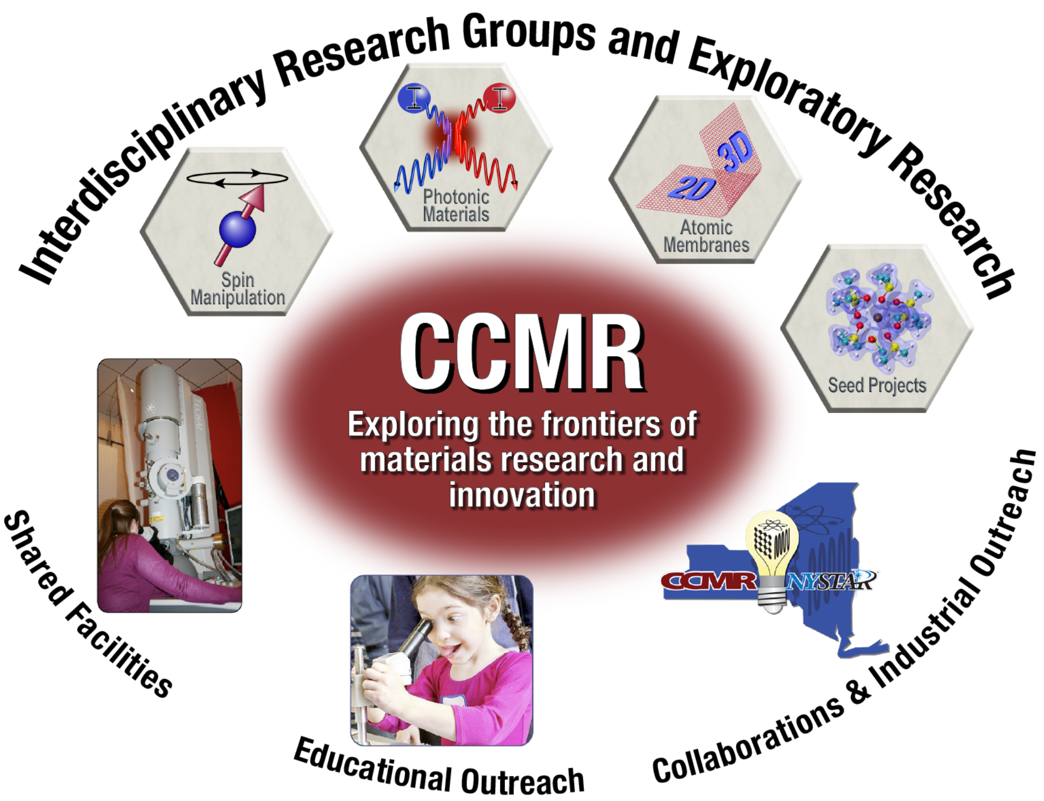
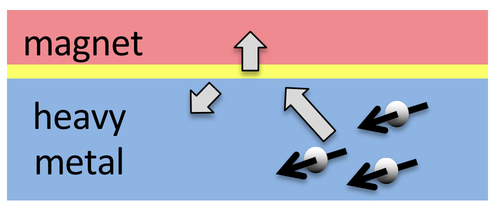
National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

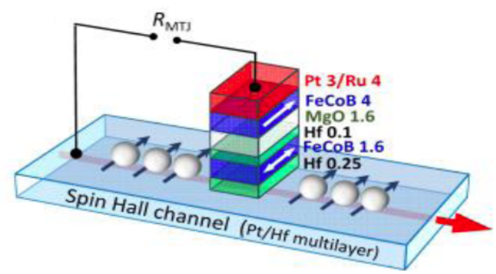
Cornell Center for Materials Research: an NSF MRSEC



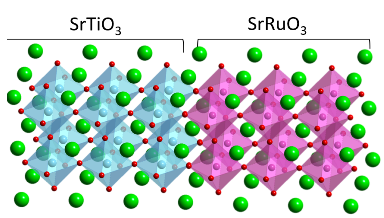
IRG-1: Mechanisms, Materials, and Devices for Spin Manipulation

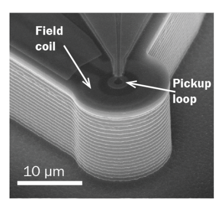
- Major advances in existing materials for spintronics, prototype devices

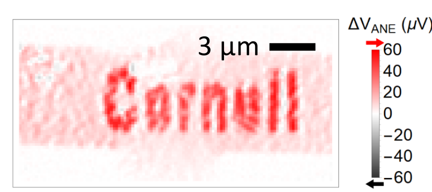




- Now investigating new materials and phenomena
- Enabled by new techniques for imaging spins

