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Inhibition of Linear Absorption, Anomalous Momentum States, Non-Specular Reflections, and Negative Refraction of Phase-Locked, Second and Third Harmonic Pulses

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Summary

We theoretically predict and experimentally demonstrate the inhibition of linear absorption in parametric processes that involve phase mismatched second and third harmonic (SH and TH) generation in absorbing materials, including semiconductors at frequencies well above the electronic band edge. The effect occurs as a result of a basic phase-locking (PL) mechanism that causes a portion of the generated pulses to become trapped by the pump. The pump is able to impress its dispersive properties on the generated pulses, including absorption or the lack thereof, so that all the fields propagate with the same effective dispersion and velocity. The requirements are that the pump be tuned in a transparency range, and that the nonlinear coefficients be non-zero. An experiment was carried out using a 100-fs incident pump field tuned to 1188nm that generates 594nm and 396nm harmonic pulses that propagate across the entire length of a GaAs substrate 450μm thick, despite the high imaginary index of refraction above the band edge.

The consequences of PL are equally dramatic in negative index materials. Using a generic Drude model for the dielectric permittivity and magnetic permeability, the fields are tuned so that the respective indices of refraction are negative for the pump and positive for the SH signal. The PL mechanism then causes part of the SH signal to become trapped by the pump and to refract negatively, even though the index of refraction at the SH frequency is positive. These circumstances lead to the creation of an anomalous state consisting of a forward-moving SH wave packet that has negative wave vector and momentum density, which in turn leads to non-specular reflections at intervening material interfaces. This describes a new state of negative refraction, associated with nonlinear frequency conversion and parametric processes whereby a beam generated at the interface can refract negatively even though the index of refraction at that wavelength is positive.

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