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EVOLUTION OF TIMING JITTER IN NON-LINEARLY GUIDED, DISPERSION MANAGED TRANSMISSION SYSTEMS

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Introduction

Timing jitter is a major factor limiting the performance of any high-speed, long-haul data transmission system. It arises from a number of reasons, such as interaction with accumulated spontaneous emission, inter-symbol interference (ISI), electrostriction etc.

Some effects causing timing jitter can be reduced by means of non-linear filtering, using, for example, a nonlinear optical loop mirror (NOLM) [1]. The NOLM has been shown to reduce the timing jitter by suppressing the ASE and by stabilising the pulse duration [2, 3].

In this paper, we investigate the dynamics of timing jitter in a 2R regenerated system, nonlinearly guided by NOLMs at bit rates of 10, 20, 40, and 80-Gbit/s. Transmission performance of an equivalent non-regenerated (generic) system is taken as a reference.

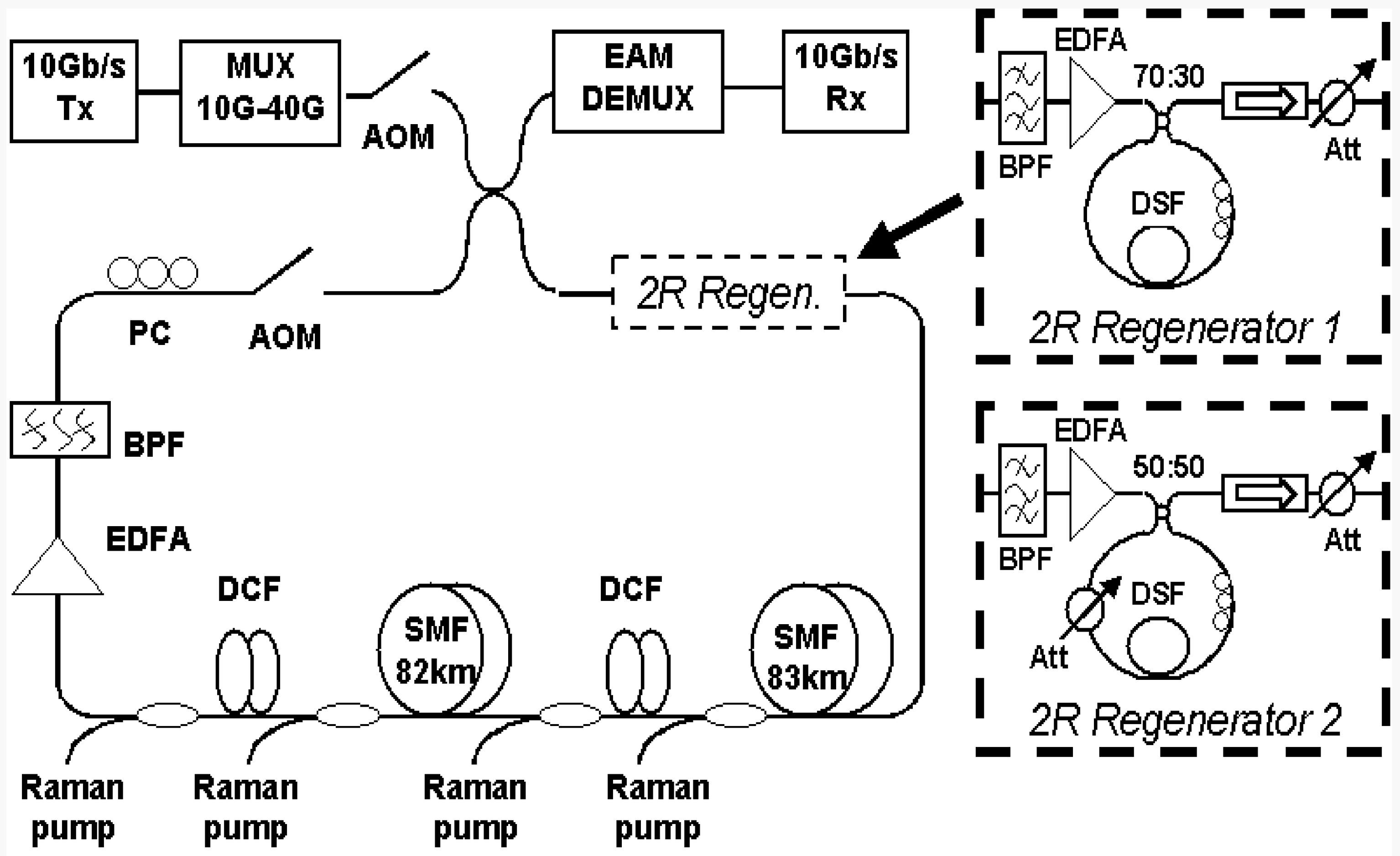

Figure 1. Recirculating loop experiment. 2R regenerator No.1 was used at data rates of 10,20 and 40-Gbit/s. The regenerator No.2 was employed during the 80-Gbit/s measurements.