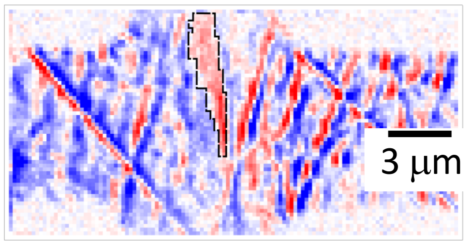




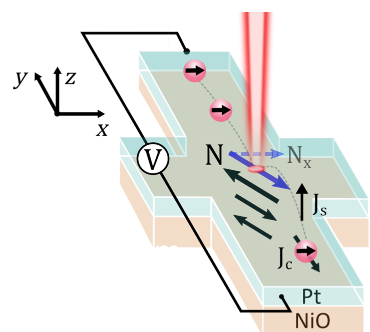


New Magnetic Imaging Techniques

Fuchs, Mak, Muller, Nowack, Shan, Gruner

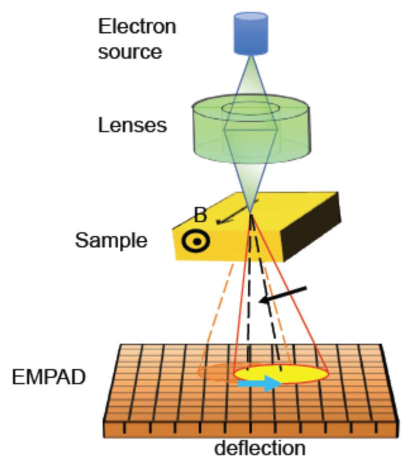


domains in antiferromagnetic NiO



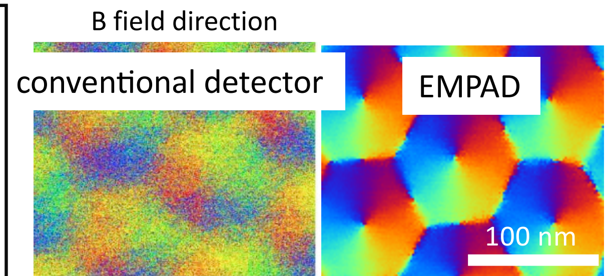
Magneto-thermal microscopy (Fuchs, Nowack, Ralph)

Phys. Rev. X **9**, 041016 (2019)

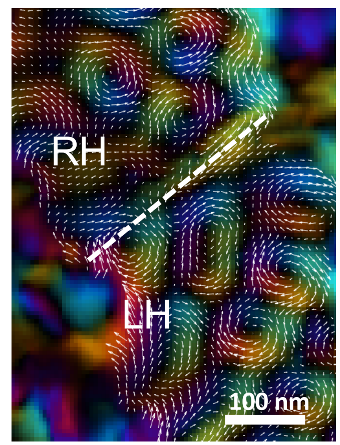


Scanning transmission electron microscopy using electron microscope pixel array detector (Muller, Gruner, Fuchs, Ralph)

Nguyen et al., under review



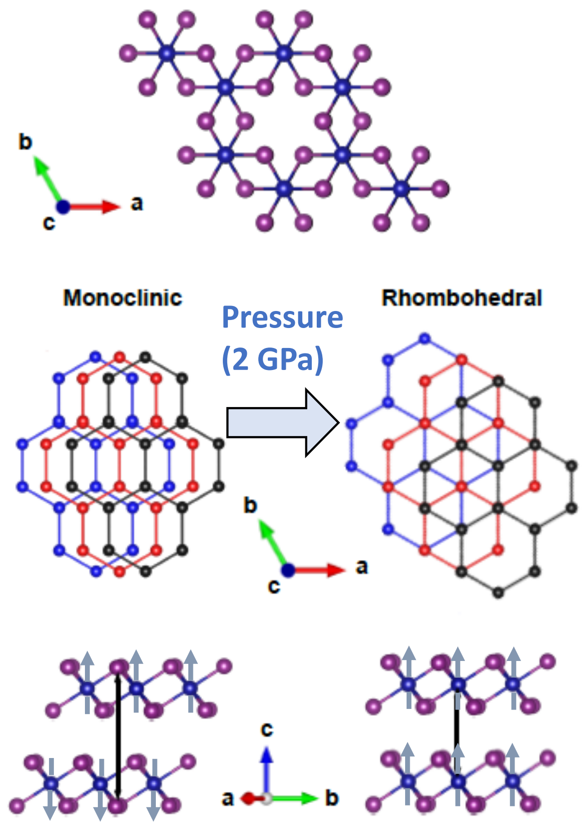
skyrmion lattice in crystalline FeGe



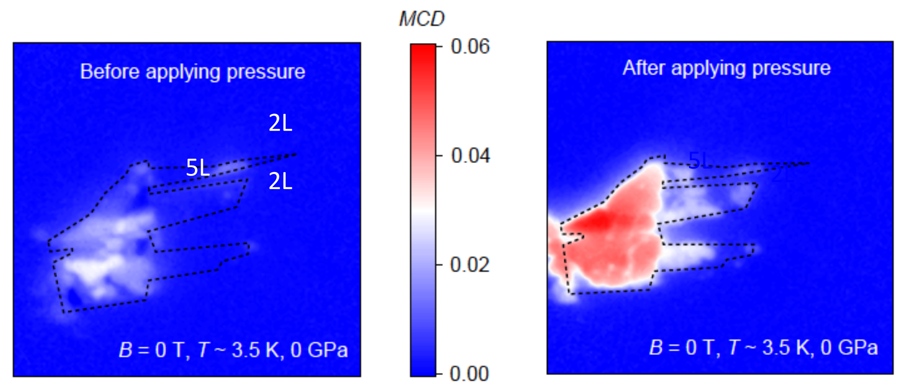
in polycrystalline FeGe

Manipulating spin alignment of 2D CrI_3 through stacking order

Fennie, Mak, Muller, Shan



Antiferromagnet Ferromagnet



- Interlayer spin alignment depends on stacking
- Explains thickness-dependent magnetic state in atomically thin CrI_3
- Opportunity for controlling spin alignment of layers

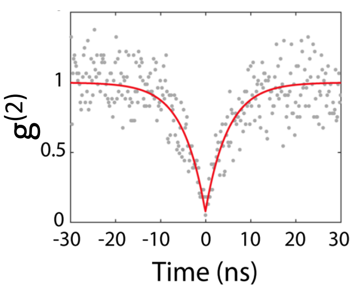
Theory: Nano Lett. **18**, 7658 (2018)

