Condensed Matter Experiment & Computation

@ Yale AP
“Quantum” materials engineering
Condensed Matter Experiment & Computation at Yale AP&P

- **Understand** the microscopic mechanisms behind material properties
- **Predict** material properties with advanced theory tools
- **Control** and **create** material properties with experimental methods

- Why is Tc so high?
- Can $F = e^2 / r^2$ be twisted?
- Harnessing the power of nano-magnetism
- Making wafer-scale 2D quantum materials
- How to best functionalize surfaces and interfaces
- Designing next gen energy materials
Quantum Materials

- Understand the microscopic mechanisms behind material properties
- Predict material properties with advanced theory tools
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We do theory with...

- First principles calculation for electronic structure prediction
- Machine learning for quantum mechanics
- Supercomputing facilities for high performance computing

We do experiment with...

- Molecular beam epitaxy
- Bulk single crystal synthesis
- Nano-fabrication
- Scanning tunneling spectroscopy
- Photoemission spectroscopy
- Synchrotron X-ray scattering
- Magnetic imaging and low-T transport
- Scanning nearfield optical microscopy...
EVERY experimentalist here has a strong tie to the national labs

Close collaborations with other departments in SEAS and FAS
  ○ Chemical Engineering, MEMS, Physics, Chemistry...
**Novel complex oxide interfaces:**
- water splitting
- artificial neurons
- spintronics & ferroelectrics

**Atomically resolved** electronic states:
- topological state of matter
- nematicity and superconductivity
- vortex and density waves

**Momentum resolved** electronic states:
- high-Tc superconductivity
- magnetic metals and vdW materials
- correlated electronic systems

**Electronic structure** w/ first principles:
- solid-gas/solid-solid interfaces
- electron correlation in oxides
- 2D material and nanostructure

**Electronic property** w/ numerical methods:
- materials for energy applications
- machine learning in materials physics
- exotic magnetism

**Magnetic nanostructures**:
- topological designer magnets
- artificial spin ice
- low temperature transport properties

**MBE, RIXS, XRD, transport…**

**STS, SNOM, RIXS, ARPES**…

**DFT, Green’s function, slave boson…**

**DFT, MD, Monte Carlo, Machine learning…**

nano-lithography, SEM, MFM, PEEM…