGN 109 (45 %)
(Business/Government/Non-Profit)


Cox
Pickett
Savrasov
Scalettar
Singh
Zimanyi
Taufour
Vishik
Condensed Matter Physics at UC Davis
... Complex Quantum
Physics in Matter
Chiang
Curro
Yu
Zhu
Zieve

Condensed Matter Physics impacts our quality of life, politics & future.



semi-conductors

everyday technology

superconducting magnets

hard-drive

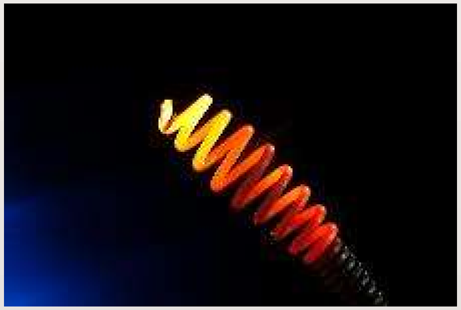
SQUID for magnetoencephalography

Wind turbine

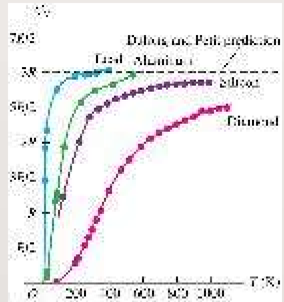
solid-state battery

solar-cells

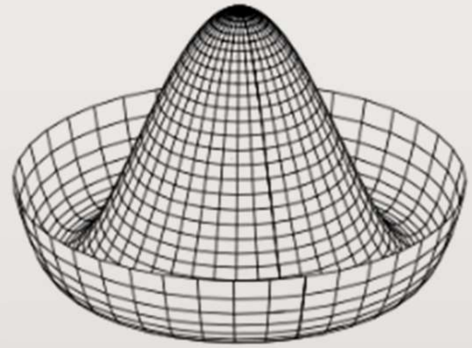
Condensed Matter Physics impacts our understanding of nature



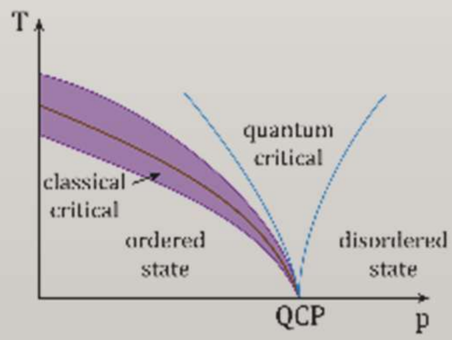
black-body radiation



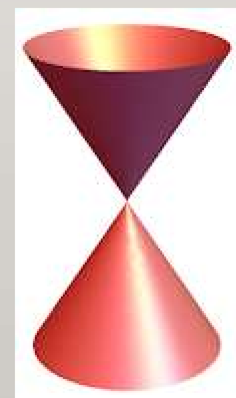
quantization of vibrations
Pauli exclusion principle for electrons



spontaneous symmetry breaking



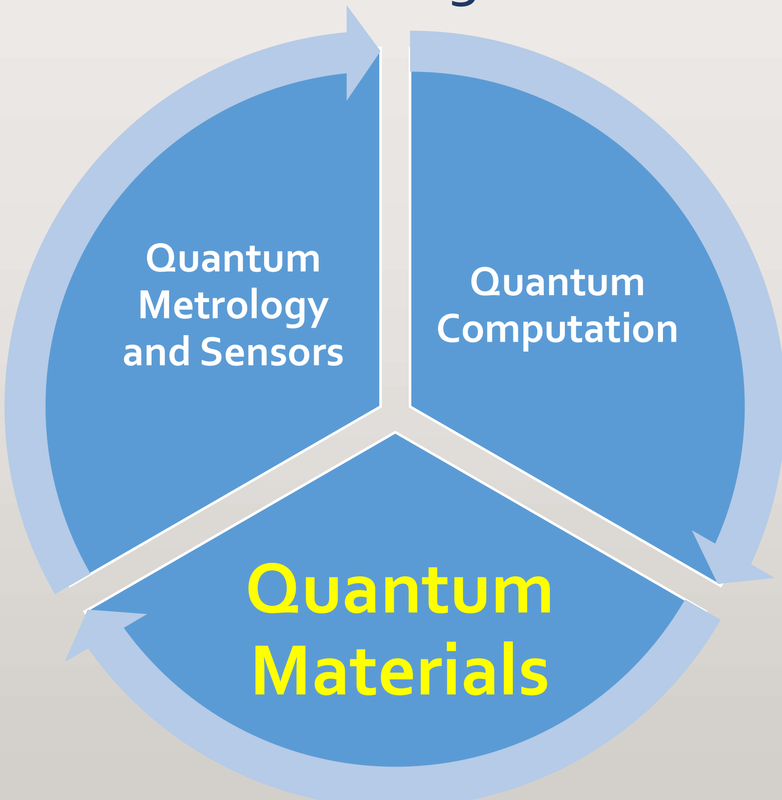
scaling laws, renormalization, quantum criticality



topological phases

A Quantum Revolution is Coming

An exciting time to be doing Condensed Matter Physics



National Quantum Initiative Act

From Wikipedia, the free encyclopedia

The **National Quantum Initiative Act** is an Act of Congress passed on December 13, 2018 and signed into law on December 21, 2018. The law gives the United States a plan for advancing quantum technology, particularly quantum computing. It passed unanimously by United States Senate and was signed by President Donald Trump.[1][2][3][4][5]

Can we harness the properties of quantum materials?

Which materials? Which properties?
What will be the 'silicon' of quantum computers?

National Quantum Initiative Act

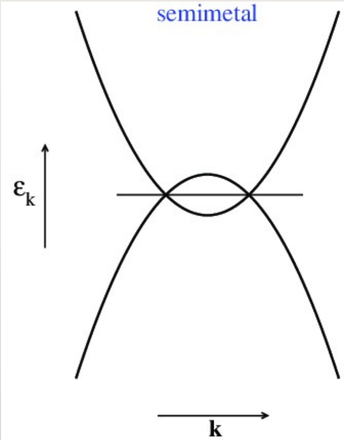
Long title	An Act to provide for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States.
Enacted by	the 115th United States Congress
Effective	December 21, 2018

Topological Materials

<u>*Energy efficient*</u> electrical transport, computers and electronics…
Beyond the qubit approach to quantum computation…

Topological Materials

- **Weyl and Dirac Semimetals**
- **Topological Insulators**
- **Topological Superconductors**
- **Majorana quasiparticles…**



semi-metals

Dirac semimetals
Double Dirac semimetals
Weyl semimetals type I
Weyl semimetals type II
nodal line semimetals
nodal ring semimetals

insulators

topological insulators
Kondo insulators
Mott insulators
Chern insulator
Anderson insulator
axionic insulators
Floquet topological insulators
charge-transfer insulators

New quantum properties that are protected by topology

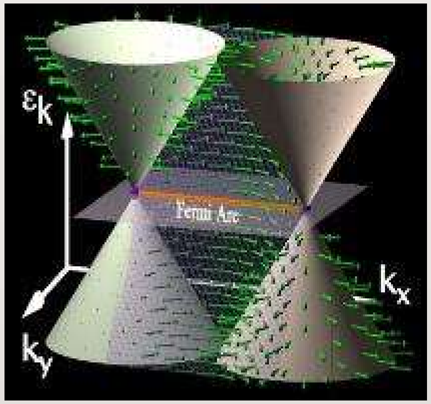
Topological Materials

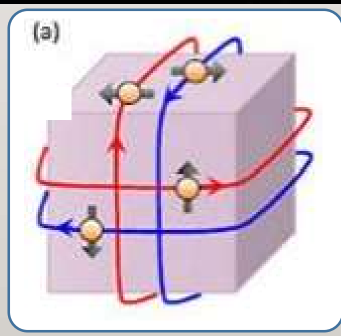
Singh

Pickett

Savrasov

Advanced Theory



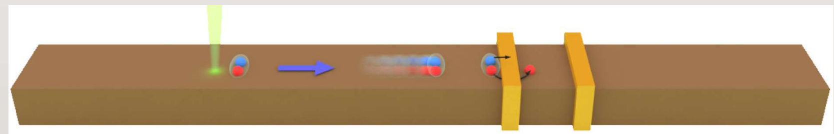


Taufour

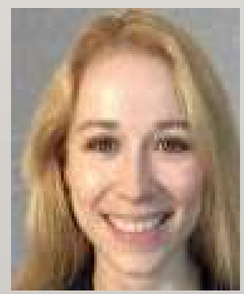
Synthesizing Materials

Zhu

Yu

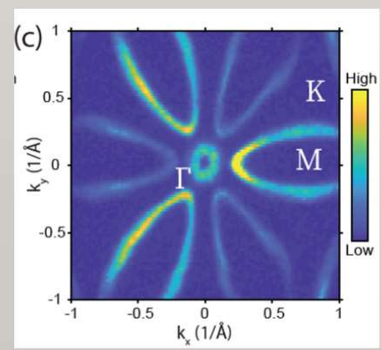


Controlling topological electrons with photons.



Vishik

ARPES



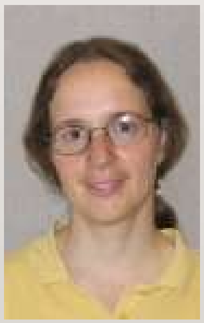
Advanced Spectroscopy

Other topics at the frontier of knowledge…

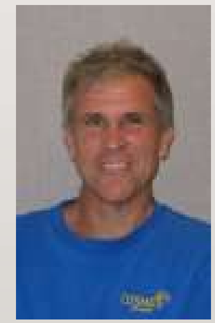
Curro

Pickett

- High-temperature superconductivity
- Exotic Magnetism
- Heavy Fermion Physics
- Quantum Phase Transitions
- Superfluid Helium



Zieve



Scalettar

Taufour

Vishik

Savrasov

Singh

Energy and the Environment

Yu

Zimanyi

How to meet our energy needs sustainably?

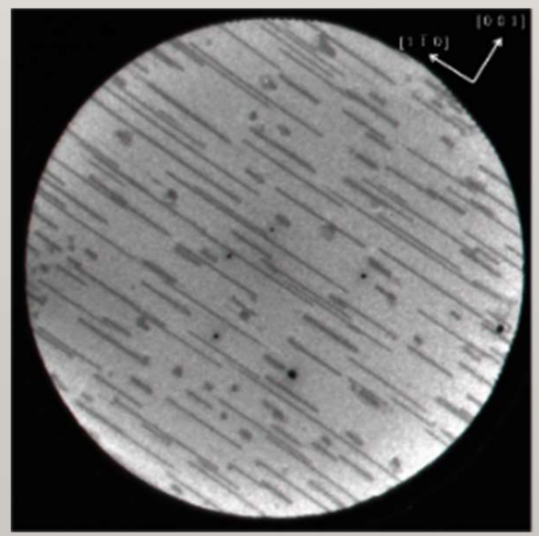
How to meet our water needs sustainably?