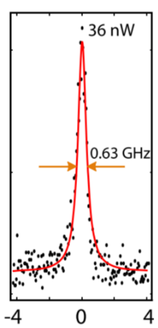
Nat. Mater. **18,** 1303 (2019)

IRG-2: Structured Materials for Strong Light-Matter Interactions

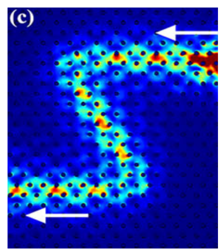
Photonic Materials

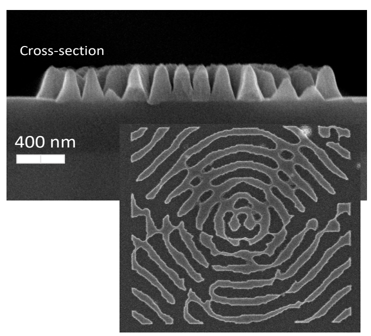
2D single photon emitters…



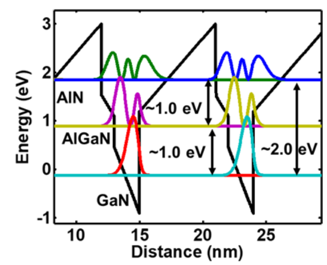


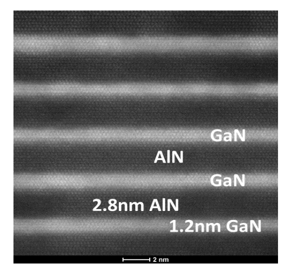
…enhanced with topological and inverse-designed cavities…



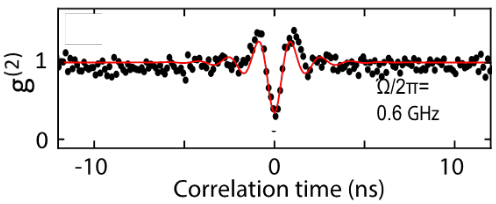


….light efficiently manipulated using extreme nonlinearities enabled by growth and materials design.

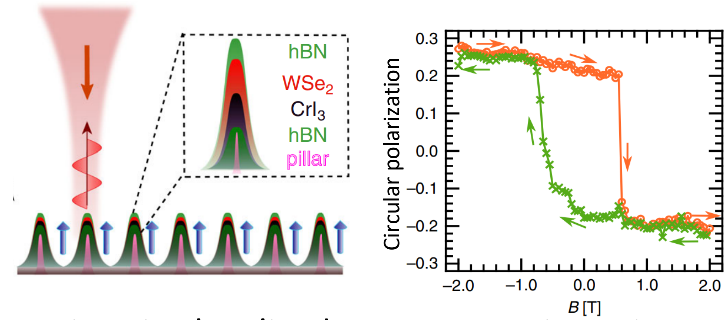




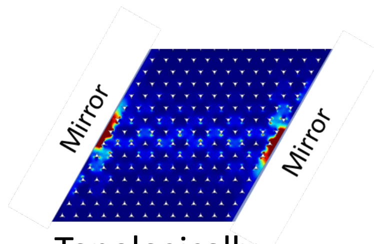
IRG-2: Research Highlights



First Rabi Oscillations of a Single h-BN Quantum Emitter Optica 2019

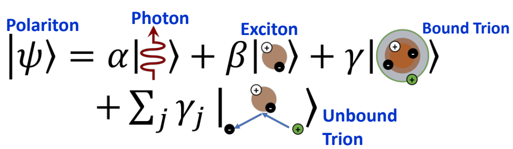


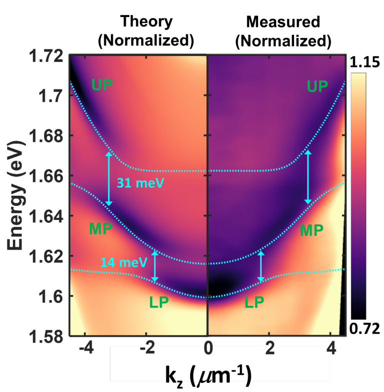
Doping site-localized quantum emitters in monolayer WSe_2 with spin-polarized electrons from a 2D magnet, Nat. Commun. (2020)



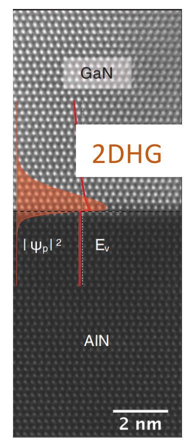
Topologically Controlled Photonic Cavities PRL 2020

Exciton-Trion-Polaritons in 2D materials





PRB 2020, PRB 2020, PRL 2020, arXiv 2021

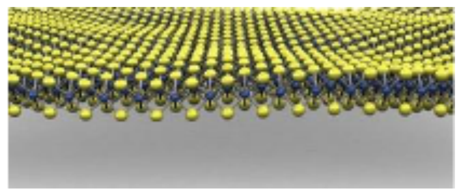


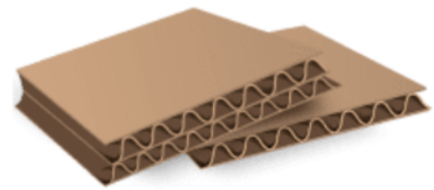
First 2D hole gas in GaN/AlN (bulk) Science 2019