Experiment.

Measurements were carried out in a re-circulating loop experiment similar to that decribed in our earlier studies [2,3] and shown schematically fig.1.

The re-circulating loop comprised two spans of standard single mode fibre (SMF-28), 82-km and 83-km long, and two slope-compensating fibre dispersion compensators (DCF). Average dispersion in the system was set to be slightly anomalous, approximately +0.003-ps/(nm.km) at the operating wavelength. The corresponding dispersion map strength is 280. Average power was always maintained at a relatively low level (–9dBm at 10Gb/s, 0dBm at 80Gb/s) in order to provide quasi-linear propagation regime.

The timing jitter was estimated from the background-free autocorrelation measurements by using a cross-correlation technique [4]. We averaged the jitter over several (up to 4) bitrate periods, thus calculating the jitter value in a form:

$$dt \sim \frac{1}{4N}\sum_{k=1}^{N}\sqrt{\frac{t_k^2 - t_0^2}{\ln 2}}$$

Additionally, timing jitter at lower bitrates was measured using a sampling oscilloscope.

The method of measuring the timing jitter was to use a gated autocorrelator by means of an AOM linked to the recirculating loop controller.

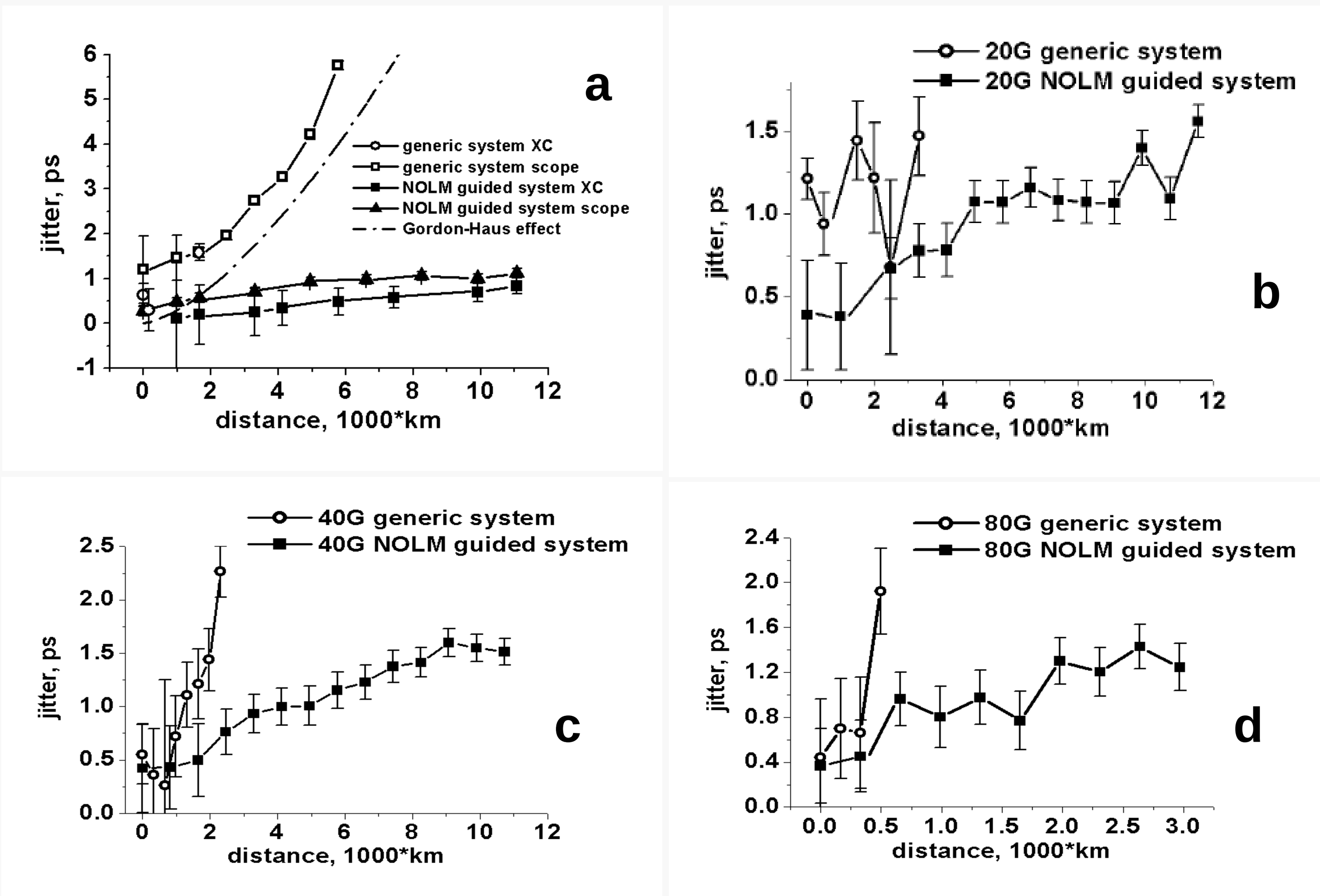

Figure 2. Evolution of timing jitter in the generic and in the nonlinearly guided system. a) 10-Gbit/s, also showing scope measurement results. b) 20Gbit/s. c) 40Gbit/s. d) 80Gbit/s.

