

## Terahertz Gain Induced by Light-Field-Driven Exciton States

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### Abstract

This work investigates excitonic dynamics in (Ga,In)As/GaAs quantum wells using ultrafast optical pump–THz probe spectroscopy. Under resonant excitation, a clear 1s–2p absorption feature reveals coherent exciton formation. Off-resonant excitation induces a distinct THz gain and blue-shifted absorption, observable only during pump–probe temporal overlap. The gain scales linearly with pump power and shows bleaching at high THz fields, consistent with exciton ionization. These effects confirm a coherent, exciton-driven origin. Microscopic simulations support the experimental findings, identifying wave-mixing and light-dressed exciton states as key mechanisms. The study demonstrates a new route for controlling excitons and achieving THz amplification in quantum wells.