論 文 の 内 容 の 要 旨

論文題目　Saturated Fiber Optical Parametric Amplification and Its Applications
（光ファイバパラメトリック飽和増幅とその応用）

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The devices based on the phenomenon of parametric amplification can be used in many fields of lightwave systems. In this work, I investigate the saturation properties of parametric amplification, and propose practical schemes to improve the devices performance.

In principle, fiber optical parametric amplifiers (FOPAs) can provide high gain uniform over a wide wavelength range. They add little noise to the amplified signal. For several signal-processing applications including optical signal regeneration, phase conjugation, and wavelength conversion, FOPAs are the promising candidates. I theoretically and numerically explain the power saturation and the additional phase noise brought by the FOPA. Based on the theory, the power saturation and the additional phase noise brought by the FOPA are explained. It is found that the saturation in a FOPA originates from the power exchanging periodically. The equation to calculate an approximation to the saturated signal output power is presented. I also propose a scheme for alleviating the phase noise brought by the FOPA at the saturated state. Amplitude-noise and additional phase noise reduction of BPSK and QPSK signals based on the saturated FOPA was numerically studied. The dispersion difference term Δk is one decisive factor for the saturated FOPA. The FOPA can be optimized by controlling the dispersion relation between the pump, signal and idler, and this provides the means to deal with PSK signals.

Fiber optical parametric oscillators (FOPOs) are coherent sources that can provide ultra-broadband tunability and high output power levels and are been

considered for applications such as medical imaging and sensing. The aim of this topic is concentrating on providing an alternative besides ordinary rare-earth doped fiber laser.

While most recent literature has focused on advancing the performance of these devices experimentally, theoretical studies are still scarce. In contrast, ordinary laser theory is very mature, has been thoroughly studied and is now well understood from the point of view of fundamental physics. The differences between the gain saturation process in lasers using ordinary gain medium and FOPOs are analyzed. For a phase insensitive FOPO with one pump, there is an optimized output coupling ratio to get a maximum output power, which is close to 1. It is significantly different from the case of lasers using an ordinary gain medium where optimized output coupling ratio is close to 0. This can help us to build a FOPO with maximum output power. By choosing a suitable output coupling ratio of the fiber optical parametric oscillator cavity, a narrowband FOPO at 1450nm based on the commercial dispersion shift fiber with multi-watt output power was proposed. The optimized ratio is in the range about 80%-90% for different cavity losses. Because the FOPO is robust to the cavity losses, a 2.4W peak-power was measured for the cavity with 70% internal loss. We observed good agreement between the theoretical and experimental results. By the optimization of coupling ratio, the FOPO with multi-watt output power is realized. The wavelength-swept source based on FOPO operating in near infrared (NIR) and short wavelength near infrared (SWIR) band is also experimentally demonstrated.