Results

Figure 2 shows the timing jitter as a function of distance, measured by means of cross-correlation technique at four different transmission speeds. Jitter dynamics in the generic (non-regenerated) system is compared to that in the guided system at each speed. Additionally, the oscilloscope measurements are shown for the bitrate of 10Gb/s in fig.2a.

- The timing jitter increase is non-linear and is considerably affected by the spontaneous noise accumulation.
- At higher bit rates, the timing jitter increase is dominated by the inter-symbol interference.
- In the guided system, pulse duration is constant at each bit rate and the timing jitter increase is almost linear, in line with our earlier studies.
- The NOLM restores the pulse shape and suppresses the spontaneous emission and dispersive wave radiation.
- Non-linear switching in the NOLM compensates for the small residual dispersion in the system thus preventing the pulse broadening during propagation.
- The NOLM operates at a point of the switching curve where the amplitude fluctuations are efficiently reduced. Therefore, transfer of amplitude fluctuations to the timing jitter is also reduced.

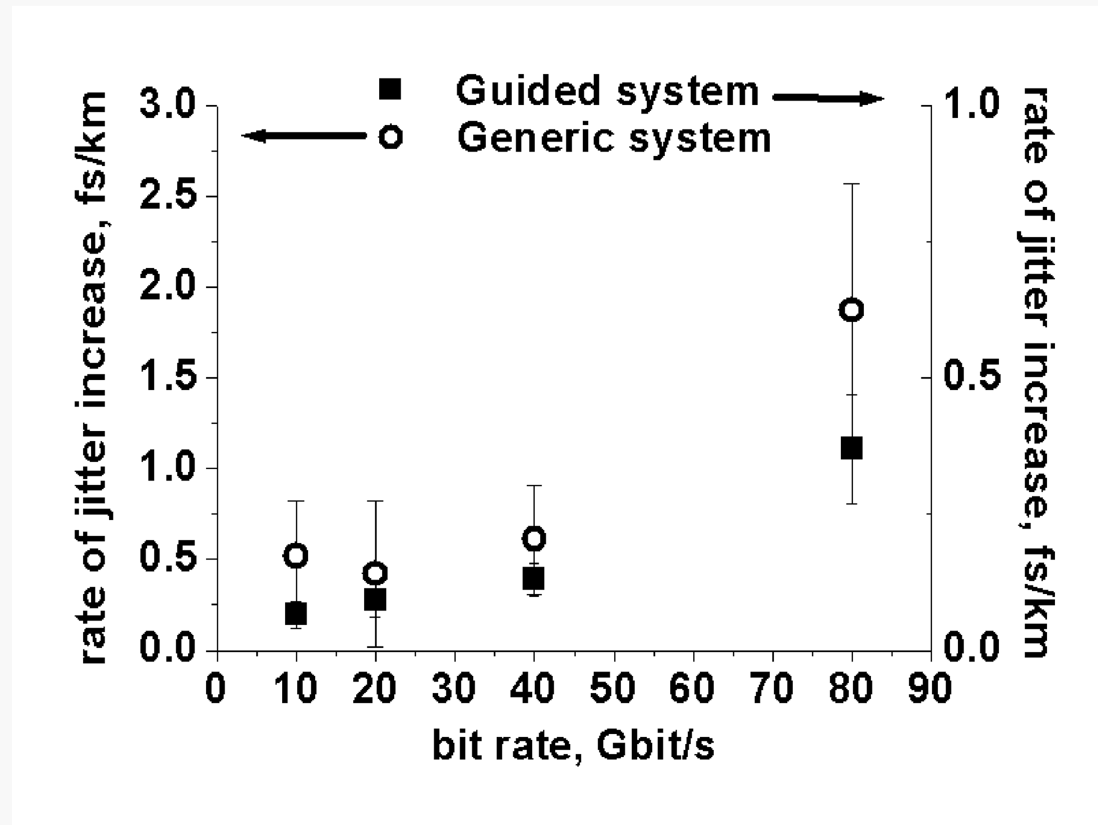

Figure 3. Rate of timing jitter increase measured at four different transmission speeds.

Conclusion

Timing jitter and jitter increase rate are considerably reduced in the nonlinearly guided system at all bit rates. Process of accumulation of timing jitter in nonlinearly guided system is dominated by different factors and develops in a different way compared to that in the "generic" , non-regenerated system.

References

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