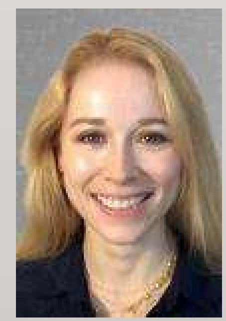
Surfaces and Interfaces

- Visual and other probes monitor surfaces.
- New physics at interfaces!

Chiang

Zhu

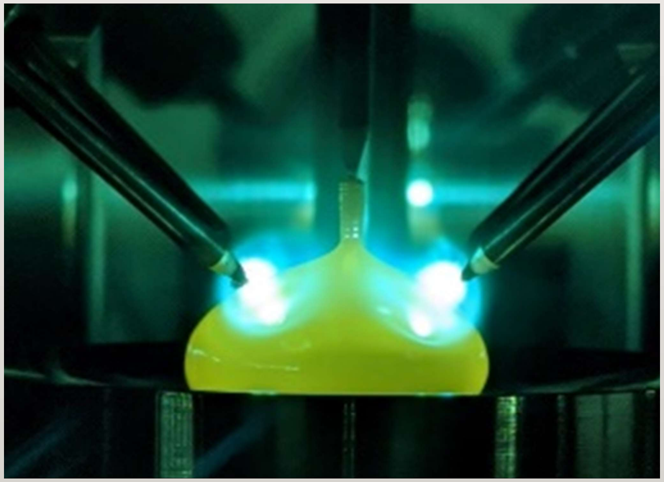




Vishik

Recent Investment in Experimental Condensed Matter Physics

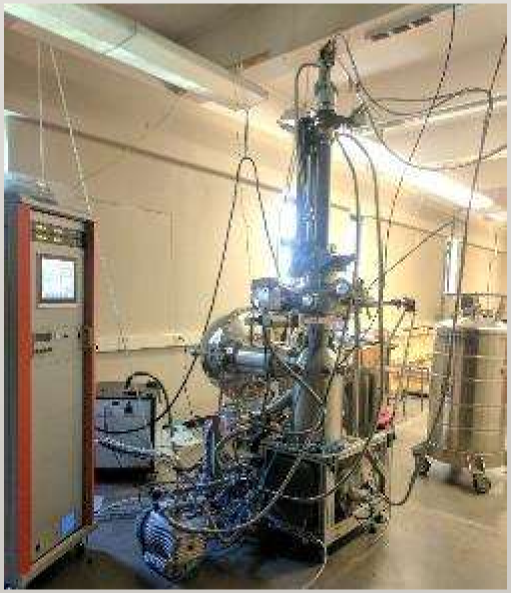
New state-of-the art equipment… Multi million $ investment.



Taufour (2nd Floor)
- Synthesis Lab
- Physical Property Measurements Lab

Condensed Matter low temperature helium lab (basement)

Vishik (basement) ARPES Lab



November 2018

January 2019

August 2019

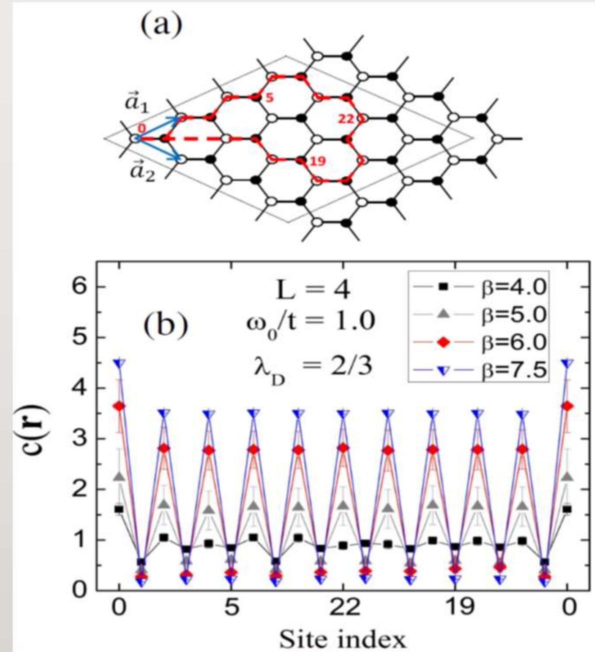
March 2020

Bright PhD students

Scalettar group

Yuxi Zhang

Wei-ting Chiu



Electron Phonon Interactions and Dirac Fermions

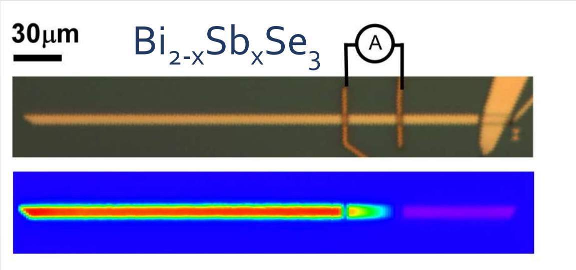
"Charge Order in the Holstein Model on a Honeycomb Lattice," Y.-X. Zhang, W.- T. Chiu, N.C. Costa, G.G. Batrouni, and R.T. Scalettar, Phys. Rev. Lett. 122, 077602 (2019).

Bright PhD students

Yu group

Yasen Hou

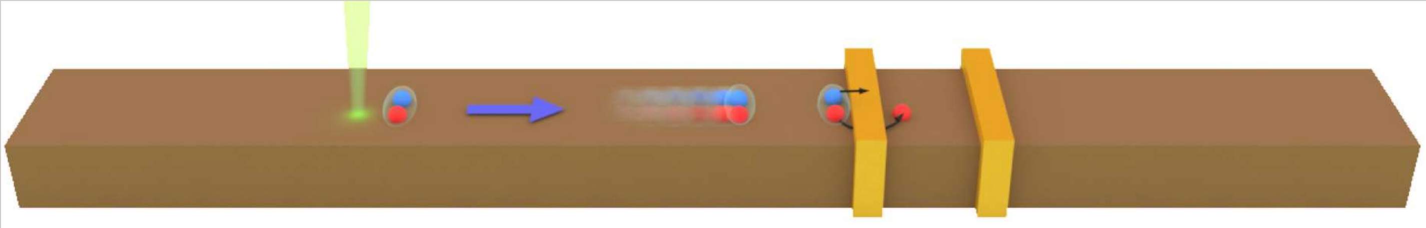
Luke McClintock



Non-local photocurrent

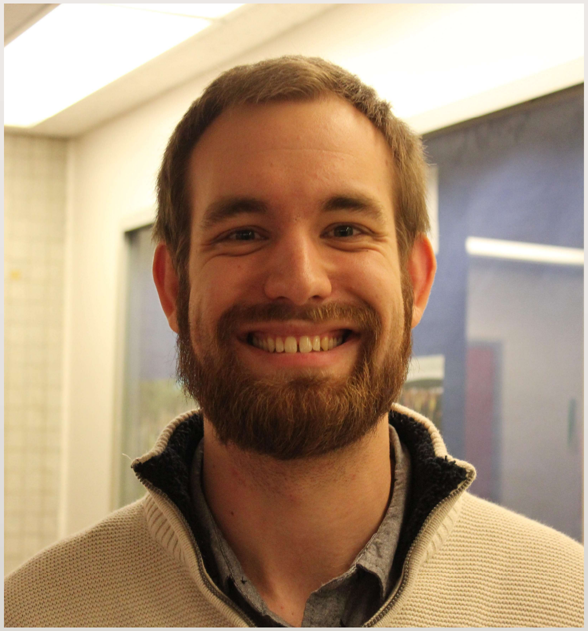
Topological exciton condensates: can excitons be a superfluid and make quantum computers?

Halide perovskites: can we make a better solar cell by manipulating phase?



Bright PhD students

Zieve group



Bobby Prater

Rotational glitches in superfluid neutron in neutron stars… or in superfluid helium in the lab

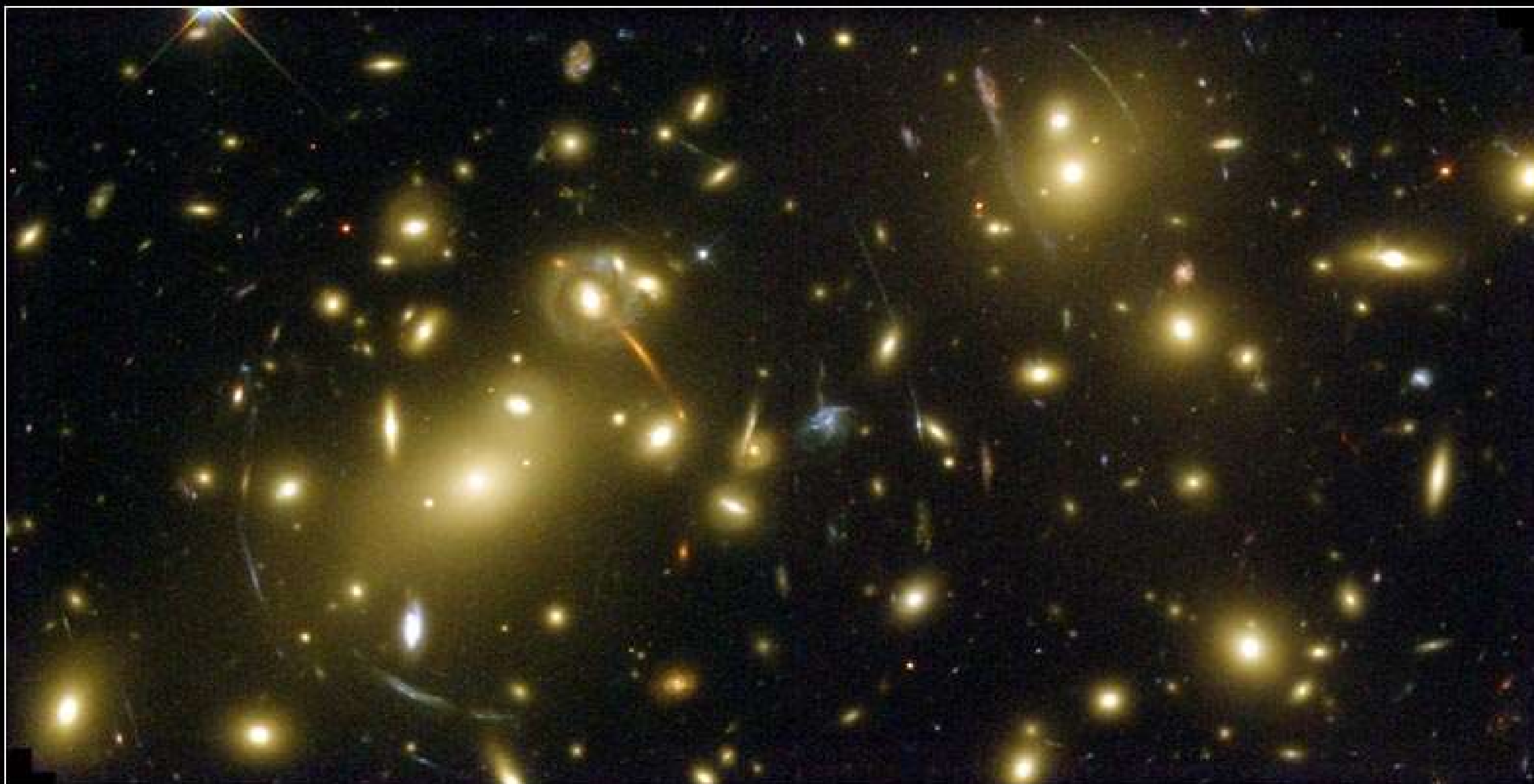
Bright PhD students

CM group

You

Join us in the new quantum revolution!!!

