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On the dispersion slope compensation in dense dispersion managed solitons

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Abstract: 12.5-ps separated dense dispersion managed soliton transmission with dispersion slope compensation is numerically evaluated. When dispersion shifted fiber for dispersion slope trimming is placed at input of EDFA repeaters, interactions between adjacent pulses can be effectively reduced.

I. Introduction

Dense dispersion managed soliton (DDMS)[1-3], which propagates in a fiber whose dispersion map is shown in Figure 1, is more attractive than dispersion managed soliton for future high speed optical communication systems because of low nonlinear interaction between adjacent optical pulses, low four wave mixing, and adaptability to longer amplifier spacing. In order to increase the bit-rate of the systems, the influence of higher order effects such as the dispersion slope and the Raman effect have to be taken into account. In this manuscript, we numerically evaluate 12.5-ps separated DDMS transmission to show the necessity and an effective way of dispersion slope compensation by estimating the nonlinear interaction.

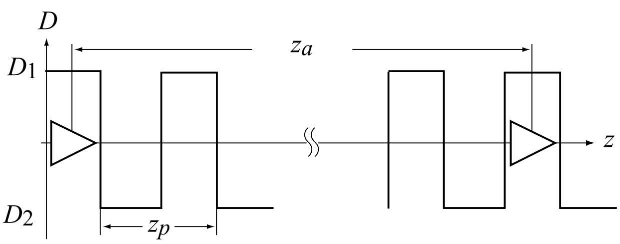

Fig. 1 Dispersion map of the transmission fiber for dense dispersion managed soliton (DDMS).

II. Effect of dispersion slope compensation on DDMS propagation

Our numerical simulations of DDMS propagation includes Kerr nonlinearity, loss of fibers, Raman effect, and second and third order dispersion. ASE noise induced by EDFA and PMD of the fiber are ignored. We define interaction distance as the transmission distance where the pulse separation changes 1/3 of the bit period in order to estimate the nonlinear interaction.

The parameters we used here are z_a = 60 km, $n = z_a/z_p$ = 11, $D_1 = - D_2$ = 2 ps/nm/km, D_{ave} = 0.01 ps/nm/km, α = 0.21 dB/km, γ = 1.86 rad/W/km, T_R = 3 fs, where D_1 and D_2 are the dispersion parameters of the fiber 1 and 2 shown in Figure 1, D_{ave}, α, γ, T_R are average dispersion parameter, loss, nonlinear coefficient, and delay of the Raman response of the fiber, respectively. The number of period n was decided to maximize the interaction distance[4]. Two 2.9 ps transform limited Gaussian pulses with the separation of 12.5 ps were launched into the fiber. Figure 2 shows the obtained interaction distance versus the peak power of the launched pulse where open circle: $DS_1 = DS_2$ = 0.07 ps/nm^2/km, open square: $DS_1 = - DS_2$ = 0.07 ps/nm^2/km, and cross point: $DS_1 = DS_2$ = 0 ps/nm^2/km. DS_1 and DS_2 are the dispersion slopes of the fiber 1 and 2, respectively.

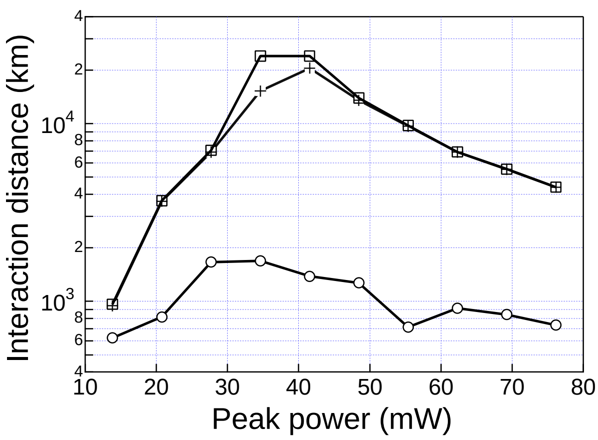

Fig. 2 Interaction distance versus the peak power of the DDMS. Open circle and square: without and with dispersion slope compensation, cross point: dispersion flattened fiber.

