Spectral Sideband Splitting in Strongly Dispersion Oscillating Fibers

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Modulation instability (MI) is an ubiquitous nonlinear process that has been widely investigated in various fields of physics and applications including plasmas, hydrodynamics and optics, to cite a few. In nonlinear fiber optics, recent experiments [1] have confirmed that fibers with a longitudinal and periodic modulation of their properties, such as a dispersion oscillating fiber (DOF), can experience MI thanks to a quasi-phase-matching (QPM)-induced MI process. Whenever the dispersion fluctuations can be considered as a perturbation to nonlinear wave propagation, that is when their amplitude is smaller or comparable with the value of the average dispersion, QPM-induced MI leads to the emergence of well-separated, and unequally spaced gain sidebands, symmetrically placed around the pump. On the other hand, when the amplitude of dispersion fluctuations grows much larger than the average GVD (strong dispersion management regime), a spectral splitting process may occur [2]. By using the Floquet linear stability analysis (LSA) of the nonlinear Schrödinger equation (NLSE), we may theoretically show that the first QPM sidebands splits into several sub-branches (Fig. (a1)).

This prediction is experimentally confirmed by using a highly nonlinear DOF pumped in the telecom C band by a sub-ns pulse. According to the pump power, several sub-branches of the 1^{st} QPM sideband are revealed when the fiber is pumped in the vicinity of its zero-dispersion wavelength (Fig. (a2)). Additional experimentally observed features that are not predicted by the LSA (persistence of the various branches, emergence of additional sidebands linked to a multiple four wave mixing process, etc…) are reproduced by the numerical integration of the generalized NLSE which takes into account the temporal details of the pump pulse shape [3].

We have also numerically investigated the amplification of a continuous wave seed located in a branch of the QPM sideband when pumped by a pulse of finite duration [4]. The generation of a short pulse doublet (Fig. (b1)) is observed, that can be linked to a bandpass power filtering process (Fig. (b2)). Interestingly, by changing the pump peak power, the time delay between the two seed pulses can be tuned in a continuous manner (Fig. (c)).

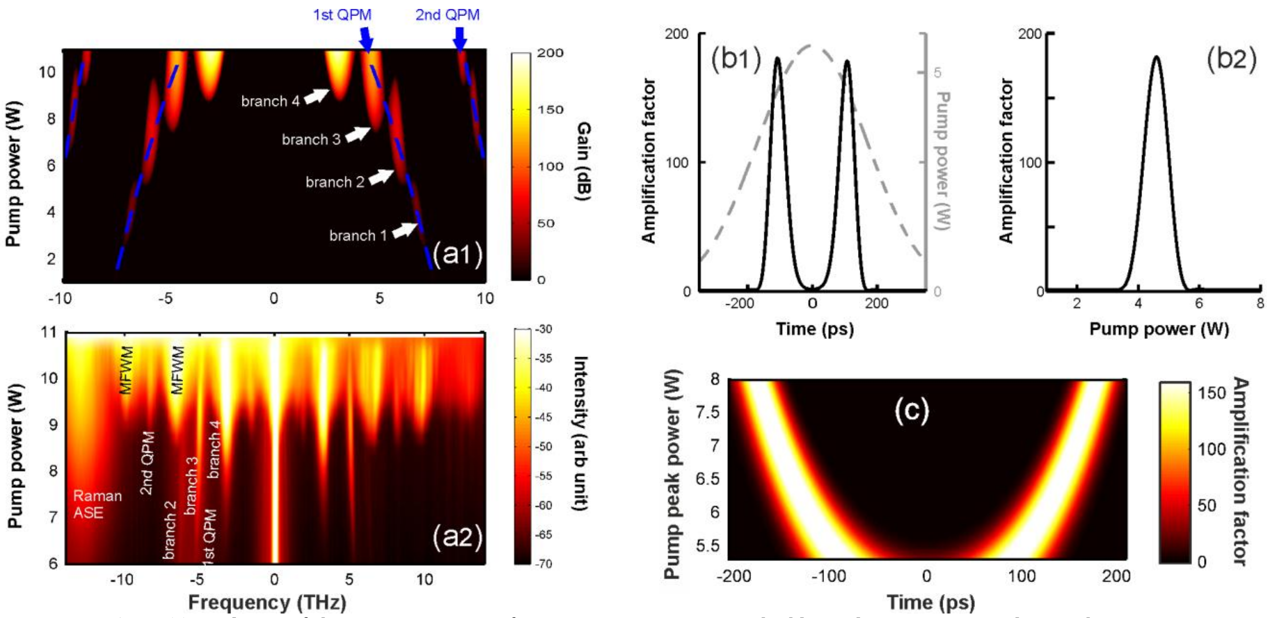

Fig. 1 (a) Evolution of the output spectrum after propagation in a 400-m highly nonlinear DOF according to the pump power. Results of the LSA (a1) are compared with experimental results (a2). (b1) Pulse doublet obtained from the amplification of a continuous seed by a pulsed pump (grey line). (b2) Power-dependant amplification factor of the seed. (c) Evolution of the doublet according to the pump peak power.

References

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