Science & Technology Center for Integrated Quantum Materials
STC NSF grant DMR-1231319

PI: Robert M Westervelt at Harvard University

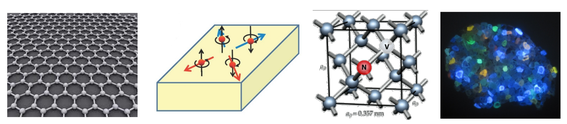
Co-Pis: Gary Harris at Howard University, Raymond Ashoori at MIT & Carol Lynn Alpert at the Museum of Science, Boston

Quantum Information Science & Technology

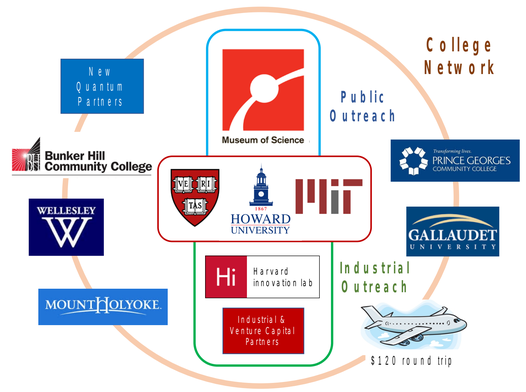
Vision:
Create atomic-scale devices and systems from quantum materials for ***quantum sensors***, ***quantum networks***, and ***quantum computers***.

Quantum Materials

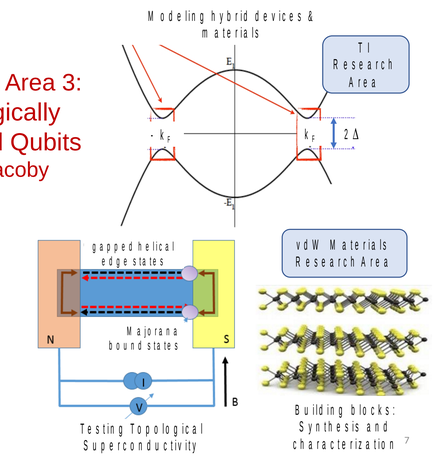
Atomic Layers: Graphene, BN, MoS_2 – *atomic scale devices*
Topological Insulators – *topologically protected data channels*
NV Center Diamond – *1 atom memory sites, quantum sensors*



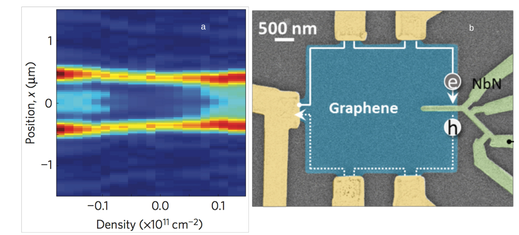
Science & Education Community



Research Area 3: Topologically Protected Qubits
Amir Yacoby



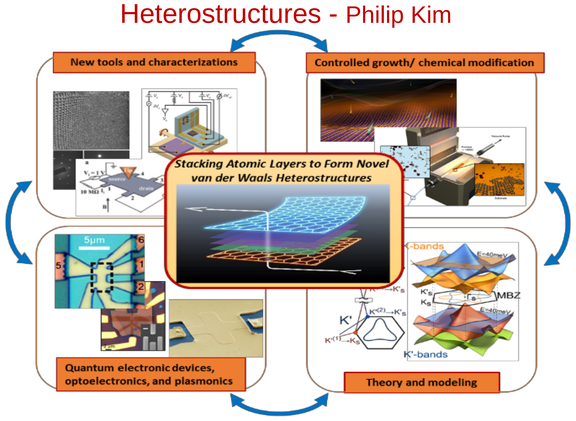
Superconducting Edge States in Graphene
Kim & Yacoby, Research Areas 1 & 3



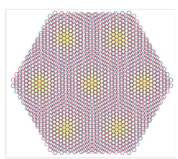
(a) Current positions *vs.* electron density, from superconducting interferometry in a graphene Josephson junction. [Allen ... Jarillo-Herrero, Levitov, Yacoby, Nature Phys (2016)]

(b) Graphene device with a narrow superconducting contact that transmits correlated eh pairs *via* crossed Andreev reflection. [Lee ... Yacoby, Kim Nature Physics (2017)]

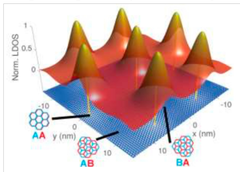
Research Area 1: Novel van der Waals Heterostructures - Philip Kim