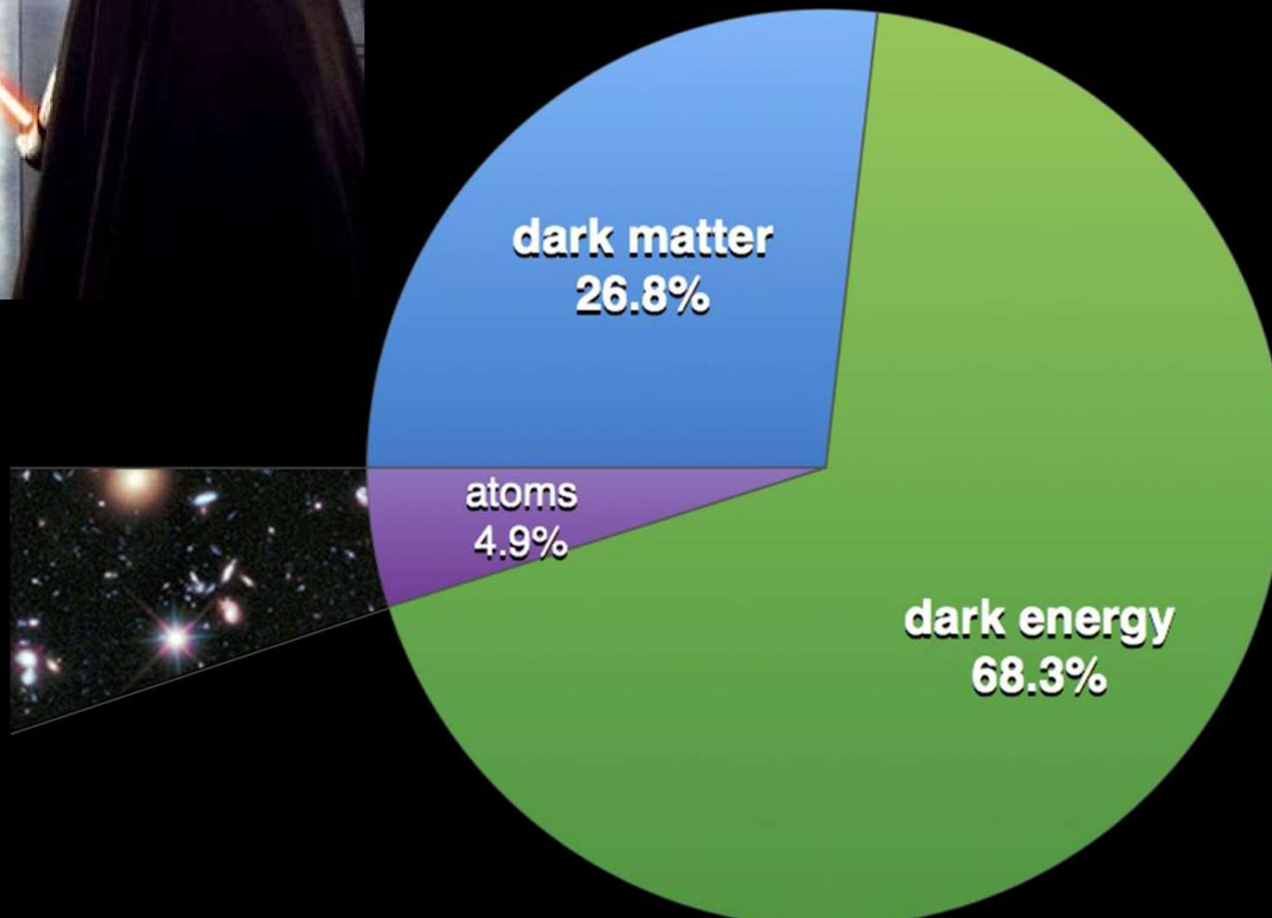
Cosmology & Astrophysics Group studying the Universe across 13.8 billion years



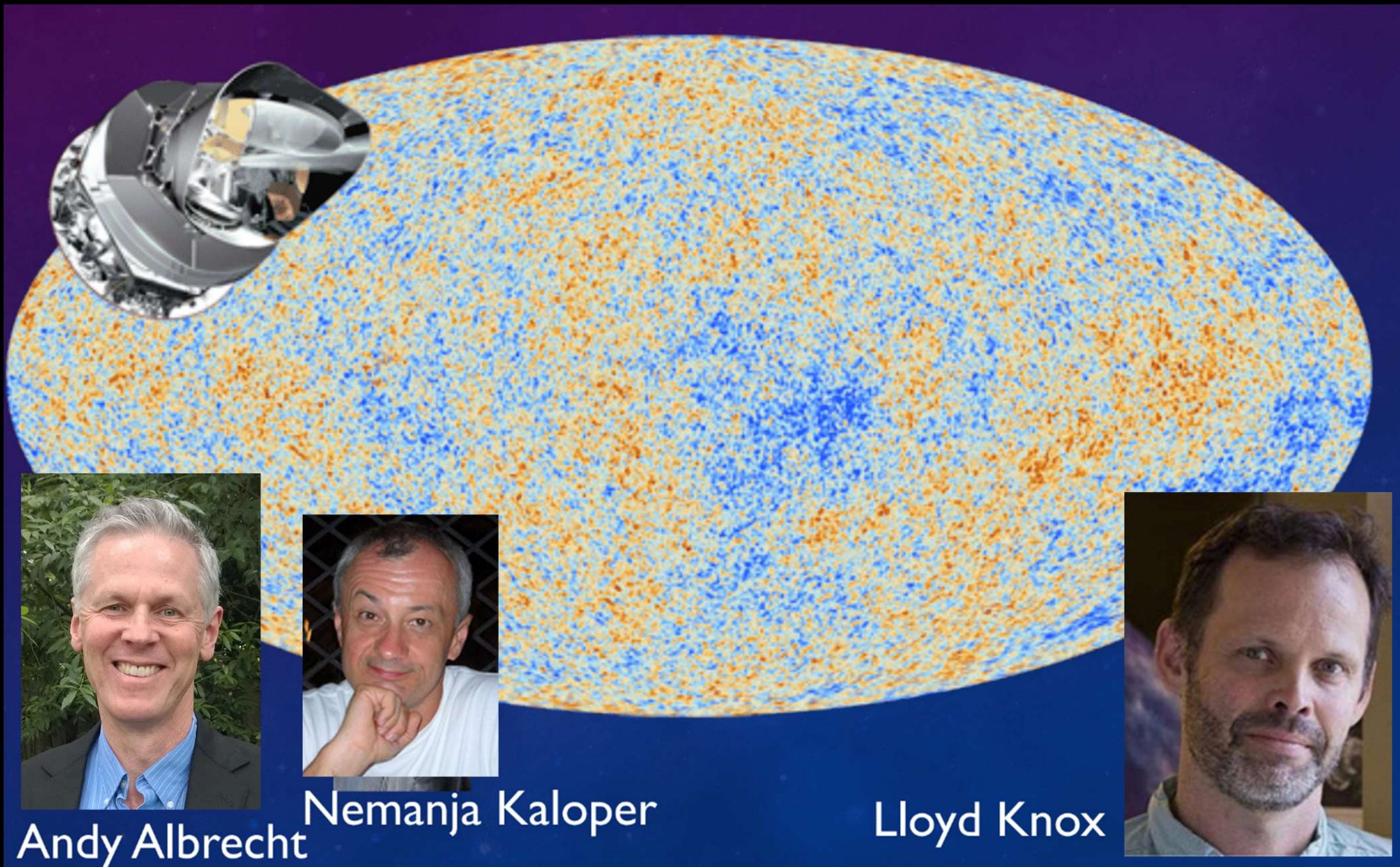
Galaxy Cluster Abell 2218 **HST • WFPC2**

NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08

we study the light side and the dark side



the early Universe, inflation, dark energy

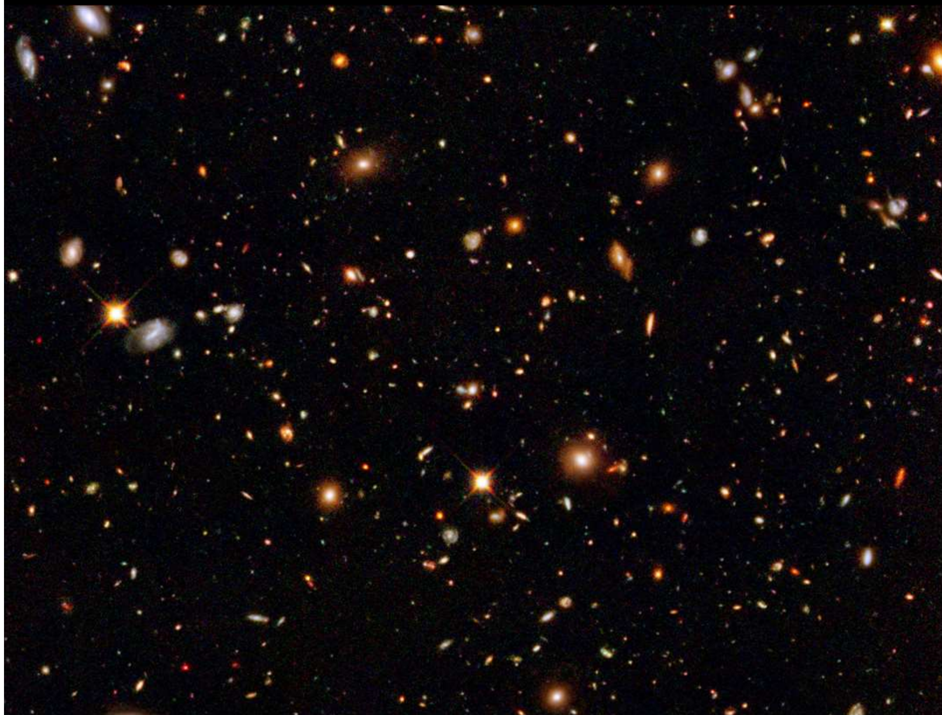


mapping dark matter across the Universe




Marusa Bradac
Tony Tyson
David Wittman
Chris Fassnacht

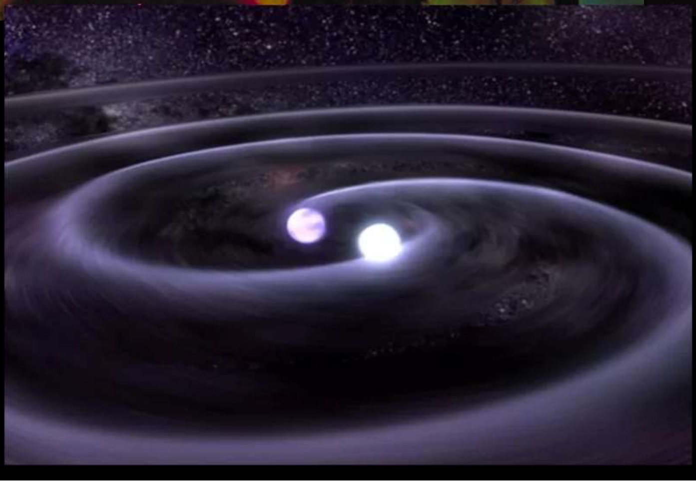
galaxy formation: from the first galaxies to the Milky Way

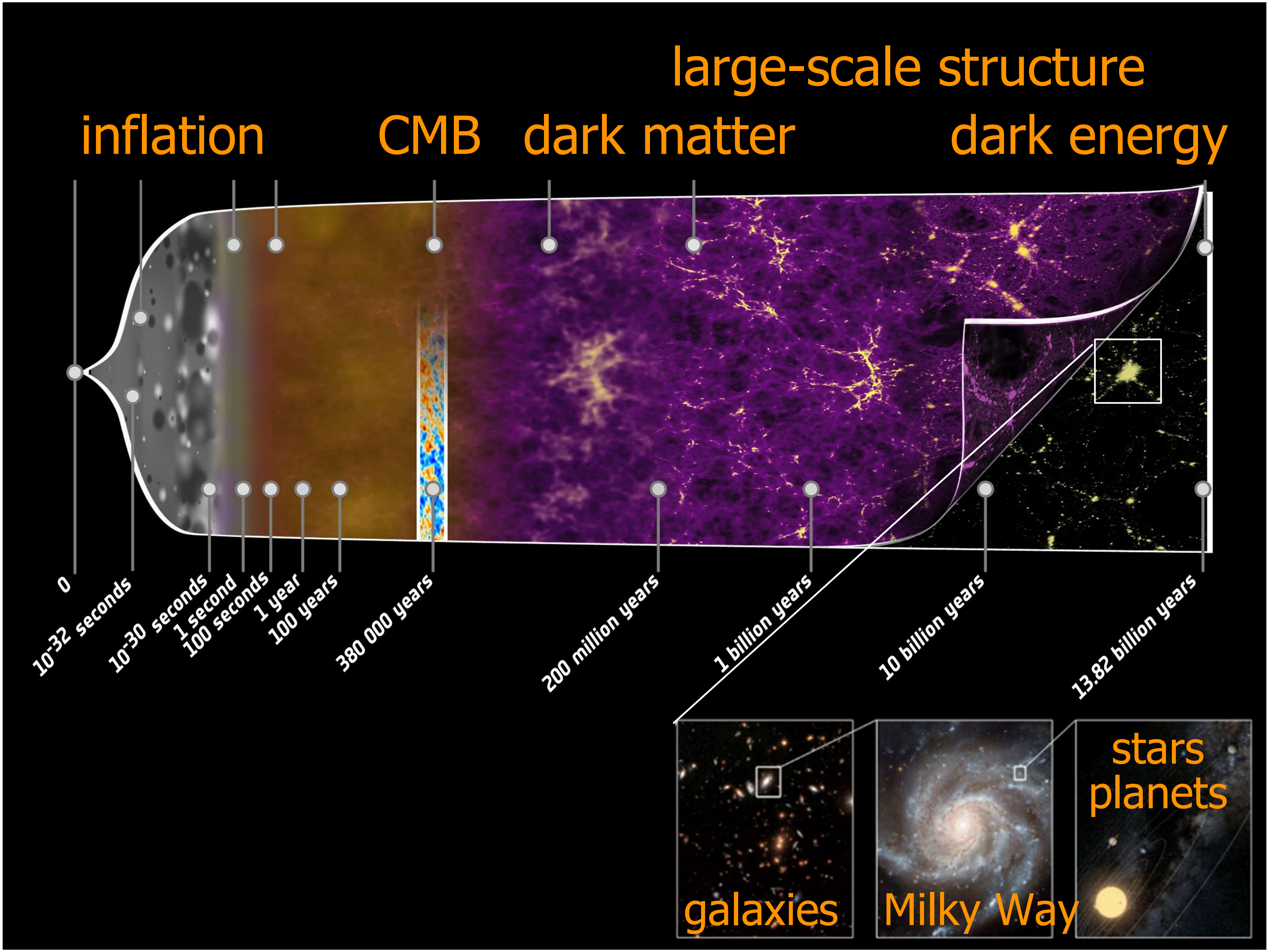


Marusa Bradac
Tucker Jones
Lori Lubin
Andrew Wetzel

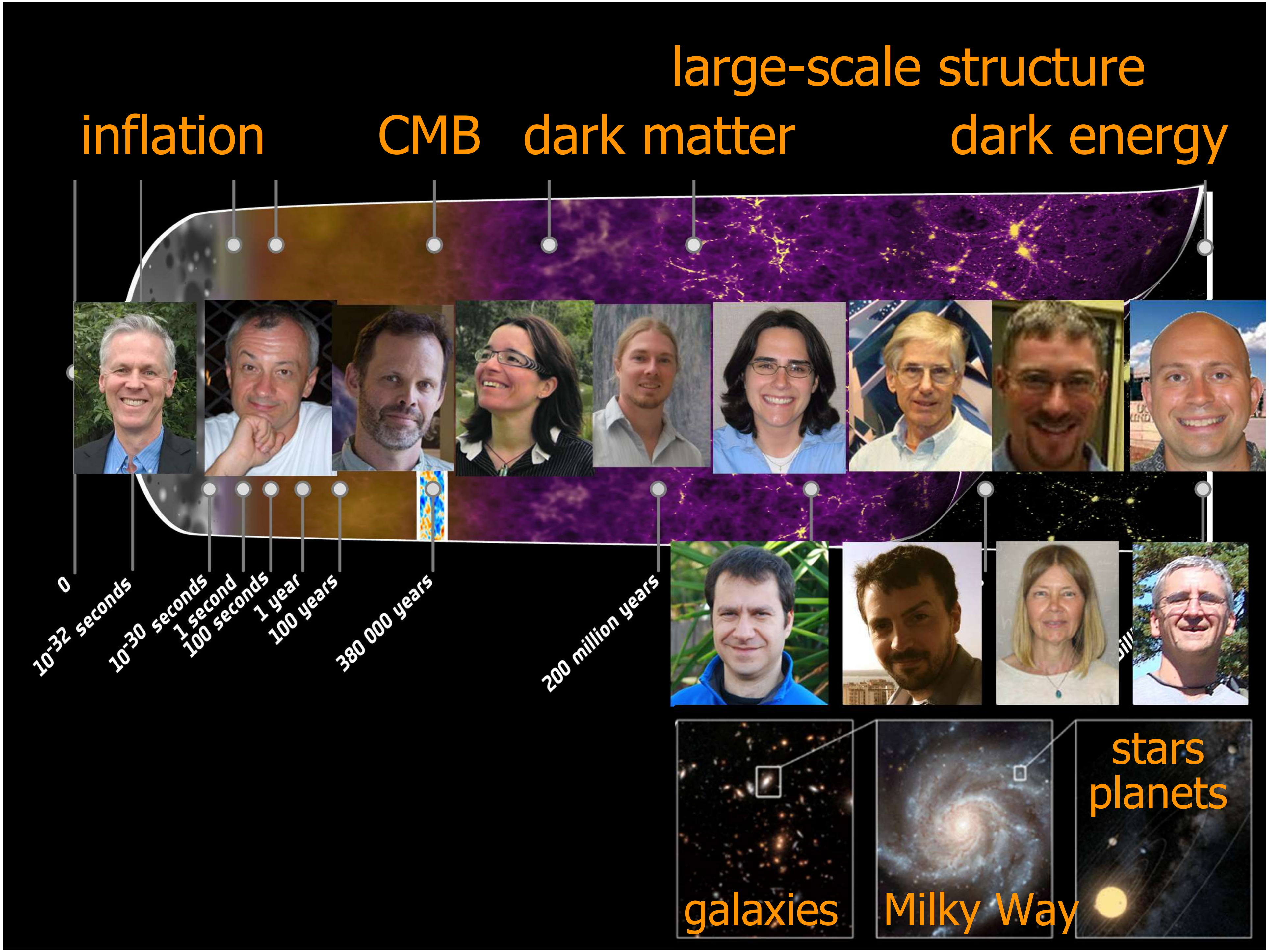
stars, their birth and death (supernovae), black holes, gravitational waves

