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Ultrafast Optics with Quantum Coherence: Physics and Applications[1]

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Quantum atomic or molecular coherence is the central feature of multiple techniques, and corresponds to a situation where atoms or molecules of a sample are prepared in a coherent superposition state. High degree of coherence can lead to astonishing results. Atomic coherence has earlier been used in electromagnetically induced transparency, ultraslow light propagation, and lasing without inversion. Recent work has shown that an increased and cleverly manipulated molecular coherence enables improvements in optical detection and sensing. Another remarkable example is a technique termed molecular modulation, which allows ultrafast laser pulse shaping and non-sinusoidal field synthesis via coherent Raman generation. Experimentally, the molecular-modulation light source is characterized by a bandwidth spanning infrared, visible, and ultraviolet spectral regions, generating bursts of light synchronized with respect to the molecular oscillations. Controlled spectral, temporal, and spatial shaping of the resultant waveform will allow arbitrary ultrafast space- and time-tailored sub-cycle optical field synthesis.

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