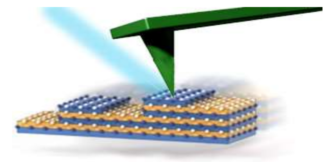
Non-linear photoelectric processes in quantum paraelectric $SrTiO_3$



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The field of photoferroelectrics has experienced a resurgence of interest, particularly with reports of novel phenomena observed in systems with broken inversion symmetry [1,2]. Recently, we discovered that when subjected to illumination, SrTiO3 single crystals exhibit oscillatory behaviour akin to that observed in high-mobility materials like GaAs or InSb [3]. When illuminated with photons possessing energy above the bandgap, SrTiO3 in its quantum paraelectric state, show non-linear transport of photocarriers, leading to voltage-controlled negative resistance. This behaviour was attributed to the Ridley-Watkins mechanism [4] that involves the transfer of free electrons from the high-mobility energy valley of the band structure to a higher energy satellite valley characterized by lower carrier mobility. The consequence of this negative resistance effect is the emergence of unstable photocurrent behaviour, which spontaneously gives rise to low-frequency oscillations reminiscent of Gunn-like oscillations.

The aim present project is to investigate the photoelectric effects in SrTiO3 in the quantum paraelectric regime in order to fully understand the mechanism of this abnormal photoelectric effect. A key aspect of the investigation involves unravelling the role of potential symmetry-breaking phenomena at the material's surface and internal domain walls. To achieve this goal, we will explore the influence of various factors, including strain and other forms of external excitation, to modulate the observed photoelectric effects. The role of ferroelastic domain walls and other structural defects in the photo effects will be also investigated by local mapping specific photoelectric quantities, e.g. generation and recombination rates using low temperature atomic force microscopy and magneto-transport.

The project's effective work will include a comprehensive characterization of the photoelectric properties of SrTiO3 in all its forms, including bulk single crystals, strained and/or suspended thin films. This characterization will involve both structural and semiconductor measurements, allowing for a systematic understanding of the material's behaviour under photoexcitation. The research will address investigation of local photoelectric properties by making use of the already-existing low-temperature Photo-AFM (Atomic Force Microscopy) system, which provides a platform for high-resolution imaging and measurements at the nanoscale.

To discuss this project further contact:

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References

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[3] Mehrzad Soleimany and Marin Alexe, *Photoinduced Negative Differential Resistivity and Gunn oscillations in SrTiO3*, Advanced Sciences, 2306420 (2023).
[4] B. K. Ridley, T. B. Watkins, Proc. Phys. Soc., **78**, 293 (1961).