longitude cavity modes within the FBG reflectivity band. Four-wave-mixing between these modes through the fiber Kerr nonlinearity is responsible for symmetrical laser line broadening [50,2,3,17] as it is seen in Fig. 6. However, apart from the Kerr nonlinearity, the cavity modes could undergo a collective parametric interaction through the SBS process, i.e. a resonance coupling between the optical modes and hyper-sound standing waves induced in the fiber media. Due to the SBS resonance this coupling is pronounced for laser modes spectrally separated from each other exactly (with the accuracy of few MHz) by the SBS shift Δ_{SBS} , i.e. the frequency of the resonantly induced hyper-sound wave. Under the conditions of full resonance all such modes pairs produce the same interference pattern, i.e. all of them contribute the same pattern of electrostrictive force wave generating the phase-matched hyper-sound wave. During this resonance interaction the cavity modes that are Stokes shifted relatively the lasing modes (within the FBG reflectivity spectrum) acquire an additional Brillouin gain at the expense of the anti-Stokes shifted modes. This causes a slight redistribution of the laser gain profile in favor of modes with the longer wavelengths providing them preferable conditions for lasing. As a result, the laser modes leaked from the right side of the FBG spectra (see Fig. 2) exhibits slightly higher powers than the modes leaked from the left side.

There are two obvious observations in our experiment that support this explanation. First, the laser power accumulated inside the fiber cavity significantly exceeds the Brillouin threshold power associated with the given cavity length and fiber parameters. We can roughly estimate the SBS threshold in our cavity to be as low as 100mW, so the presence of 12W radiation inside the cavity ensures an efficient interaction of the laser modes through the SBS process. Second, an asymmetric enhancement of the modes leaked from the right side of the FBG reflectivity spectrum (Fig. 2) is observed with a shift of ~0.08 nm from the FBG reflectivity band that is in a good agreement with the SBS frequency shift $\Delta_{SBS} \approx 16GHz$ estimated for laser operating at ~1.08µm [47]. Besides, our qualitative picture agrees with a theoretical and numerical model that we recently developed and will be described elsewhere. The numerical simulations have been performed on a computational cluster of the Novosibirsk University Scientific Computing Centre. Each cluster node is a dual processor server equipped with Intel Xeon 5355 processors. Typical computational time for a single run was about an hour.

5. Conclusions

We have developed a theoretical model for the description of the performance of CW fiber lasers with large nonlinear single path dynamics manifesting itself through spectral broadening of radiation. The proposed model shows good agreement with the experimental results. We believe that the proposed approach based on combination of the nonlinear Shrödinger equations and simplified material equations for the gain medium can be used for characterization of the strongly nonlinear evolution of intra-cavity laser radiation in a range of high power lasers.

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