Pat Boeshaar
Matt Richter
Stefano Valenti

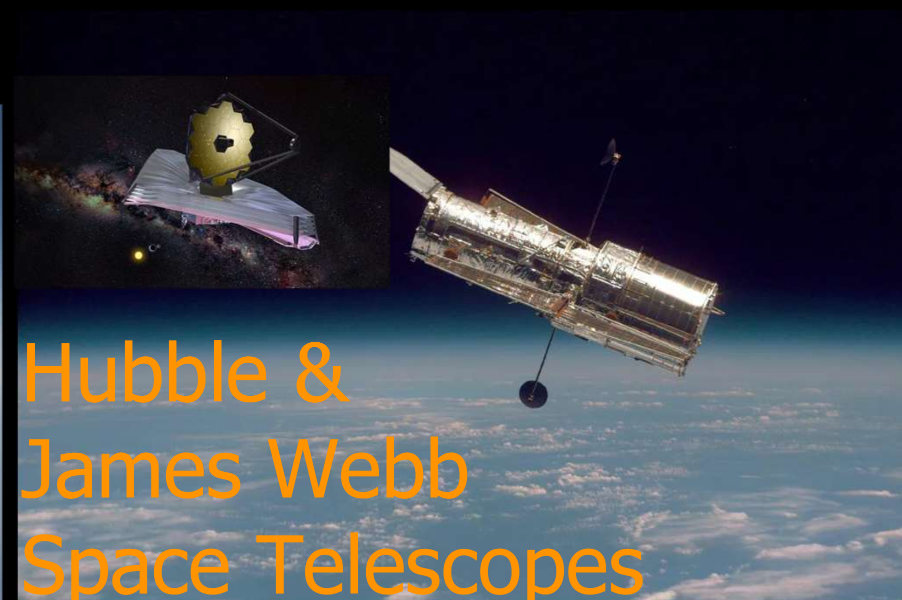




large-scale structure
inflation
CMB
dark matter
dark energy
0
10-32 seconds
10-30 seconds
1 second
100 seconds
1 year
100 years
380 000 years
200 million years
1 billion years
10 billion years
13.82 billion years
galaxies
Milky Way
stars
planets

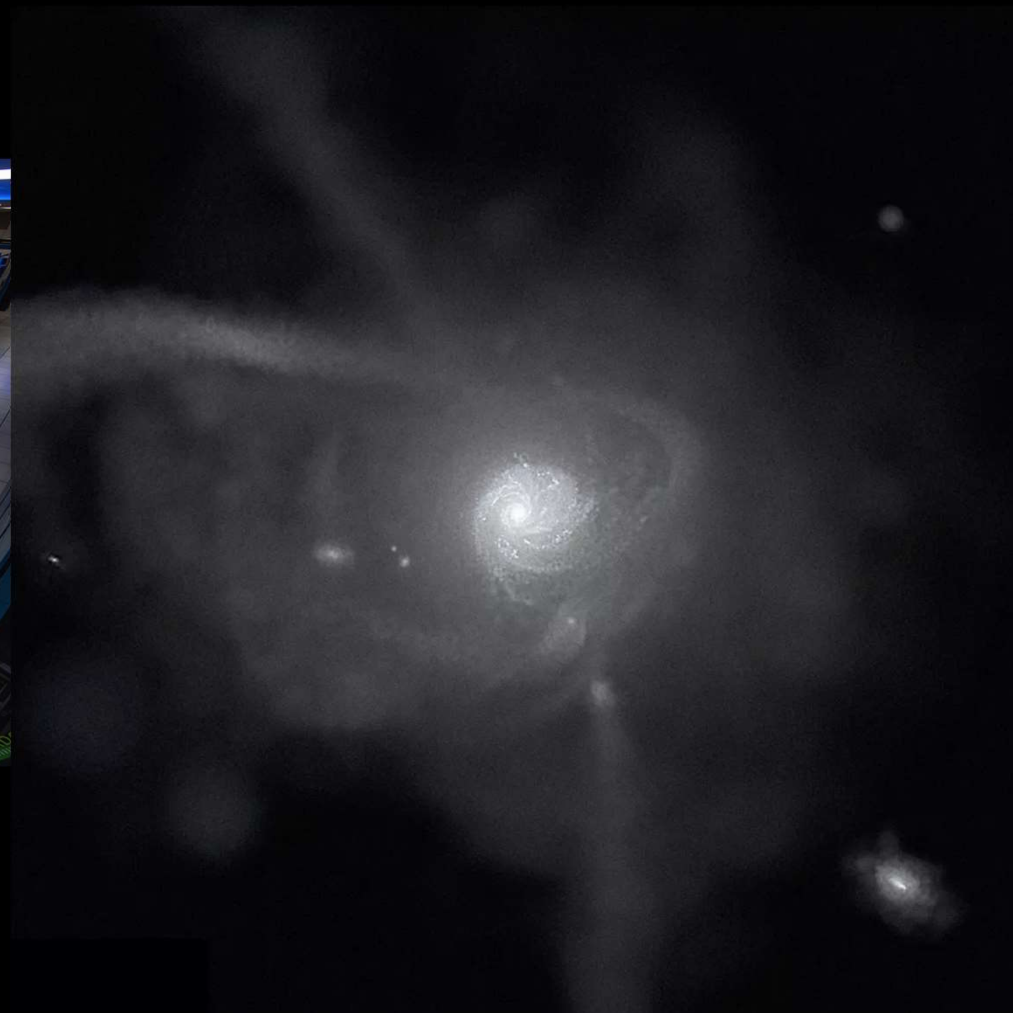

large-scale structure
inflation
CMB
dark matter
dark energy
0
10^{-32} seconds
10^{-30} seconds
1 second
100 seconds
1 year
100 years
380 000 years
200 million years
galaxies
Milky Way
stars
planets

what our graduate students (you?) do



what our graduate students (you?) do

pleiades supercomputer



Complexity @ UC Davis

Int’l Institute of Complex Adaptive Matter

Daniel Cox, Director

Biological Physics

Dan Cox

Rajiv Singh

Gergely Zemanyi

Xiangdong Zhu

Mark Goldman

Complexity Sciences Center

Jim Crutchfield, Director

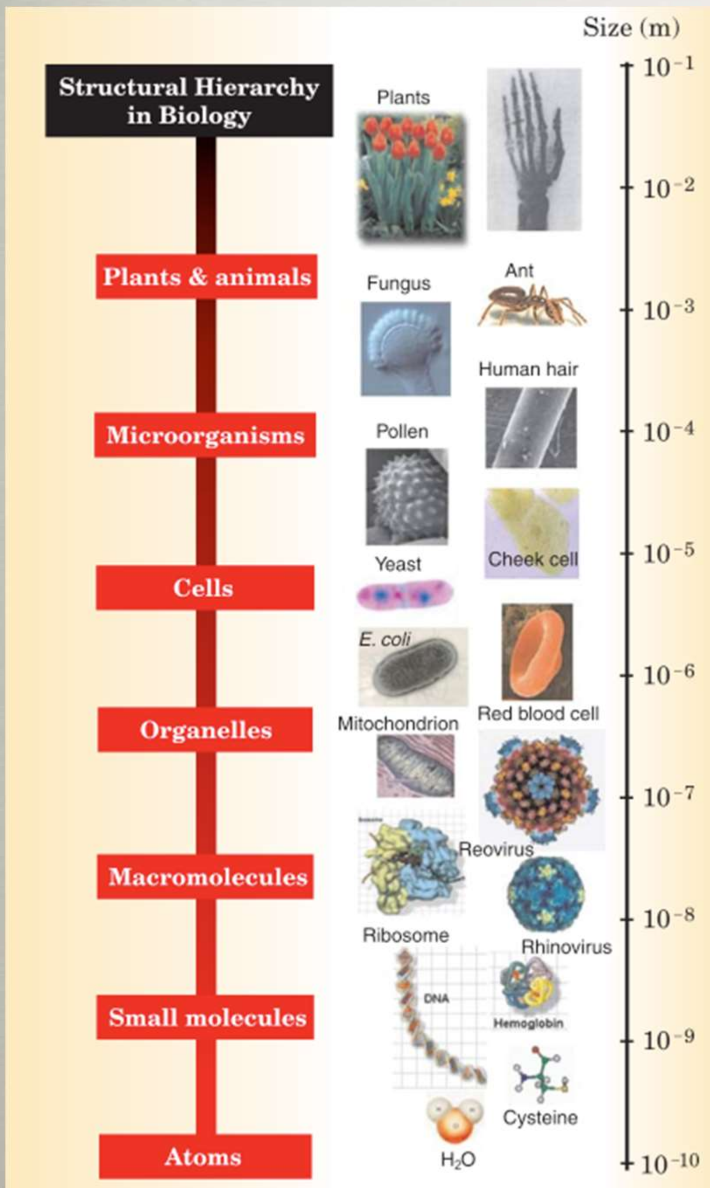
Jim Crutchfield

Raissa D’Souza

John Rundle

Physics of Information

Biological Physics



What distinguishes biological matter?

Features:

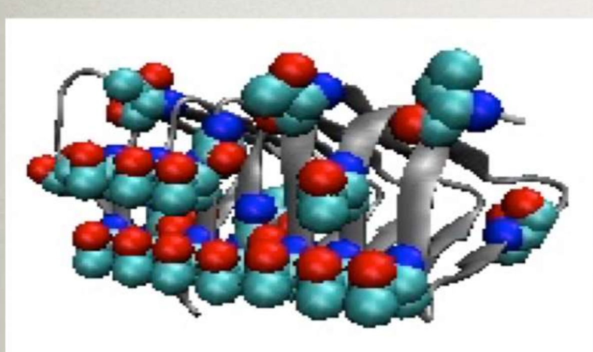
Multiple length scales
Multiple time scales
Emergent properties

Approaches:

Models and phenomenology
"Systems" level approaches
Multiple disciplines

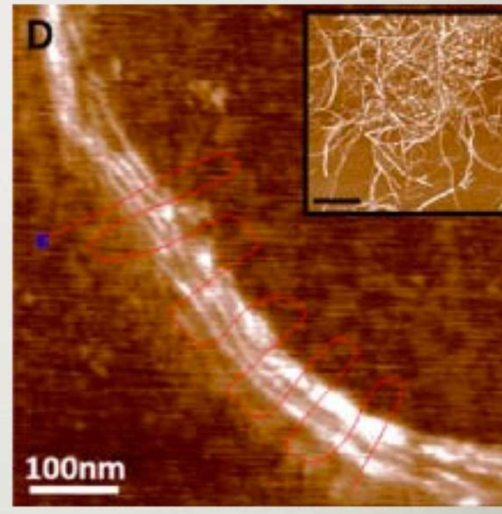
Biological Physics

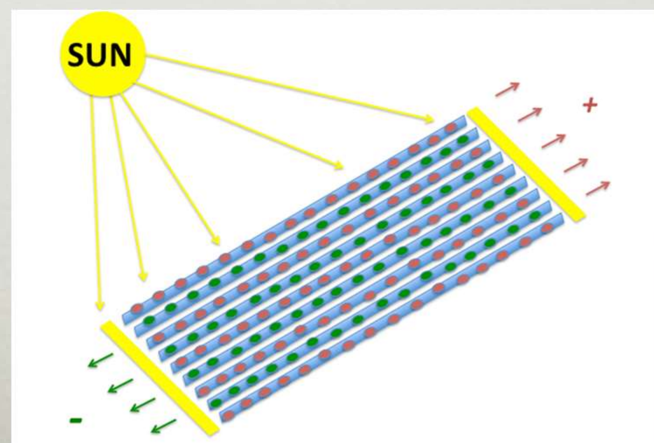
Molecular Legos:
Stick proteins together to make useful things!