IRG-3: 2D Atomic Membranes for 3D Systems

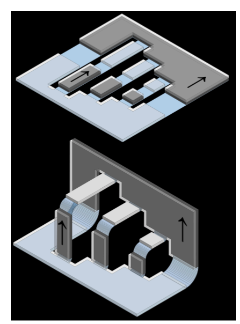
2D 3D Atomic Membranes

- Synthesis and characterization of "smart paper" that is atomically-thin

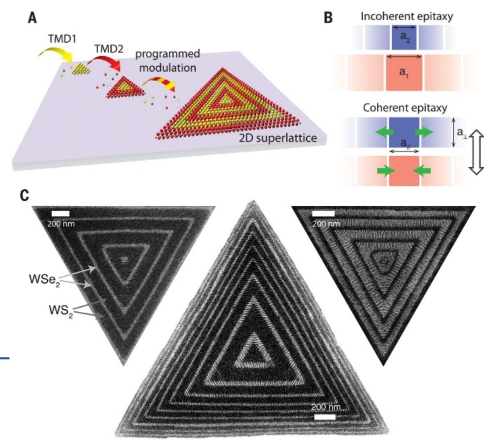




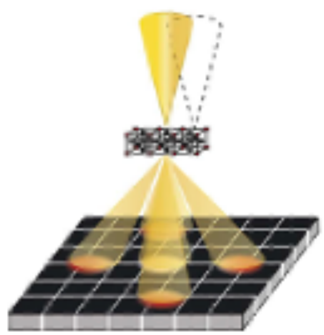
- Approaches to bend and fold membranes in response to environment



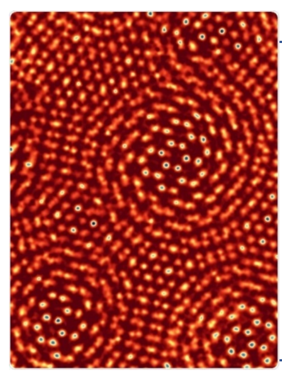
Lateral 2D superlattices



Park, Muller, DiStasio
Science (2018)



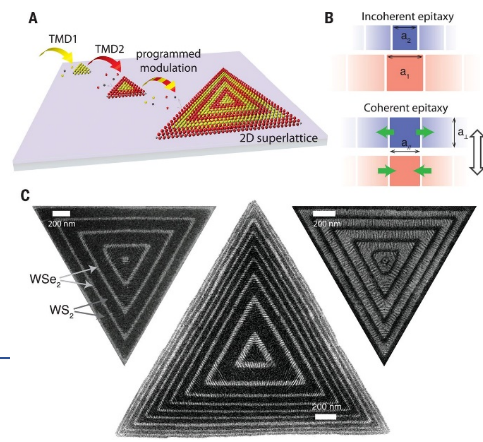
EMPAD



Electron ptychography

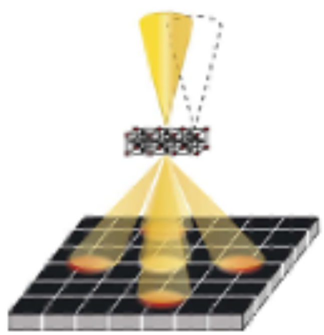
Image resolution increases 3x

Park, Muller
Nature (2018)



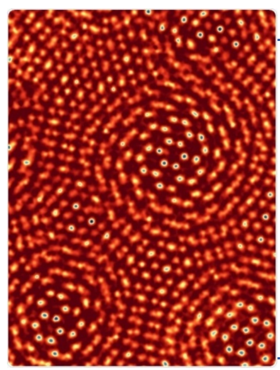
Lateral 2D superlattices

Park, Muller, DiStasio
Science (2018)