As seen in the figure, the interaction distance is nearly one order magnitude larger when the dispersion slope of the fiber is zero and when the dispersion slope compensation is made. The interaction distance is maximized at a certain value in the peak power. This is because smaller the peak power, larger the pulse width of the steady state DDMS, and larger the peak power, higher the stretching ratio of the DDMS. Both cases result in increase the temporal pulse overlap.

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III. Dispersion slope trimming by dispersion shifted fiber

There have been reported that the average dispersion and dispersion slope can be trimmed by use of three kinds of fiber[5, 6]. We adapt this technique to DDMS for realistic dispersion slope compensation. In this simulation, we set DS_1 = 0.03 ps/nm^2/km, γ = 4.73 rad/W/km and DS_1z_1/DS_2z_2 = -2 so that the average dispersion slope can be compensated by a standard dispersion shifted fiber (DSF), whose dispersion slope is 0.07 ps/nm^2/km. The zero dispersion wavelength of the DSF was chosen so as to keep the average dispersion the same. The peak power of the DDMS was adjusted to maximize the interaction distance. Figure 3 shows the simulated results of DDMS transmission where the DSF was placed at the end of (a) the first segment and (b) the last segment of the dense dispersion management.

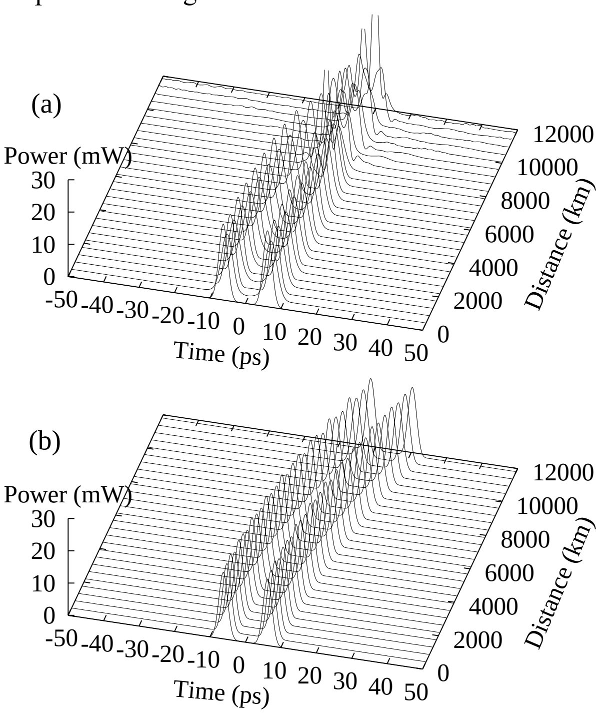

Fig. 3 DDMS transmission where the DSF for the dispersion slope compensation is placed at the end of (a) the first segment and (b) the last segment of the dense dispersion management.

As seen in Fig. 3, the interaction distance is 8,500 km for (a) while > 12,000 km for (b). For comparison, we made a simulation where the nonlinear coefficient of the DSF is set to zero. The DSF position is the same as the case of Fig. 3 (a). Fig. 4 shows the result. The interaction distance of > 12,000 km is obtained. Thus, we can conclude that the nonlinear phase shift in the DSF distorts the

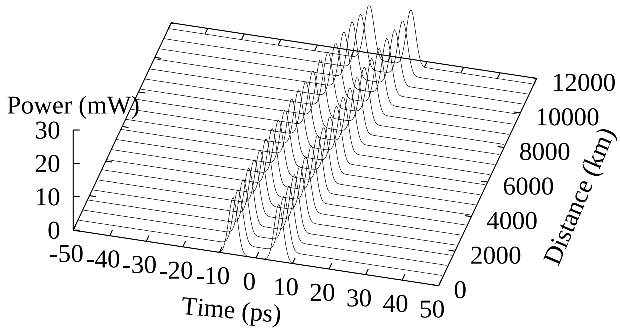

Fig. 4 DDMS transmission where the nonlinear coefficient of the DSF is set to zero. The DSF position is the same as the case of Fig. 3 (a).

complex amplitude of the steady state DDMS that may result in increase the nonlinear interaction.

IV. Conclusion

We numerically estimate the interaction distance in 12.5-ps separated DDMS transmission with dispersion slope compensation. The nonlinear interaction between adjacent pulses can be effectively reduced when dispersion shifted fiber for dispersion slope trimming is placed at input of EDFA repeaters.

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