

# School of Physics and Astronomy

## COLLOQUIUM



**Professor Emanuel Tutuc**  
*The University of Texas at Austin*

### Electron Physics in Rotationally Controlled van der Waals Heterostructures

Heterostructures of atomic layers such as graphene, hexagonal boron-nitride, and transition metal dichalcogenides (TMDs) can serve as testbed for novel quantum phenomena in two-dimensions (2D), and potential device applications. A key ingredient that can add a new dimension to the atomic layer heterostructures palette is the rotational control, and alignment of different 2D layers. We discuss here an experimental technique that enables rotationally controlled atomic layer heterostructures with accurate alignment and control of individual layer crystal axes.

We illustrate the applicability of this technique to rotationally aligned double layers of graphene or TMDs, as well as to realize controlled moiré patterns of 2D materials. In rotationally aligned double layers of 2D materials we will explore resonant, energy- and momentum-conserving tunneling in vertical transport in samples with independent contacts to each layer, and discuss findings consistent with single particle calculations, as well as findings consistent with a collective state when the two layers have equal densities of electrons and holes.

In samples with two 2D layers are overlaid with a relative twist, the resulting heterostructure shows a clear periodicity when viewed from a distance. This new type of moiré superlattices are beginning to be systematically investigated as platform for strongly correlated electron physics owing to flat energy bands. We discuss the electron transport in tunable moiré patterns realized in twisted bilayer graphene, and double bilayer graphene heterostructures. In twisted double bilayer graphene an applied transverse electric field can be used to tune the spectral isolation of flat moiré bands, which favors the appearance of correlated insulators at  $1/4$ ,  $1/2$ , and  $3/4$  band filling. These findings are consistent with a mean-field picture in which insulating states are established by breaking both spin and valley symmetries in a moiré flat band.

Date:	Wednesday 29 January
Time:	2pm
Venue:	L1, Seminar Room 107, 10 College Walk, Clayton