EMPAD
now catalog product
v2 funded by TFS

ThermoFisher SCIENTIFIC

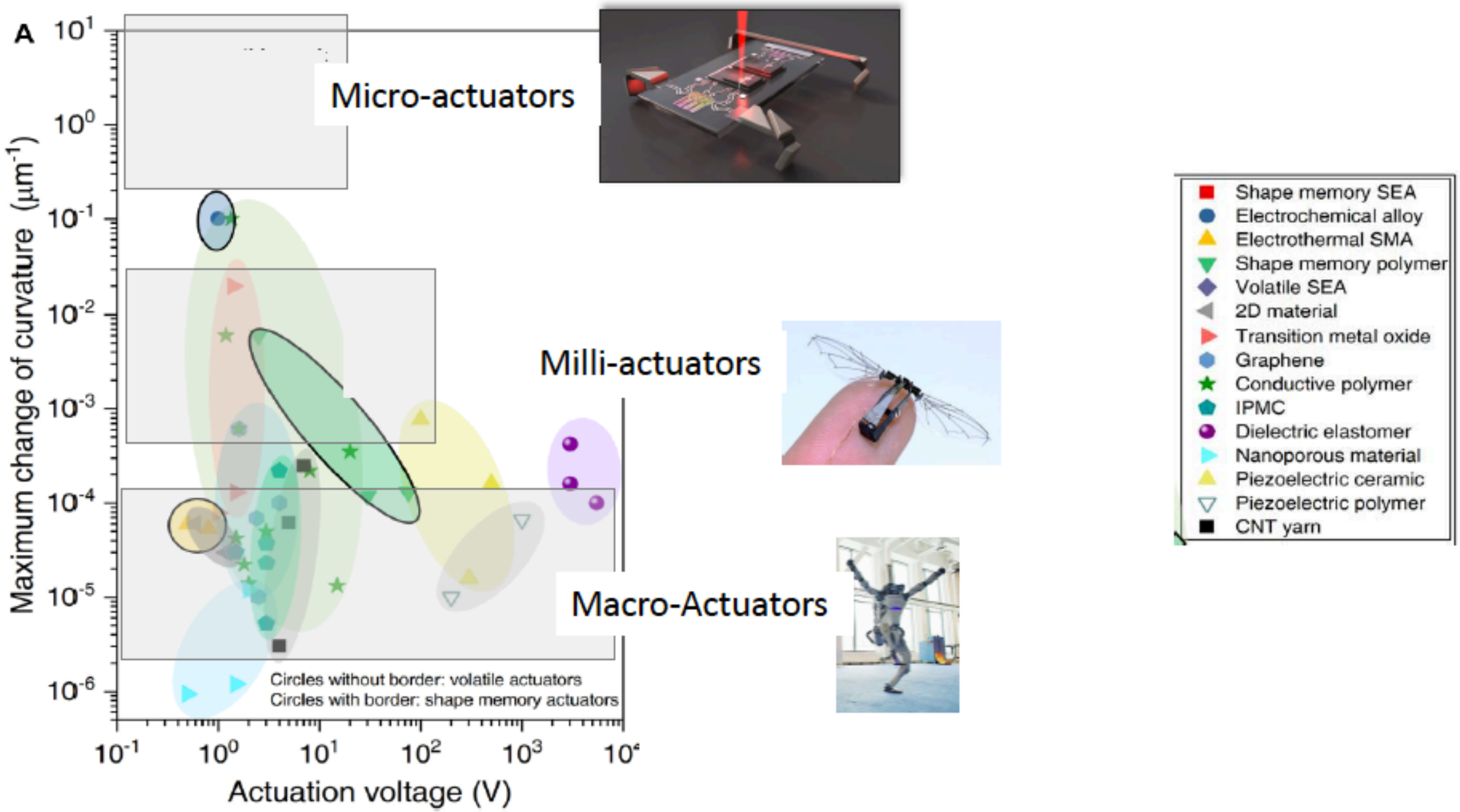


Electron ptychography

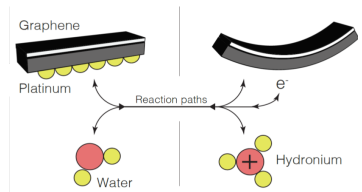
Image resolution increases 3x

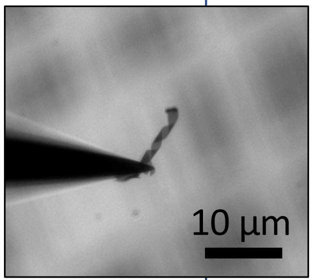
Park, Muller
Nature (2018)

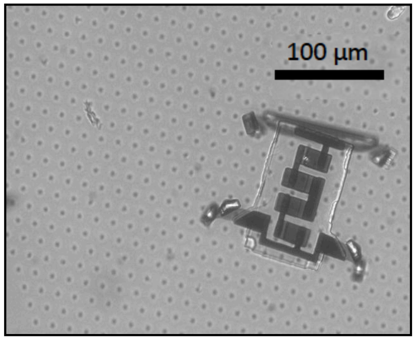
Micro-actuators: an unsolved nanomaterials problem



Microactuating nanomaterials

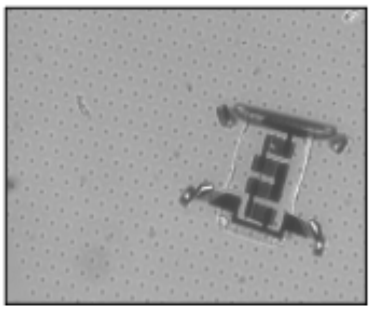






Cohen, McEuen, Muller
Nature (2020)

Disseminating Research Broadly



"smallest walking robot"

Prof. Paul McEuen and postdoctoral associate Mark Miskin present a TED talk on micro-robots. Miskin is now a faculty member at U. Pennsylvania.

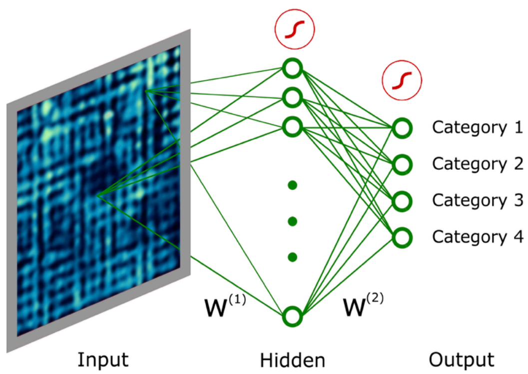
> 300,000 views

Cornell Center for Materials Research: an NSF MRSEC

iSuperSEED2 Supplement from NSF

Harnessing the Scanning Probe Data Revolution with Machine Learning

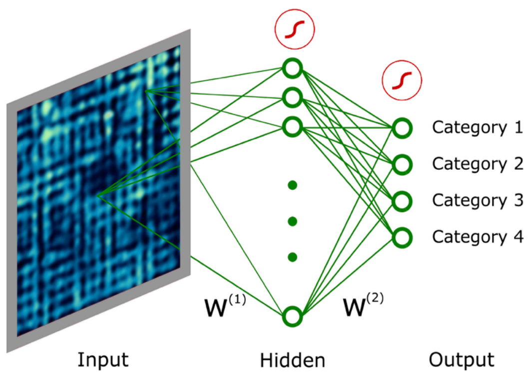
Kim (Phys), Davis (Phys), Weinberger (CompSci)

