GAWBS SCATTERING EFFICIENCY ESTIMATION IN OPTICAL COMMUNICATION SYSTEMS

Paolo Serena[1], Federica Poli[1], Alberto Bononi[1], Alexis Carbó Meseguer[2], Jean-Christophe Antona[2]*

1 Department of Engineering and Architecture, University of Parma, Parma, Italy
2 Alcatel Submarine Networks (ASN), Nozay, France
**paolo.serena@unipr.it*

An estimation technique is proposed to separate GAWBS power from other nonlinear impairments to calculate the total scattering efficiency in modern optical communication systems.
Keywords: GAWBS, optical fiber, Brillouin scattering, long-haul transmission

1. Introduction

The effect of guided acoustic wave Brillouin scattering (GAWBS), which occurs in optical fibres due to the interaction of acoustic modes with light, has recently been shown to be far from negligible in modern ultra long-haul transmission systems, as pointed out, e.g., in [1]. Typically, the variance of GAWBS-induced distortions amounts up to 10% of signal distortions occurring along the line. Recently, a closed-form expression of the total scattering efficiency γ_{GAWBS} due to pure radial R_{0m} acoustic modes has been proposed [2]. This formula, which shows an inverse dependence on the fibre effective area A_{eff}, is useful to quickly estimate the GAWBS variance.
In the present work, we evaluated this parameter at variable fiber effective area by numerically solving the nonlinear Schrödinger equation (NLSE) properly extended to account for GAWBS. The scattering efficiency is derived by estimating the GAWBS side-lobes generated by a constant wave plus amplified spontaneous emission (ASE) noise. The behaviour of γ_{GAWBS} versus the fiber A_{eff} has been evaluated by changing the channel input power P and the link length L. Simulation results have been compared with theoretical ones obtained in [2].

2. Scattering efficiency estimation

Simulations have been performed at variable link length from L = 1520 km to 13680 km. Each fiber is 80 km long, and an optical amplifier with noise figure of 6 dB recovers its loss. A CW channel at 1550.7 nm with power P varied in the range between -9.8 dBm and 2.2 dBm is sent in the system, which is based on fibers having chromatic dispersion of 20.6 ps/km/nm, loss of 0.17 dB/km and A_{eff} in the range 80-150 μm^2.
The inset of Fig. 1 reports an example of the received power spectral density (PSD), showing the typical GAWBS lines with a frequency separation of about 46 MHz [2]. The NLSE has been solved with the split-step Fourier method with constant step-size of 100 m. The nonlinear step has been split into the cascade of the Kerr step and the GAWBS step [1]. The GAWBS peaks arise on a plateu of ASE showing modulation instability (MI), which should be properly removed for a reliable estimation of γ_{GAWBS}. To this aim, we propose to isolate GAWBS by subtraction of the MI-inflated ASE power, thus assuming superposition in power. First of all, PSD valleys between two neighbouring GAWBS peaks, affected only by MI, are identified. By interpolating these values, the MI plateau is evaluated and then subtracted in linear scale from the PSD. After removing also the CW signal contribution, the GAWBS power is calculated as the integral of the residual PSD. Finally, γ_{GAWBS} is obtained by dividing the estimated GAWBS power by P and L values considered in the simulation scenario.
As shown in Fig. 1, all curves scale with the inverse of A_{eff}, with a good accuracy of the estimation technique except at P = 2.2 dBm and small A_{eff} where the Kerr nonlinearity is too big, destroying the superposition of the Kerr/GAWBS powers. Further results for longer link lengths will be shown at presentation time.

3. Conclusions

An estimation technique has been developed to evaluate the total GAWBS scattering efficiency from the PSD of ASE inflated by GAWBS and MI.

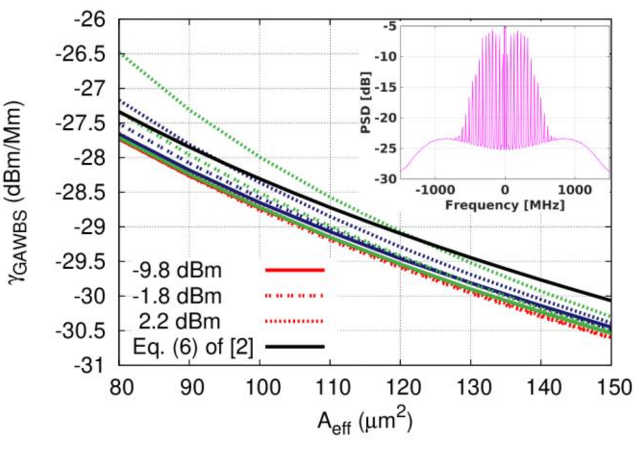

Fig. 1 γ_{GAWBS} versus A_{eff} for different P values and link length of 1520 km (red), 3040 km (blue), 4560 km (green). Black line: Eq. 6 of [2]. Inset: PSD with P = 2.2 dBm after 4560 km.

References

1. Paskov M., Bolshtyansky M.A., Cai J.-X,. et al., *Proc. OFC 2019*, San Diego, United States, March 2019, paper Tu3J.3
2. Serena P., Poli F., Bononi A., et al., *Proc. ECOC 2019,* Dublin, Ireland, September 2019, paper Tu.1.C.2