Modify existing β-solenoid proteins, like this antifreeze protein

Grow modified proteins into 2D filaments arrays





Grow nanoparticles on arrays to produce photovoltaic

Biological Physics

- Biology respects physics, but ...
  - Dynamical processes
  - Far out of equilibrium
- What distinguishes biological matter?
  - Structure, control, & function
  - Information Processing (Machine Learning and Neuroscience)

Information versus Energy?

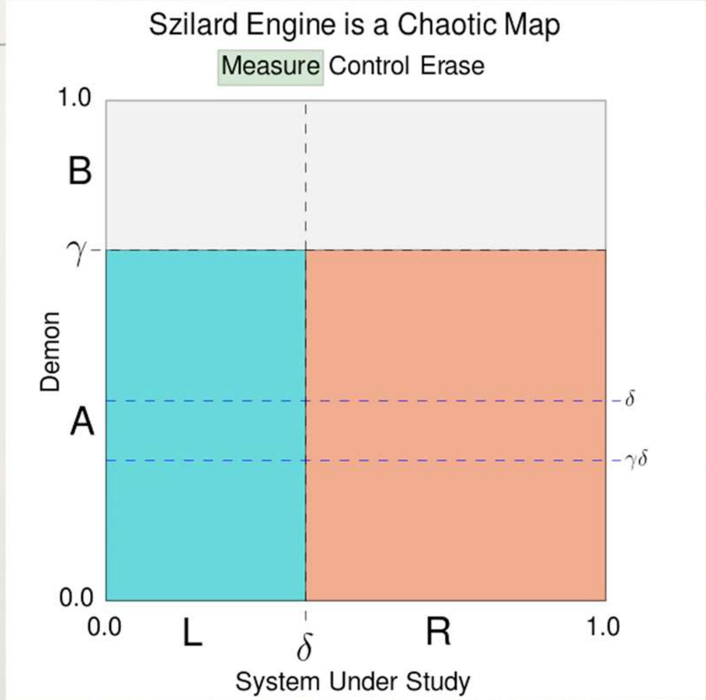
- Landauer's Principle:

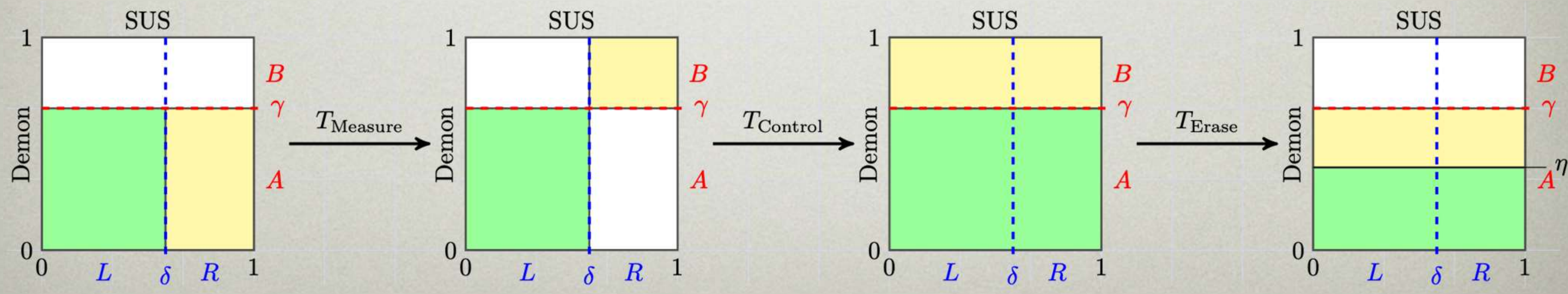
$$\Delta S_{\text{erase}} \geq k_B T \ln 2$$

- A Maxwellian Demon:

Szilard's Engine is Chaotic ...

A. B. Boyd and J. P. Crutchfield *Demon Dynamics: Deterministic Chaos, the Szilard Map, and the Intelligence of Thermodynamic Systems,* **Physical Review Letters** 116 (2016) 190601.

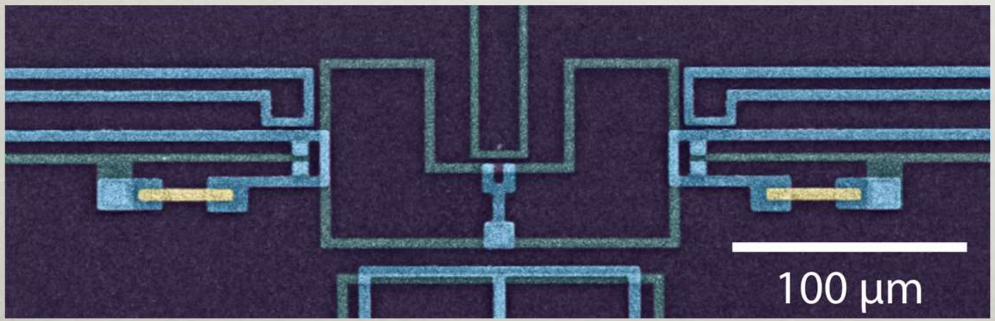


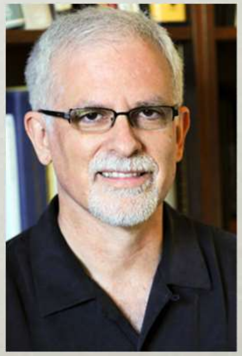


Information Engines

informationengines.org

- Direct Measurement of Energetics in Computation
- First *direct* experimental test of Landauer's Principle
- Flux Qubit:





Michael
Roukes
Caltech

Jim
Crutchfield
UC Davis

Complexity Sciences Center

J. P. Crutchfield, R. M. D'Souza, J. B Rundle, …
Statistical Physics & Complex Systems

Network Science

Toward a Physics of Intelligence

RESEARCH NEWS

Seeking intelligence...and no biology allowed

Human beings are proof that intelligence is possible, but we don't have a monopoly. Computers, although not on par with people for some tasks, compute. Even tiny chemical reactions perform computations.

Perhaps that's where we should be looking for intelligence: embodied in the world around us, says SFI External Professor Jim Crutchfield.

"The paradigm we've come to associate with digital computing is very limited," Jim says, "and there might very well be other kinds of biological, chemical, and physical intelligence that transcend this digital, discrete computation paradigm."

So he and SFI External Professor Arthur Hübler have set out to find it. They've just received a grant from DARPA to define, identify, and measure intelligence in physical systems.

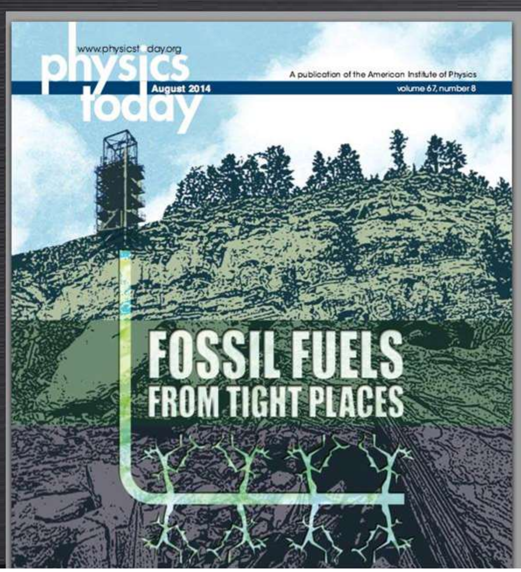
But they have a strict ground rule: "No biology is allowed," says Jim. "No neurons, no cells, no human being, no subjective criteria like the Turing test."

Instead, they're looking at structures like self-repairing dendritic trees, self-replicating RNA, and metal-organic frameworks.

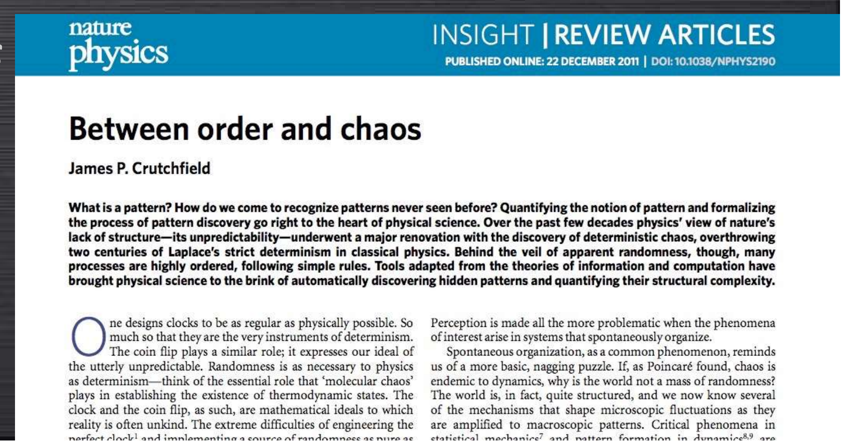
Furthermore, the intelligence they find must be rigorously measurable, Jim says. "The artificial intelligence model is 'We know it when we see it.' Our physical intelligence model is: 'We know it when we measure it.'"

Ball bearings in oil form a tree-like st voltage current runs through it. Mov slightly and it will return to its origina the whole structure and a new patte same number of endpoints and bran (Im

Super Fracking



Physics of Information



nature physics

INSIGHT | REVIEW ARTICLES

PUBLISHED ONLINE: 22 DECEMBER 2011 | DOI: 10.1038/NPHYS2190

Between order and chaos

James P. Crutchfield

What is a pattern? How do we come to recognize patterns never seen before? Quantifying the notion of pattern and formalizing the process of pattern discovery go right to the heart of physical science. Over the past few decades physics' view of nature's lack of structure—its unpredictability—underwent a major renovation with the discovery of deterministic chaos, overthrowing two centuries of Laplace's strict determinism in classical physics. Behind the veil of apparent randomness, though, many processes are highly ordered, following simple rules. Tools adapted from the theories of information and computation have brought physical science to the brink of automatically discovering hidden patterns and quantifying their structural complexity.

One designs clocks to be as regular as physically possible. So much so that they are the very instruments of determinism. The coin flip plays a similar role; it expresses our ideal of the utterly unpredictable. Randomness is as necessary to physics as determinism—think of the essential role that 'molecular chaos' plays in establishing the existence of thermodynamic states. The clock and the coin flip, as such, are mathematical ideals to which reality is often unkind. The extreme difficulties of engineering the perfect clock[1] and implementing a source of randomness as pure as

Perception is made all the more problematic when the phenomena of interest arise in systems that spontaneously organize.

