Experimental Observation of Anomalous RIN Transfer in Random Distributed Feedback Raman Fiber Lasers

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Experimental observation of anomalous RIN transfer in random distributed feedback Raman fiber lasers

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Despite being demonstrated only in 2010 [1], ultralong random distributed feedback Raman fiber lasers (RDFLs) have been extensively investigated for their unique features and potentially excellent performance in a number of applications, including sensing and optical communications [2]. Although relatively simple in design, these devices display great complexity in operation, presenting multiple regimes and possible configurations, which make determining the optimal configuration for a particular application a daunting task. In particular, the relative intensity noise (RIN) transfer function (TF) of an RDFL [3] is highly dependent on multiple parameters and often imposes a limit on overall system performance. Recently [4], it was theoretically shown that in some particular configurations, maximum RIN transfer in RDFLs can be displaced towards high frequencies in spite of the filtering effect associated to the faster averaging of pump oscillations, which could help manage noise in sensing and communication schemes. In this paper we demonstrate this effect experimentally for the first time and show, with the help of precise numerical simulations, the physical mechanisms leading to such "anomalous RIN transfer function".

The selected RDFL is based on a forward-pumped topology (Fig.1(a)), with a 50 km single mode fiber (SMF) cavity operating as distributed mirror, and a recirculating system based on a circulator and a filter at 1555 nm with a 0.3nm linewidth. Two wavelength division multiplexers (WDMs) are used for injecting the pump laser at 1445nm and for removing the residual pump at the output. A fiber isolator at the output is used to avoid reflections. The RIN TF is retrieved by dividing the RIN of the laser output by the pump RIN [5]. The RIN of both pump laser and RDFL are accurately characterized with low noise photodiodes and electrical spectrum analyzers. Figure 1(b) shows a comparison between the measured TF function and the numerically simulated one for a 2.6 W pump power and a RDFL output power of 100mW.

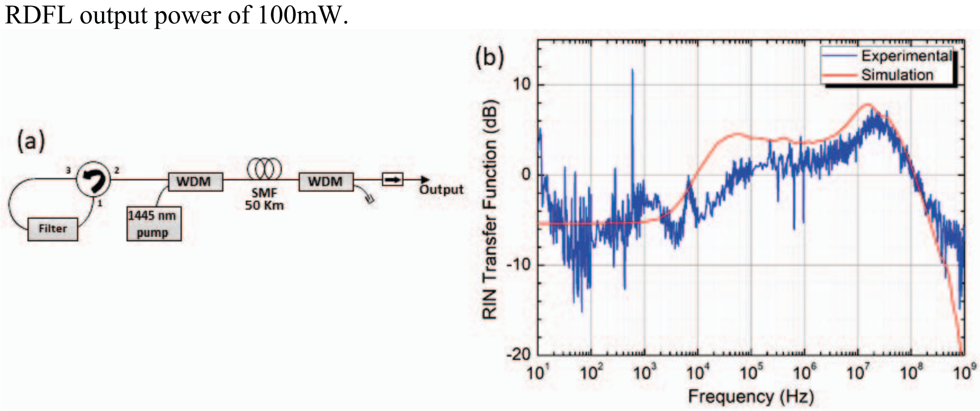

Fig. 1 Schematic of the RDFL setup (a). RIN transfer function (b).

At high frequencies the RIN TF exhibits a low pass filter behavior with a corner frequency around 50 MHz, determined by the pump losses and the signal-pump walk-off. The maximum of the TF is obtained at high frequency just before the TF roll-off, as expected from [4]. The simulation exhibits good agreement with the experimental results providing an effective model for the selective depletion of low-frequency RIN noise, in which output RIN depends on several parameters such as fiber length, dispersion slope, Raman gain coefficient, Rayleigh backscattering coefficient and pump power. This work paves the way to partial RDFL RIN TF tailoring via laser design.

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