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Gain and quantum noise in fiber multi-mode phase sensitive amplifiers

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Optical fiber technologies form the back-bone of today's high-speed internet infrastructure. Optical fibers can carry light waves with encoded information enabled high-speed and voluminous data-transmission links. The emergence of high-gain optical amplifiers in the past few decades led to the realization of optical fiber links spanning thousands of kilometers. Recent progress in the field of fiber optics led to the development of fiber-optic phase sensitive amplifiers (PSAs) with high gain and ultra-low noise properties making them a potential candidate for a variety of applications in communication systems.

The working principle of a PSA is based on nonlinear interaction of different waves in a single mode fiber that enable conversion of pump photons from a strong laser source into signal photons leading to signal amplification. However in practice, when the fiber nonlinearity is strong, complex four-wave mixing (FWM) interactions between different waves in the fiber can lead to generation of high-order parasitic sidebands that influence the evolution of all the other waves inside the amplifier, and introduce extra input ports for vacuum fluctuations, leading thus to a degradation of the noise figure (NF). Therefore, it is worth investigating the basic mechanisms that govern the amplification process of a PSA, as well as the gain and noise performances of multi-wave PSAs.

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