Spontaneous organization, as a common phenomenon, reminds us of a more basic, nagging puzzle. If, as Poincaré found, chaos is endemic to dynamics, why is the world not a mass of randomness? The world is, in fact, quite structured, and we now know several of the mechanisms that shape microscopic fluctuations as they are amplified to macroscopic patterns. Critical phenomena in statistical mechanics[7] and pattern formation in dynamics[8,9] are

Contact Jim Crutchfield for more information

<crutchfield@physics.ucdavis.
edu>

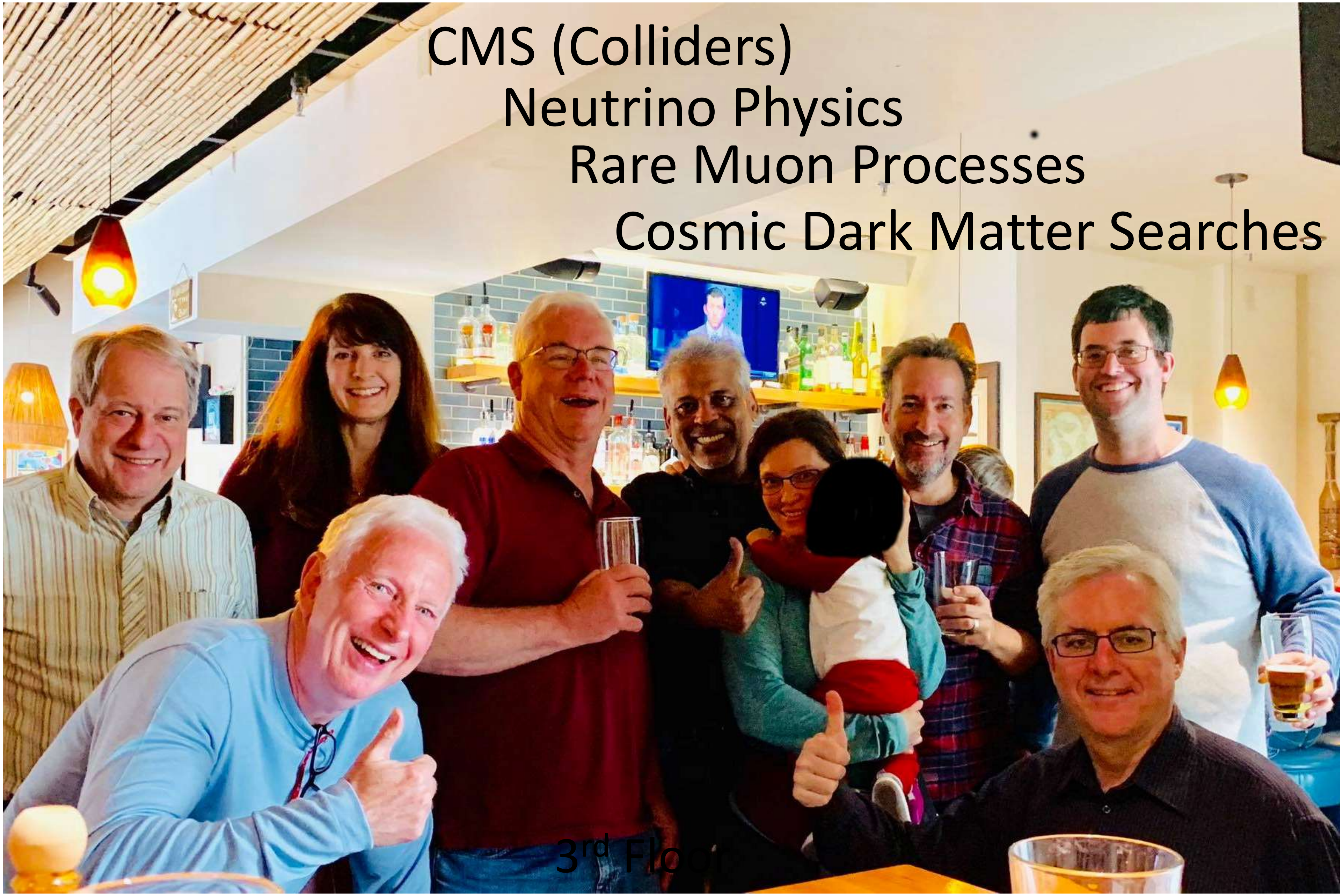
Experimental Particle Physics

CMS (Colliders)

Neutrino Physics

Rare Muon Processes

Cosmic Dark Matter Searches



3rd Floor

Cutting edge of High Energy Particle Physics

CMS group working on analysis of a 4-year run and various upgrades.

CMS students spend a lot of time @CERN

CMS Forward Pixel Detector

CMS UCD:10 graduate students and 4 postdocs

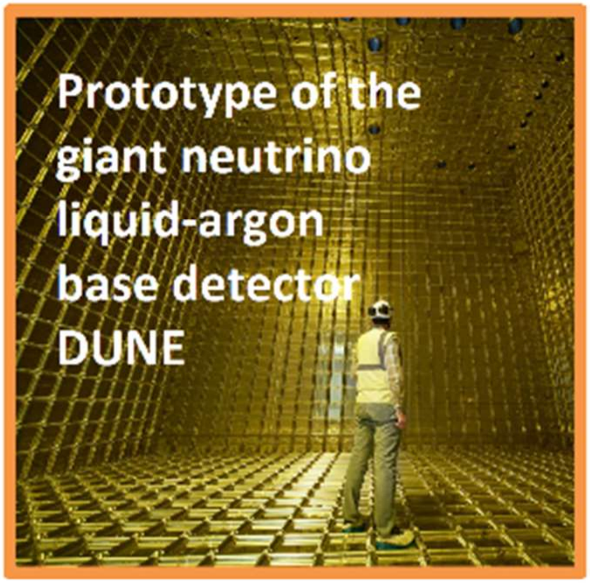
Development of
high-luminosity tracker
module

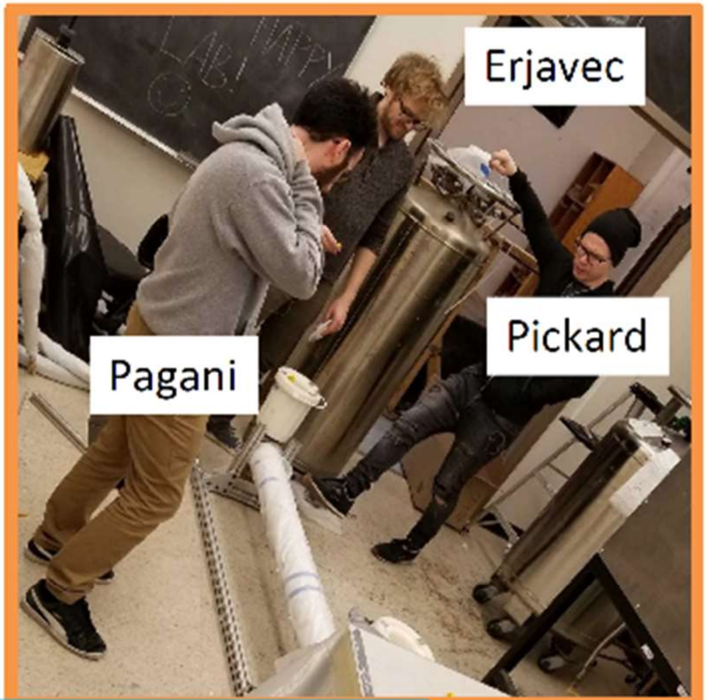
Development of
Gas electron multiplier
detectors for endcap muon
upgrade

Rich phenomenology of Neutrino physics

Neutrino group working on variety of new experiments:
(proto)DUNE, ANNIE, Theia, SNO+, ARTIE

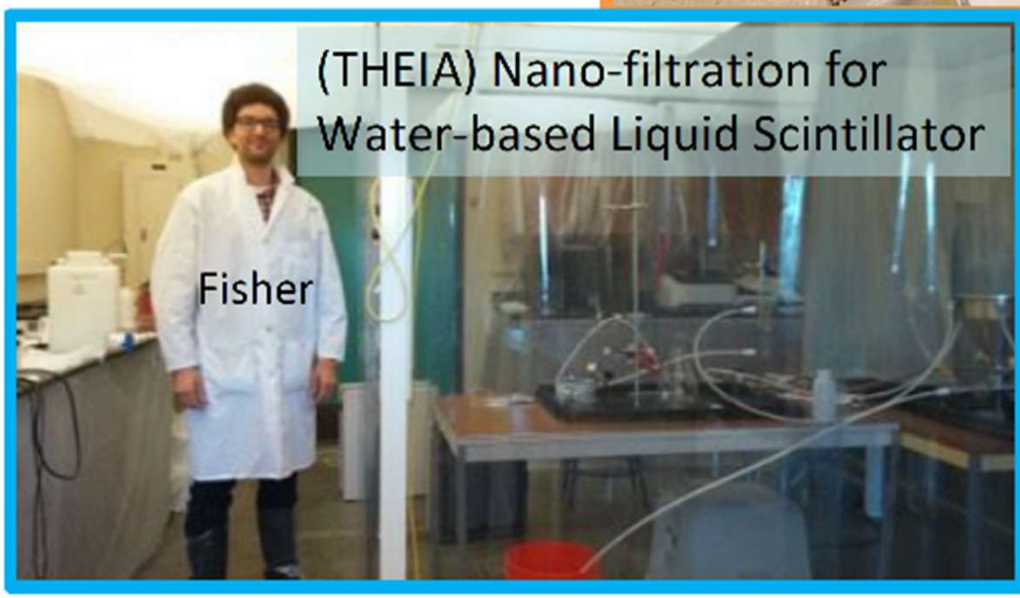
Nu UCD:6 graduate students and 3.5 postdocs





How far neutrons travel in liquid argon? (ARTIE)

Search for neutrinoless double beta decay (SNO+)



