QUANTUM OPTICS

Squeezed Light-emitting Diode Arrays

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A new type of squeezed light optoelectronic system has been devised[1] that has potential applications in lightwave communications and instrumentation situations where performance is shot-noise limited. An electrically coupled tandem array of light-emitting diodes or laser diodes operates as a modulated photon number amplifier of sub-shot noise light.

Initial theoretical work on the generation of amplitude squeezed (sub-shot noise) light by light-emitting diodes [2] and laser diodes[3] has led to a number of laboratory investigations that demonstrate the ease with which amplitude squeezed light may be generated by semiconductor junctions, particularly light-emitting diodes.[4,5]

In the course of a recent investigation[4] we were able to demonstrate, for the first time, the generation of quantum-correlated, sub-shot noise, twin-light beams from a pair of electrically-connected light-emitting diodes. This demonstration opens up the possibility of novel squeezed light devices and systems that use the quantum correlations between multiple light wave beams generated by a tandem array of semiconductor light emitters.

For example, if a tandem array of N semiconductor light emitters is driven by a high impedance source, or, alternatively, if the number, N, is sufficiently large, quantum noise is suppressed below the normal shot noise level (SQL) in the individual beams. The resulting composite beam, whether coherently or incoherently formed, will preserve the enhanced signal-to-noise ratio (SNR) characteristic of modulated sub-shot noise light. Moreover, this enhanced SNR can be made robust against attenuation,[6] and thereby overcome the usual degradation of squeezed light in lossy systems.

Such an array may therefore be considered a modulated photon number amplifier of sub-shot noise light. Applications include operation and a sub-shot noise optoelectronic coupler with current gain greater than unity (incoherent operation) and as a generator of robust high SNR lightwave signals suitable for optical fiber input (coherent operation).

If the array is driven by a high quantum efficiency detector, it becomes a low noise photon number amplifier with a limiting noise figure of unity for both classical and non-classical light.[1]

"Wired " optical systems of this type are of theoretcial interest because they demonstrate direct coupling between macroscopic, classical electronic circuit noise and non-classical (sub-Poissonian) photonic noise. They are well described semiclassically [5] and consequently easily accessible to engineering analysis and design.

A variety of electronic and photonic manipulations is possible using electrically and optically coupled semiconductor sources and detectors. These may be more easily implemented than more conventional techniques using gas lasers and nonlinear media.

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Time-dependent Emission Spectra from Molecular Wave Packets

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Wave packet states of atoms and molecules play an important role in studying the boundary between the classical and quantum domains. Such states are essentially nonstationary. Characterizing them requires determining the *dynamics* of the probability distribution of the particular degree of freedom in which the wave packet is excited. One way to accomplish this goal is to track the wave packet via the time-dependent spectrum of spontaneous emission.[1] We have performed such measurements for a wave packet in the nuclear degree of freedom of a sodium dimer.[2] This technique permits tracking of the nuclear wave packet in a single excited electronic state over a substantial fraction of its periodic trajectory. It has important applications for studying wave packet excitations in quantum confined electronic microstructures and larger molecules. For example, the quantum control of molecular dynamics is an important goal in chemistry, and the ability to track a wave packet accurately is a significant step toward that objective.

To understand why optics plays such a significant role in this endeavor, consider a wave packet generated by a coherent superposition of vibrational levels in a diatomic molecule. A short optical pulse, resonant with the lowest