Physics Department Candidate Colloquium

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Atomic Legos: Building next-generation electronics in the 2D limit

Single-atomic-layer crystals can display extraordinary properties. In graphene, a well-known example, the electrons behave as if they have no mass and show quantum coherence phenomena at room temperature. The library of 2D materials is rapidly growing. Boron nitride, dubbed ``white graphene,'' is an excellent insulator, molybdenum disulfide is a semiconductor, and materials like germanene have yet to be fully characterized. These atomic sheets present exciting new opportunities to tune material properties: electronic properties can be controlled by altering their surfaces, and stacks can be assembled to create artificial crystals. Because of their customizability, 2D materials have the potential to form the basis for the next generation of electronic devices. They could lead to better transistors and solar cells, novel devices for spintronics and valleytronics, and devices that have yet to be invented. In this talk, I will describe using scanning tunneling microscopy (STM) to explore the creation and control of artificial materials based on 2D crystals. STM allows us to image the materials with atomic resolution and also study their local electronic properties. In experiments with graphene grown on copper, we are measuring the effect of the copper on the electronic properties of the nearby graphene sheet. This information will help us understand how layers in 2D material stacks interact with each other. We are also performing experiments in selectively bonding hydrogen atoms to the graphene sheet using the STM tip. Graphene is an excellent conductor, but its hydrogenated cousin, graphane, is an excellent insulator. Using the properties of graphene versus graphane, we hope to be able to write circuits directly into a 2D material canvas.

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