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Inverse Saturable Absorption in Non-linear Amplifying Loop Mirror Mode-Locked Fiber Laser

Authors : Haobin Zheng, Xiang Zhang, Yong Shen, Hongxin Zou

Abstract : The research focuses on mode-locked fiber lasers with a non-linear amplifying loop mirror (NALM). Although these lasers have shown potential, they still have limitations in terms of low repetition rate. The self-starting of mode-locking in NALM is influenced by the cross-phase modulation (XPM) effect, which has not been thoroughly studied. The aim of this study is two-fold. First, to overcome the difficulties associated with increasing the repetition rate in mode-locked fiber lasers with NALM. Second, to analyze the influence of XPM on self-starting of mode-locking. The power distributions of two counterpropagating beams in the NALM and the differential non-linear phase shift (NPS) accumulations are calculated. The analysis is conducted from the perspective of NPS accumulation. The differential NPSs for continuous wave (CW) light and pulses in the fiber loop are compared to understand the inverse saturable absorption (ISA) mechanism during pulse formation in NALM. The study reveals a difference in differential NPSs between CW light and pulses in the fiber loop in NALM. This difference leads to an ISA mechanism, which has not been extensively studied in artificial saturable absorbers. The ISA in NALM provides an explanation for experimentally observed phenomena, such as active mode-locking initiation through tapping the fiber or fine-tuning light polarization. These findings have important implications for optimizing the design of NALM and reducing the self-starting threshold of high-repetition-rate mode-locked fiber lasers. This study contributes to the theoretical understanding of NALM mode-locked fiber lasers by exploring the ISA mechanism and its impact on self-starting of mode-locking. The research fills a gap in the existing knowledge regarding the XPM effect in NALM and its role in pulse formation. This study provides insights into the ISA mechanism in NALM mode-locked fiber lasers and its role in selfstarting of mode-locking. The findings contribute to the optimization of NALM design and the reduction of self-starting threshold, which are essential for achieving high-repetition-rate operation in fiber lasers. Further research in this area can lead to advancements in the field of mode-locked fiber lasers with NALM.

Keywords : inverse saturable absorption, NALM, mode-locking, non-linear phase shift
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