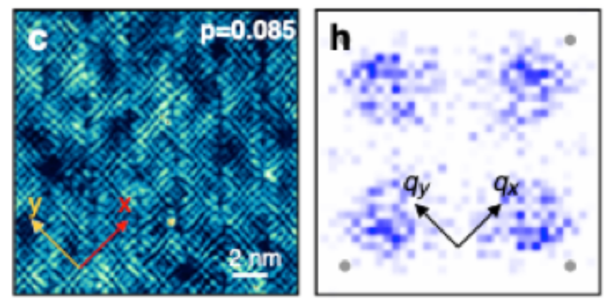


iSuperSEED2 Supplement from NSF

Harnessing the Scanning Probe Data Revolution with Machine Learning

Kim (Phys), Davis (Phys), Weinberger (CompSci)





Neural networks discover
- periodic, symmetry-breaking state
- coincident nematic state

Strong-coupling theories consistent with observations

Zhang et al, *Nature* 570, 484 (2019)

Products of iSuperSEED2

Publications

One-component order parameter in URu_2Si_2 uncovered by…machine learning
Ghosh, Matty et al., Sci. Adv. (2020)

Attention-based quantum tomography on noisy data from IBMQ
Cha et al., arXiv:2006.12469

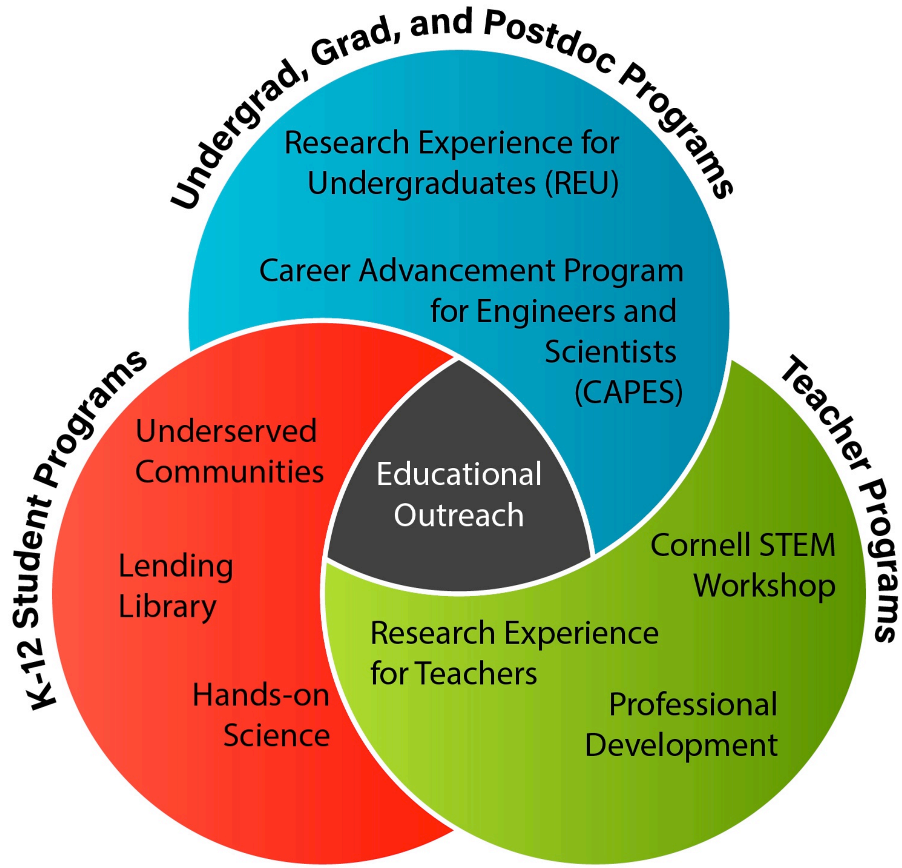
Order parameters in 8 TB of XRD data in 15 minutes
Venderley et al., arXiv:2008.03275

Funding (Kim and Weinberger)

Collaborative Research: Understanding Subatomic-scale Quantum Matter Data Using Machine Learning Tools NSF
Data Science for Discovery in Chemical and Materials Sciences DoE
Frameworks: Enabling widespread adoption of unsupervised machine learning methods by synchrotron x-ray users NSF

Harnessing the Data Revolution (HDR): Institutes for Data-Intensive Research in Science and Engineering
submitted Jan 2021

Educational Outreach



Nev Singhota
Director

National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

Cornell Center for Materials Research: an NSF MRSEC

Online Lending Library of Educational Modules

CCMR
Cornell Center for Materials Research | An NSF MRSEC

Search here...

RESEARCH FACILITIES INDUSTRY EDUCATION ABOUT INTERNAL Site Map

Home / Education / Educational Resources / Lending Library of Experiments / Physics Kits

Lending Library of Experiments

- **Physics Kits**
  - Airboats
  - Alka-Seltzer Rockets
  - Boat Building
  - Bridge Building
  - Buoyancy
  - Catapult (9-12)
  - Catapult (3-8)
  - Discovering Density
  - Density
  - Demystifying Diffraction
  - Drop Tube
  - Electromagnets
  - Friction
  - How a Microscope Works
  - Launch Tube
  - Light Waves (MS)
  - Light Waves (HS)
  - Magnetic Mad Libs
  - Marvelous Magnets
  - Newton's Second Law of Motion

