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Ultrafast Dynamic Screening in Insulators: Tuning and Probing Electronic Properties

Tuning the electronic properties of materials is typically achieved by altering chemical composition or thermodynamic parameters. An alternative route relies on ultrafast light excitation, which can create transient phases inaccessible with conventional parameters, such as light-induced superconductivity and hidden insulator-to-metal transitions. In this talk, I will show how light-driven dynamic screening of core excitons and electron correlations serve as a sensitive fingerprint of the electronic structure in insulators near their band gap. In ZnO, photoinduced screening of core excitons reveals the density and distribution of photoexcited carriers in phase-space [1, 2]. In NiO, a prototypical charge-transfer insulator, light excitation transiently weakens electron correlations, stabilizing a metastable phase with potential for passive optical switching [3].

[1] Rossi, T. C. et al. Dynamic control of X-ray core-exciton resonances by Coulomb screening in photoexcited semiconductors. Communications Materials 6, 0 (2025).
[2] Rossi, T. C. et al. Charge Carrier Screening in Photoexcited Epitaxial Semiconductor Nanorods Revealed by Transient X-ray Absorption Linear Dichroism. Nano Letters 21, 9534–9542 (2021).
[3] Rossi, T. C. et al. Dynamic control of electron correlations in photodoped charge-transfer insulators, Science Advances, in press

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