FUNDAMENTALS OF HETERODYNE DETECTION IN LASER COMMUNICATIONS

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ABSTRACT

The use of optical heterodyne detection in a communication system requires a local oscillator laser beam to be coincident with the incoming signal on the detector. After detection, the signal behaves in every way like a classical microwave or radio signal which has been detected with a heterodyne receiver. This discussion of the use of optical heterodyne detection in laser communications thus includes consideration of modulation formats as well as the special geometrical requirements of combining the local oscillator and signal. Modulation formats of interest are amplitude modulation, frequency modulation and phase modulation, and both heterodyne and homodyne detection techniques are considered.

The physical and geometric treatment of optical heterodyne detection is given. General equations are derived for the signal to noise ratio of a coherent receiver in terms of the distribution functions of the signal and local oscillator fields and the size of the detector. The most efficient local oscillator field distribution function is when it exactly matches that of the signal field distribution over the detector surface. A special case of interest is when the signal field is an Airy function and the local oscillator field is uniform. This special case is shown to be feasible with a small penalty in heterodyne mixing efficiency.

An analysis of the heterodyne NEP includes factors from geometrical mixing efficiency, thermal noise, dark current, and electrical load mismatch. The degree of degradation is then a function of the amount of local oscillator power. Practical limits on heterodyne NEP's are established.