Physics Kits

Experiment	Objective	Grade Levels	Subjects
Airboats	What causes an object to move? Learn about Newton's 3 Laws of Motion, while constructing and testing airboats.	6-8 3-5	Physics
Alka-Seltzer Rockets	Launch a rocket using a film canister and an alka-seltzer tablet. Students will be able to observe and understand how the laws of motion apply to their rocket. They will also investigate how a variable might affect the flight of it.	6-8 3-5	Physics
Boat Building	How do boats float? Classify different materials and see which ones float or sink. Use this knowledge of materials to engineer your own boat and see how much weight you can carry. Students can be introduced to the concept of buoyancy.	K-2	Physics
Bridge Building	How is a bridge able to support all that weight on it? Students examine the forces that affect bridges, learn the advantages and disadvantages between different types of bridges, and build their own bridge to meet certain specifications.	6-8 3-5	Physics
Buoyancy	What is Archimedes' Principle and how does it apply to me? Learn about this famous discovery and why objects are able to float. Students will also work on their measuring skills for mass and volume. They will apply these concepts by constructing a Cartesian diver.	6-8 3-5	Physics
Casting	This kit is not available.	6-8	Physics
Catapult	How does a catapult work? Students will build a basic catapult that hurls marshmallows at targets. Introduce your students to levers, as well as potential and kinetic energy. They will then test variables to engineer the most accurate catapult. A great tie-in with ancient and medieval history	6-8 3-5	Physics

Catapult (3-8) Kit Request

Kit Request Form

* Required

Request Kit *
Catapult (Middle and Elementary School)

