Uniaxial Control of Cuprate Superconductors

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I will present our recent advances in using uniaxial pressure as a clean "surgical" tool to tune quantum phases while simultaneously obtaining microscopic insights via scattering experiments. The realizations of the experiments are enabled through technical developments by minimizing the background and enabling the tuning in-situ [1].
To achieve the fine-tuning, we have designed a uniaxial device based on an actuator-motor mechanism, efficient feedback loops, and a sample-holder design enabling rapid exchange of the samples [2]. I will demonstrate the capabilities of this device by reporting the control of charge and structural degrees of freedom as studied by X-rays in an archetypal cuprate [3,4]. We extend the in-situ experiments to neutron scattering of magnetism in cuprates characterized by small moments, which remains challenging for pressure studies. We overcome these difficulties by designing a low-background uniaxial strain cell, performing neutron-tracing simulations and using aggressive focusing and energy analysis. Such a setup allowed us to track the spin order parameter [5] and the superconducting transition temperature as a function of uniaxial pressure applied in different directions [6]. I will finish by discussing our ongoing work on studying the interplay of magnetism and superconductivity in uniaxially pressurized systems.

[1] 1. Simutis et al., Swiss Neutron News 62, 14 (2023).
[2] 2. Simutis et al., Review of Scientific Instruments 94, 013906 (2023).
[3] 3. Guguchia et al., PNAS 121 (1) e2303423120 (2023).
[4] 4. Thomarat et al., Communications Physics 7, 271 (2024).
[5] 5. Simutis et al., Communications Physics 5, 296 (2022).
[6] 6. Philippe et al., In preparation.