NLSE-based modelling of a random distributed feedback fiber laser

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Random distributed feedback (DFB) fiber lasers have attracted a great attention since first demonstration [1]. Despite big advance in practical laser systems, random DFB fiber laser spectral properties are far away to be understood or even numerically modelled. Up to date, only generation power could be calculated and optimized numerically [1,2] or analytically [3] within the power balance model. However, spectral and statistical properties of random DFB fiber laser can not be found in this way. Here we present first numerical modelling of the random DFB fiber laser, including its spectral and statistical properties, using NLSE-based model.

In order to simulate lasing in random DFB fibre cavity we used a set of non-linear Schrödinger equations (NLSEs) similar to used earlier for investigation of conventional Raman fiber laser (RFL), ytterbium, Brillouin lasers and supercontinuum sources [4-7], but with additional terms that describe extremely small Rayleigh scattering. We have overpassed challenge to model the very long system (84 km in our case) while one has to take into account random Rayleigh scattering on submicron scale nonlinear index inhomogeneities.

Firstly, we calculate the power performances. The calculated generation threshold (0.8 W) corresponds exactly to experimental observations [1] and analytical calculations [3], as well as obtained linear generation power grows. The power distributions also agree well with those observed earlier and analytically calculated [3]. Thus, power performances of the random DFB fiber laser are predicted well in NLSE-based model.

Moreover, we can now calculate typical generation spectrum, Fig. 1b. The spectrum becomes narrower (in logarithmic scale) than initial Raman gain profile. We do not have spectral narrowing if random distributed feedback is zeroed, that proves a principal role of tiny random feedback to form the laser generation. The calculated time dynamics of random DFB fiber laser reveals strong fluctuations and is almost stochastic and characteristic times of 50 ps. Intriguingly, statistical properties of random DFB fiber laser are very similar to those of conventional FBG-based Raman fiber laser, Fig. 2c: The statistics of intensity fluctuations is not exponential revealing partial mode correlations [8-9]. It is worth to note that radiation of random DFB fiber laser is believed to be truly modeless, so the origin of non-exponential intensity fluctuations statistics have to be further investigated.

Detailed results of full NLSE-based numerical modeling of random DFB fiber laser will be presented at the conference.

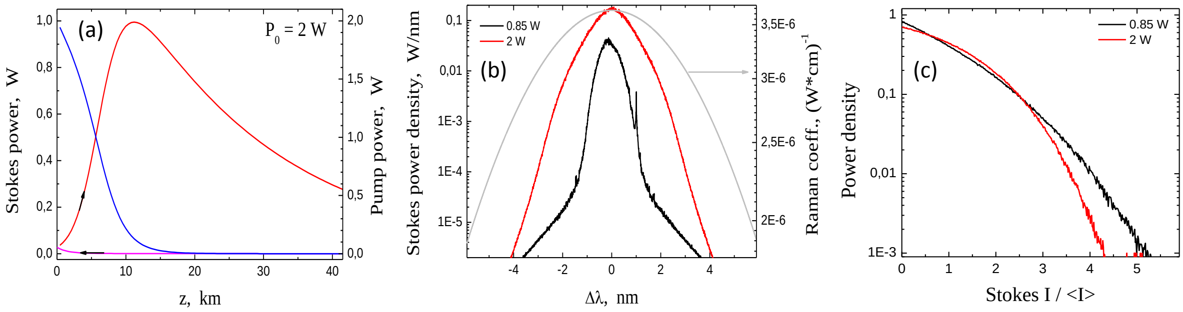

Fig. 1. (a) Longitudinal power distribution for pump (blue line) and generation wave (red and magenta lines for forward and backward waves) at 2 W of pump power. (b) Output generation spectrum (Δλ = λ–1556 nm) together with Raman gain profile (grey) at different pump power. (c) Intensity probability density functions for generation wave, I/<I>.

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