Condensed Matter Physics Seminar Series

Slippery and flat: Ultrathin bismuth grown inside atomically-flat van der Waals materials

Javier Sanchez-Yamagishi

UC Irvine

In a helical conductor, spin orientation is tied to propagation direction, enabling the electrical generation and detection of spin polarization. Bismuth hosts helical states on its surfaces and edges which have been studied extensively by STM and ARPES. However, electrical measurements have been limited by the quality of thin crystals where conduction through the semimetallic bulk is quenched. This challenge in growing thin uniform crystals is general to most materials that are not of the van der Waals layered form.

We have developed a new approach to thin crystal synthesis by growing bismuth within a nanoscale mold made of van der Waals (vdW) materials. The atomically-flat vdW mold templates the bismuth crystals to create ultraflat surfaces. The vdW-molded bismuth shows exceptional electronic transport, enabling us to observe quantum oscillations originating from the surface state Landau levels. Such Shubnikov–de Haas oscillations of the magnetoresistance were first discovered in bismuth in 1930, but have not been previously observed in the bismuth surface states. These crystals enable us to study the intrinsic properties of confined bismuth and its boundary modes. Beyond bismuth, the vdW-molding approach provides a low-cost way to synthesize thin crystals and directly integrate them into a vdW heterostructure.

I will also discuss our recent work in studying mechanically-tunable vdW heterostructure devices, where device geometry, moire structure, and heterostrain can all be modified post-fabrication and in-situ with electrical measurements. This approach is also enabled by the slippery and flat atomic structure of van der Waals materials

Javier Sanchez-Yamagishi is an Assistant Professor in the Department of Physics & Astronomy at the University of California, Irvine. His lab studies quantum electronic transport in van der Waals and topological materials with a special emphasis on developing new nanofabrication and measurement techniques. Previously, he was a postdoctoral fellow at the Harvard Quantum Optics Center, where he explored the application of spin qubits as nanoscale magnetometers for 2D materials. He did his PhD at MIT, where he studied the electronic properties of twisted graphene heterostructures.

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4-330 PAB