

Gate-Modulated Polarization Rectification for Giant Nonlinear Enhancement in Heterojunctions



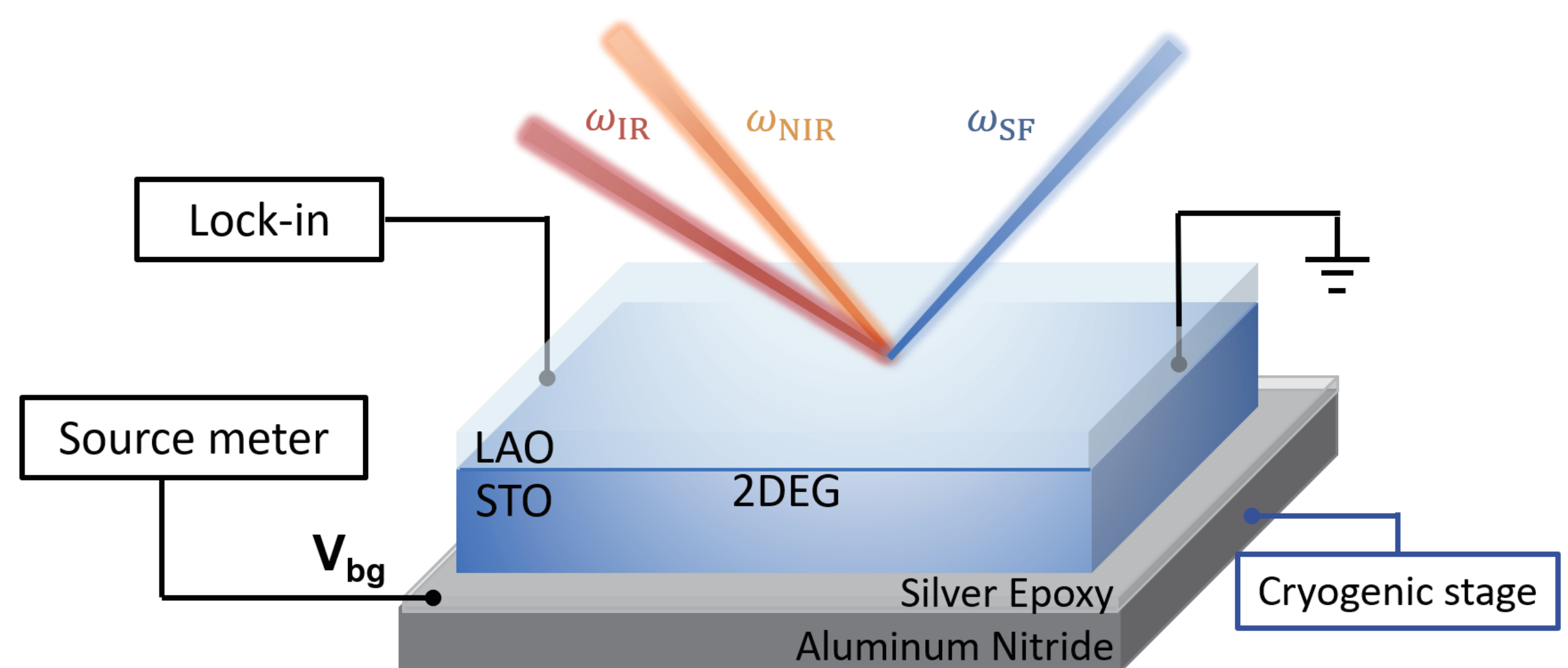
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Introduction

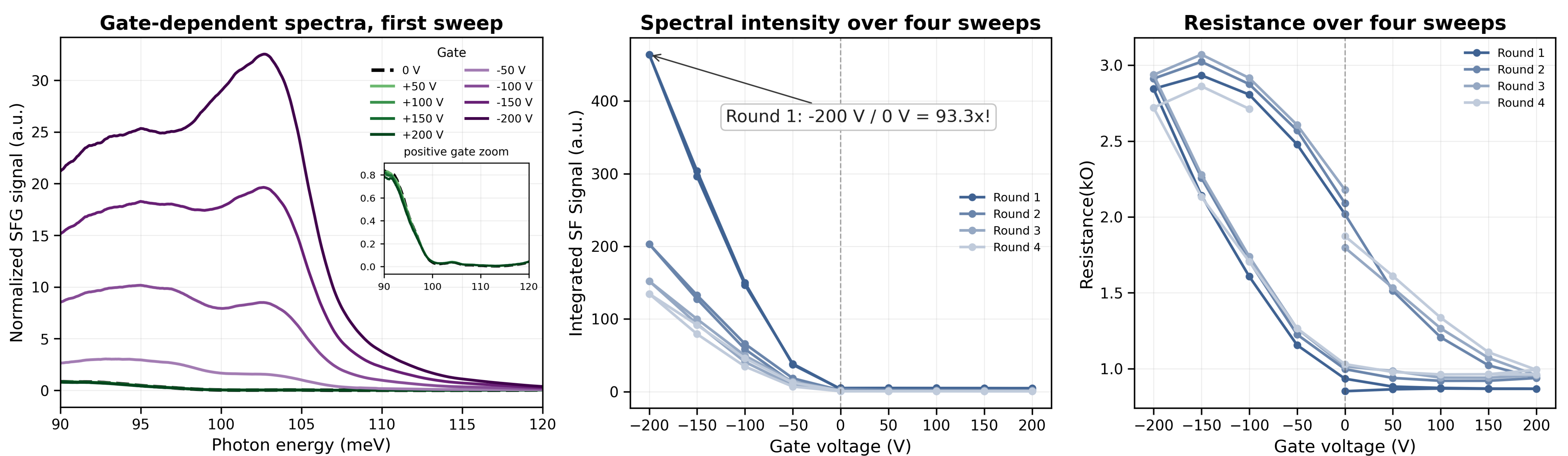
Background: Correlated oxide interfaces host quantum-confined phenomena (e.g., two dimensional electron gas and superconductivity), holding great promise for next-generation electronics.

Challenge: Dynamically manipulating these states and directly probing the gate-driven inversion symmetry breaking at buried interfaces remain experimentally difficult.

Methodology: We utilize interface-sensitive sum-frequency generation (SFG) spectroscopy to investigate gate-tunable dynamics in perovskite $\text{LaAlO}_3/\text{SrTiO}_3$ and $\text{LaAlO}_3/\text{KTaO}_3$ heterointerfaces.



Results



- **Spectral Assignment:** The 103 meV peak corresponds to the anti-phase vibrational mode of Ti-O_6 octahedra.
- **Unidirectional Modulation:** Positive back-gate bias leaves the signal nearly unchanged, while negative bias drives a massive $\sim 93.3x$ enhancement at -200 V and 35 K.
- **Contrasting Hysteresis:** Transport measurements exhibit a pronounced hysteresis loop, whereas the SFG optical response shows negligible hysteresis.
- **Fatigue & Recovery:** Continuous sweeps cause a progressive fatigue decay in SFG enhancement (while resistance remains fully repeatable), which recovers after 12 hours in a cold, dark environment.

Discussion

- **Quantum Well Confinement:** Negative back-gate narrows and steepens the interfacial quantum well.
- **2DEG Depletion:** The interfacial 2DEG is depleted, leading to suppressed electronic screening.
- **Field Penetration:** The DC electric field penetrates deeper into the STO bulk region.
- **Symmetry Breaking:** The penetrating field breaks the inversion symmetry, inducing polarization within the bulk STO.
- **Origin of Enhancement:** The giant SFG enhancement is primarily dominated by the electric-field-induced (EFI) bulk response.