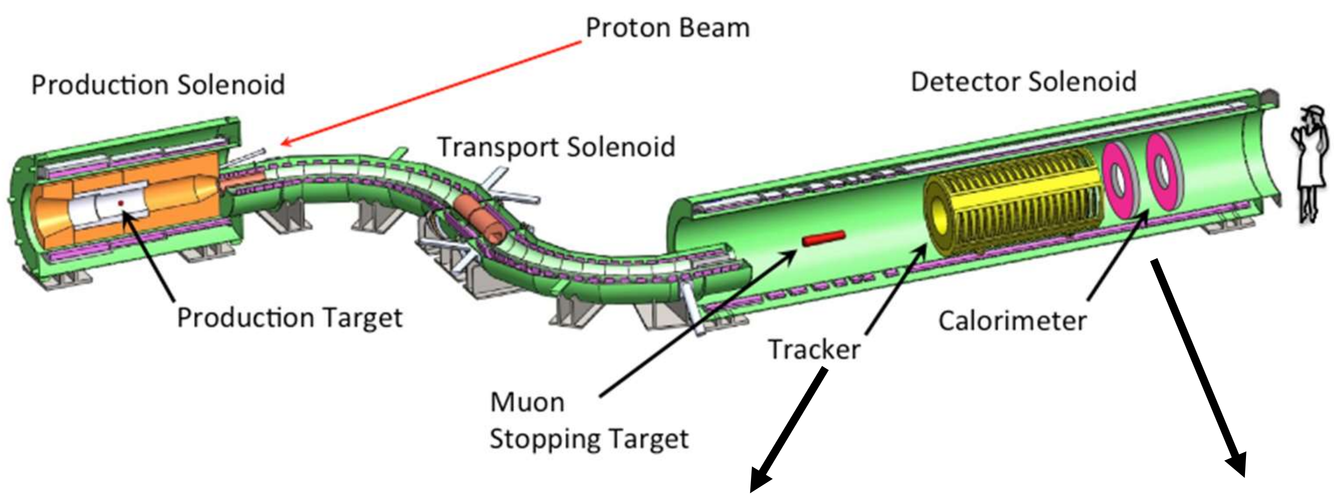
Nu UCD:6 graduate students and 4 postdocs

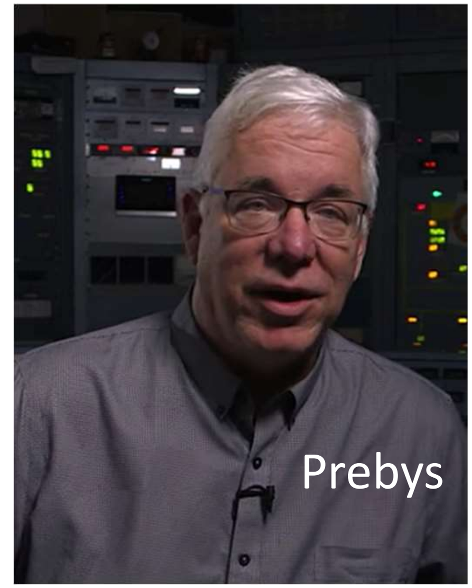
Development, fabrication and analysis of Accelerator Neutrino Neutron Interaction Experiment (ANNIE)

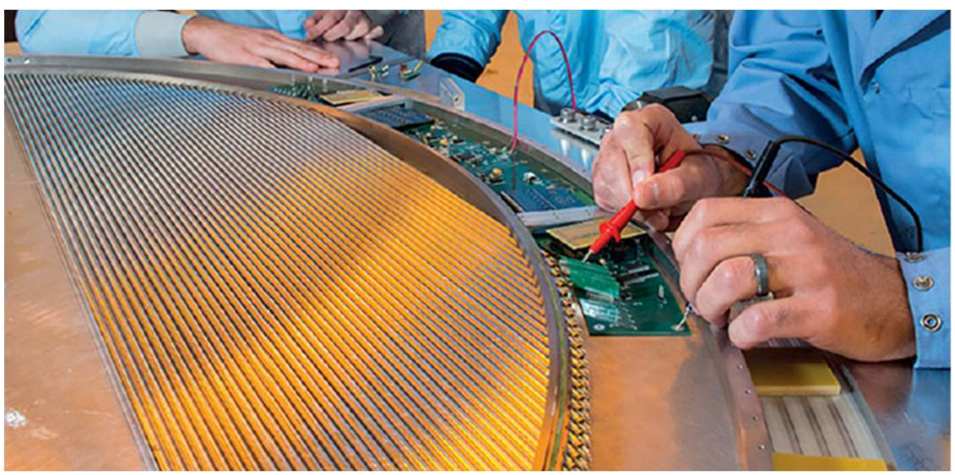
Charged lepton flavor violation in Muon Physics

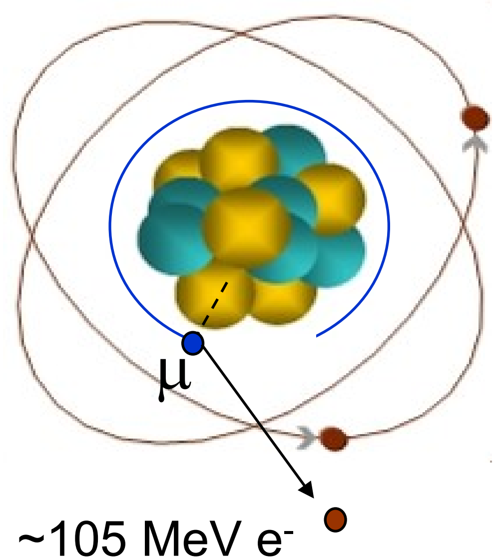
Mu2e UCD group: developing and construction Mu2e@FNAL

2 graduate students and one postdoc



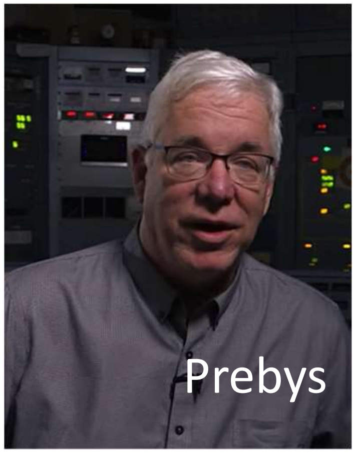






Radiation effects and cancer therapy at the UCD Cyclotron

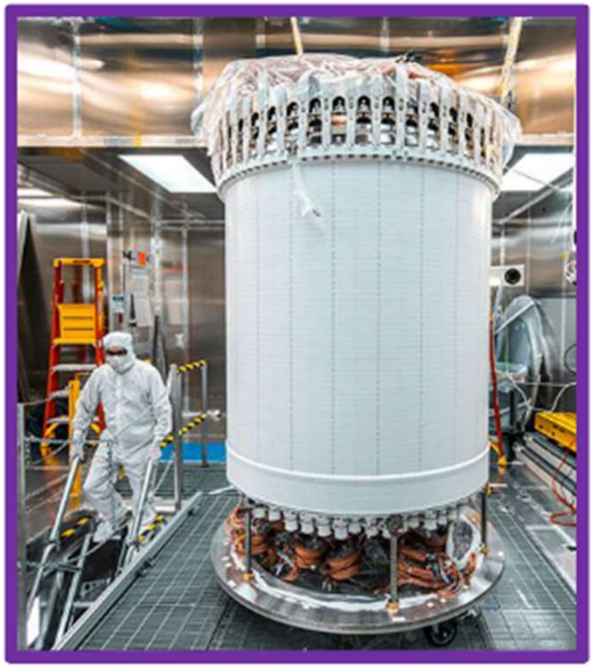
Instrumentation studies of interest to the High Energy Physics community and much wider.



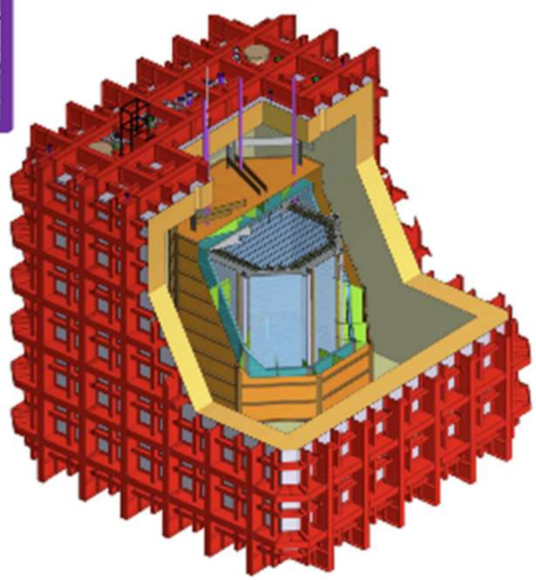
Direct search for Dark Matter with noble liquids

DM UCD: development & construction of

6 students and 1.5 postdocs



LZ - 7 ton LXe detector to start taking data later this year @SURF.



Darkside-20k -50 ton LAr detector under construction @ LNGS.

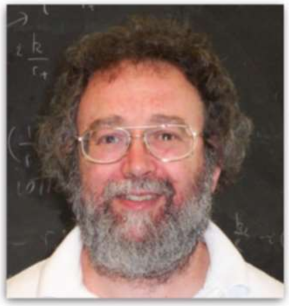
THANK YOU!

UCDAVIS
UNIVERSITY OF CALIFORNIA

Center for Quantum Mathematics and Physics (QMAP)

A research center aimed at fostering a vibrant research environment for addressing foundational questions in modern theoretical and mathematical physics

Fields, Strings & Gravity


Steven Carlip


Veronika Hubeny

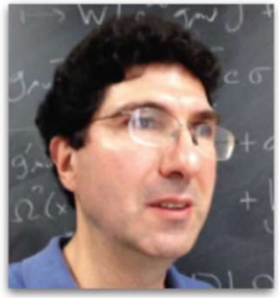

Mukund Rangamani


Jaroslav Trnka

- What is quantum gravity? What is string theory?
- Are spacetime and gravity emergent phenomena?
- Are black holes the most efficient quantum computers?
- Why is gravity holographic?
- What new mathematical structures lie behind quantum field theory?

Elementary Particle Theory

Hsin-Chia Cheng



Markus Luty

John Terning

- What is quantum field theory beyond perturbation theory?
- What is the origin of the exponentially large hierarchies of scales in the fundamental laws of nature?
- What new physics lies beyond the Standard Model of particle physics?
- What is the microscopic nature of dark matter?
- How can we search for new physics in experiments?

Theoretical Cosmology

Andreas Albrecht

Nemanja Kaloper

Lloyd Knox

- How did our universe begin?
- Why is our universe so large and long-lived?
- How do we use quantum mechanics to describe the whole universe?
- What model of cosmic inflation describes our universe?
- What can we hope to learn experimentally about “dark” physics?
- What can we learn from precision cosmological data?

QMAP Office/Interaction Space

Coming Fall 2020…

Agenda

Friday March 13

4:00-5:30pm Faculty Overview/Question & Answer Session

Saturday March 14

8:30-11:30am Virtual Lab and Office Visits with Individual Groups

(separate list of meeting IDs will be sent via email)

12:00-1:15pm Grad Student Panel Discussion

(same meeting ID as this one)

1:15-1:30pm Grad OPS

(same meeting ID as this one)

1:30-2:30pm Faculty Panel Discussion

(same meeting ID as this one)