Symposium on Quantum Materials Synthesis, Porto, October 22 - 24, 2025

Negative differential photoconductivity and Gunn-like oscillations in $SrTiO_3$ single crystals

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SrTiO3 (STO) holds significant potential for application in the field of oxide electronics as a wide band gap semiconductor, displaying a plethora of effects that include metallic-like conductivity by n-type doping, high electron mobility exceeding 10^4 $cm^2V^{-1}s^{-1}$, superconductivity at 0.28K, large Seebeck coefficient, quantum paraelectric state under 37K, and room temperature ferroelectricity under compressive strain. The STO-based heterostructures, the most relevant being the epitaxial $LaAlO_3$ grown on STO (100), are showing even more interesting properties spanning from 2D electron gas to ferromagnetism and superconductivity. Notably, STO and its heterostructures in the low-temperature regime, overlapping with the quantum paraelectric state, display remarkable photoelectric activity featuring anomalous photoconductivity and photoluminescence or coherent photo-electron emission.

Here we show that when photo-excited with band gap energy photons, $SrTiO_3$ exhibits non-linear transport of photocarriers and voltage-controlled negative resistance, resulting from an intervalley transfer of photo-induced electrons. As a consequence of the negative resistance, the photocurrent becomes unstable and spontaneously gives rise to low-frequency Gunn-like oscillations.[1,2] These effects are coupled with the field quenching of the main photoluminescence, revealing a complex band structure.

References:

[1] M. Soleimany, M. Alexe, Photoinduced Negative Differential Resistivity and Gunn Oscillations in SrTiO3. *Advanced Science* **10**, (2023).
[2] A. C. Newing, M. Alexe, Non-linear Photoexcited Negative Differential Conductivity in Bulk SrTiO3 Single Crystals. *Advanced Electronic Materials*, (2024).