Superconducting Carbon – Twisted Bilayer Graphene

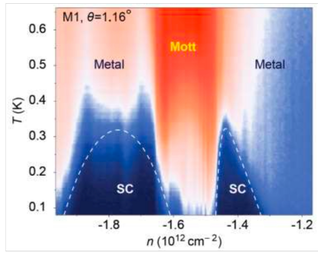


Magic Angle Graphene Bilayer



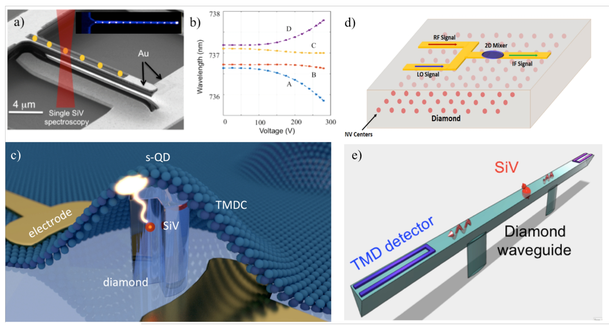
Electron pools form a Mott insulator

Analogous to High Tc Superconductors



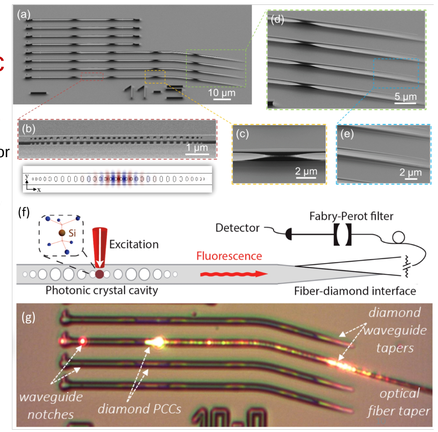
Y Cao, **V Fatemi**, **A Demir**, **S Fang**, **S Tomarken**, **J Luo**, J Sanchez Yamagishi, T Taniguchi, **E Kaxiras**, **R Ashoori**, and **P J arillo-Herrero,** Y Cao et al. *Nature* ***556****, 43* (2018); Y Cao, **V Fatemi**, **S Fang**, K Watanabe, T Taniguchi, **E Kaxiras**, **P J arillo-Herrero** Nature 556, 80 (2018).

Research Area 4: Quantum Networks with Solid-State Quantum Emitters – Marko Loncar

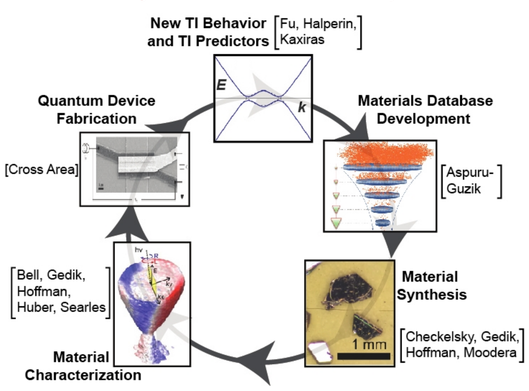


On-chip Diamond Nanophotonic Network
Lukin & Loncar

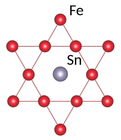
SEM images: (a) resonator array with key parts (b) diamond nanobeam photonic cavities with SiV color centers (c) waveguide support (d, e) diamond tapers for >98% fiber-coupling. (f) SiV fluorescence in the diamond waveguide is collected by optical fiber. (g) Optical fiber taper in contact with a diamond waveguide taper. [Burek ... Nature Comm. (2014)]



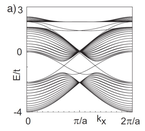
Research Area 2: Discovery of New Topological Crystals - Joe Checkelsky



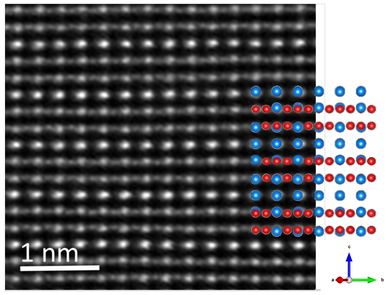
Fe_3Sn_2 –New Ferromagnetic Kagome Metal



Kagome Bilayer



PHYSICAL REVIEW B **80**, 113102 (2009)
H.-M. Guo and M. Franz



STEM Image theory

Ye, Bell, Fu, Comin, Checkelsy et al, Nature (2018).

Nanodays 2018 - Museum of Science - Boston

Joe Checkelsky with high school students

New Collaborations with Industrial R&D

Quantum Sensing, Networks & Computer Programs
at Raytheon / BBN and MIT Lincoln Laboratory

Raytheon BBN Technologies

MIT Lincoln Laboratory

University Collaborations
Graduate Student / Postdoc internships

CIQM CENTER for INTEGRATED QUANTUM MATERIALS

VE RI TAS

HOWARD UNIVERSITY 1867

MIT

Museum of Science