First Name
Margaret

Last Name
Rodrigue

Email *
mrodrique@ebrschools.org

School Name *
Wildwood Elementary School

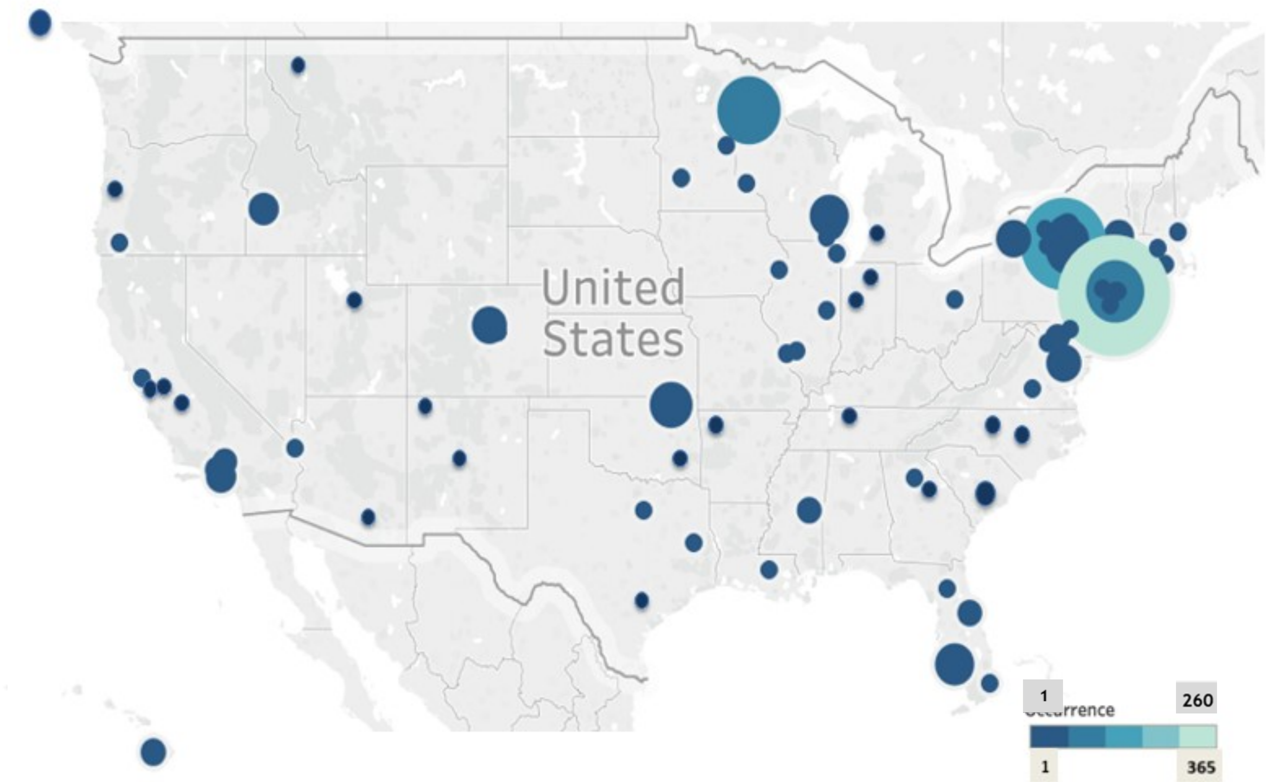
Address

Street *
444 Halfway Tree Rd, Baton Rouge

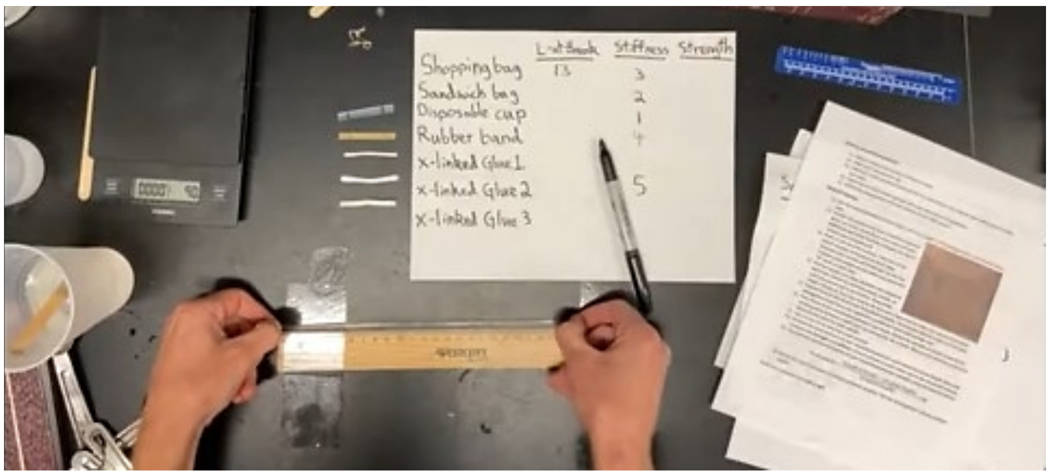
We ship to any teacher in the US!

Lending Library Use (2017-2020)

- 160 schools
- 350 educators
- 9,000 students

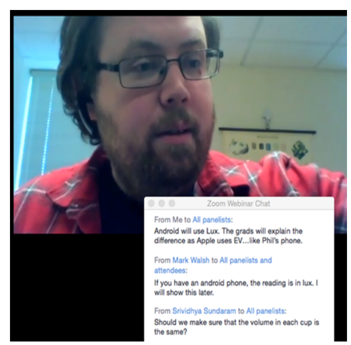


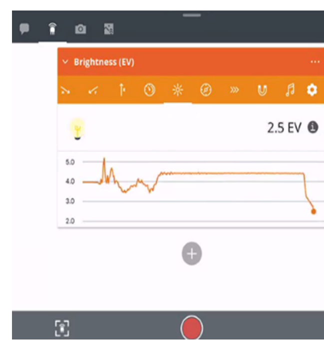
Adapting Lending Library to Remote (Home) Learning



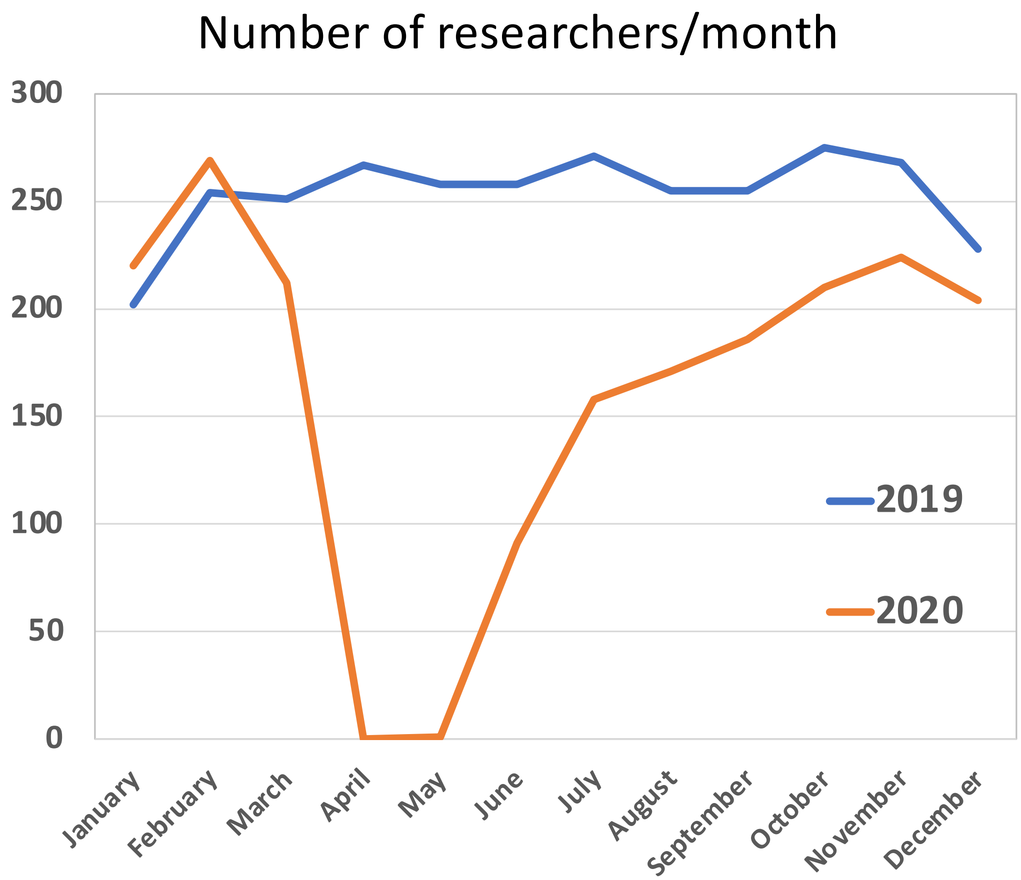
- Observe properties of household plastics
- Make and test “silly putty” polymer

- Optical spectroscopy with a cell phone





Activity in Shared Facilities



- Facilities opened conservatively
- Info from MRFN workshop
- Modified training methods

Jon Shu
Associate Director


Interdisciplinary Research Groups and Exploratory Research
Spin Manipulation
Photonic Materials
Atomic Membranes
2D
3D
Seed Projects
CCMR
Exploring the frontiers of materials research and innovation
Shared Facilities
Educational Outreach
CCMR
NYSTAR
Collaborations & Industrial Outreach