

Superpuddles Lab: Naples–Dresden joint facility for superconducting 2D materials and twistronics in quantum technologies

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I will introduce the Superpuddles Lab, a joint facility in Dresden and Naples that I have founded, devoted to the fabrication and spectroscopy of complex artificial two-dimensional quantum materials. The two sites will exchange students and combine expertise in complex quantum materials synthesis with advanced van der Waals techniques for interface fabrication and electrical contacting, aiming to develop new platforms for superconducting quantum communication and quantum computing. I will discuss how cryogenic stacking, interface engineering, and nanoscale spectroscopy are transforming complex two-dimensional quantum materials, with a focus on cuprate-based heterostructures. Originally developed to preserve fragile cuprate interfaces, these techniques can now be integrated in ultra-high vacuum and extended to other two-dimensional superconductors and multilayer twisted architectures, enabling cleaner interfaces, scalability, improved electrical contacts, including superconducting resonators, and better control of Josephson physics. Finally, I will discuss microscopic mechanisms made accessible by these improved capabilities, including parity protection from Cooper-pair co-tunneling and Fano resonances arising from the coupling between charge-density-wave puddles and phonon modes in two-dimensional superconductors.

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