TITLE:
Layered materials in 3D: Interlayer charge dynamics in metallic transition metal dichalcogenides

AUTHOR: Edoardo Martino

Abstract Body:
Layered metallic transition metal dichalcogenides (TMDs) are conventionally seen as two-dimensional conductors, despite a scarcity of systematic studies of the interlayer charge transport. Motivated by the prevailing strategy of functionalizing 2D materials by creating van der Waals heterostructures, we initiated an in-depth study of out-of-plane charge dynamics and emergent properties arising from interlayer coupling. Unprecedented results have been obtained thanks to employing Focused ion beam (FIB) assisted 3D microfabrication, which enables tailoring geometry and current paths with submicron precision.
In this talk, I will introduce you to the fabrication process [1], highlighting details and challenges, and present a variety of advantages that this approach offers for the investigation of charge transport in layered materials.
I will conclude by discussing a new set of results that was obtained for 1T-TaS$_2$, a compound with the richest charge density wave phase diagram among TMDs. This layered material presents a peculiar nanoarray of charge density wave, along with a $c$-axis oriented orbital texture originating from the Ta $d_{x^2}$-orbitals. Electrical conductivity anisotropy, measured on FIB-tailored samples, reveal a robust coherent out-of-plane transport, while in-plane conduction is hindered by the CDW nanoarray. The results have a further implication in the understanding of the highly debated metal-insulator transition in 1T-TaS$_2$. In light of the preferential out-of-plane conduction, the electronic transition is better described as a Peierls-like instability of the $c$-axis-oriented orbital chains, in opposition to the long-standing Mott localization picture.