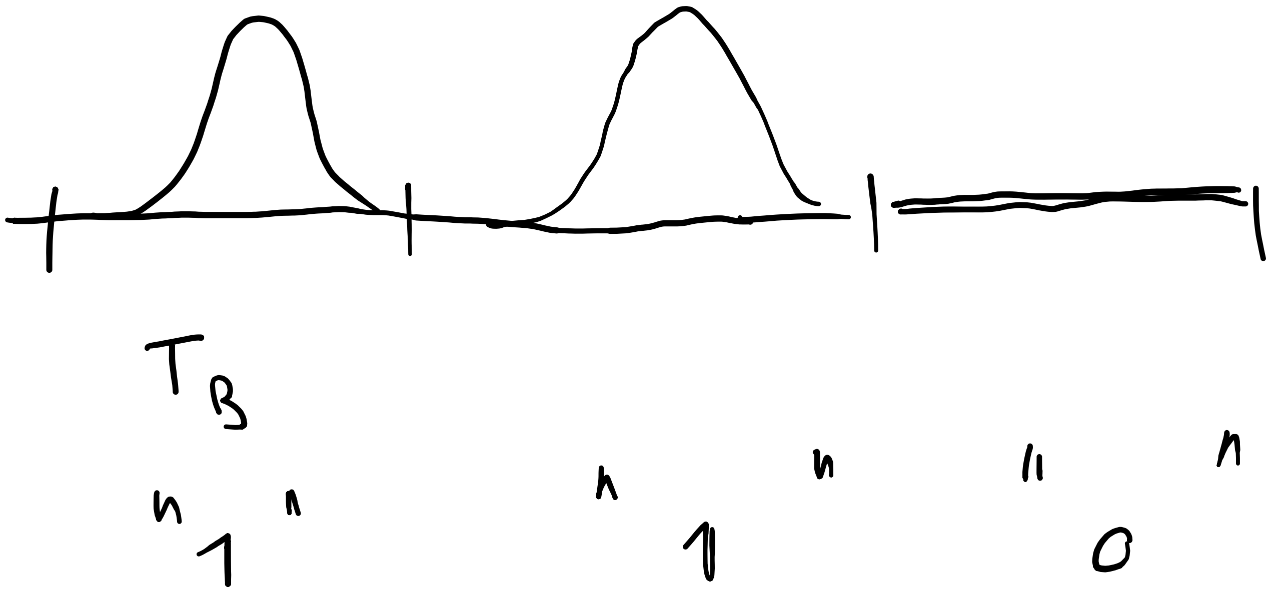
SOLITON INTERACTION

The temporal interval T_B between two neighboring bits or pulses determines the bit rate of a communication system as $B = 1/T_b$.



OOK FORMAT

Thus it is important to determine how close two solitons can come without affecting each other. Interaction between two solitons has been studied analytically and numerically.

Here, i show to you a little about the mutual interaction and its effect on individual solitons.

As to a theorethical point of view, we have to consider the total envelope $F = F_1 + F_2$ where

$$F_i(z,t) = \eta_i \operatorname{sech}\left[\eta_i (t - q_i)\right] \exp(j\phi_i - j\delta_i t)$$

with $i = 1, 2$. It is F that satisfies the NLSE, rather than F_1 and F_2 individually.

In fact, by substituting $F = F_1 + F_2$ in the NLSE

$$j F_z + \frac{1}{2} F_{tt} + |F|^2 F = 0$$

we

can obtain the following equations for F_1 and F_2, respectively:

$$j\frac{\partial F_1}{\partial z} + \frac{1}{2}\frac{\partial^2 F_1}{\partial t^2} + |F_1|^2 F_1 = -2|F_1|^2 F_2 - F_1^2 F_2^*$$

$$j\frac{\partial F_2}{\partial z} + \frac{1}{2}\frac{\partial^2 F_2}{\partial t^2} + |F_2|^2 F_2 = -2|F_2|^2 F_1 - F_2^2 F_1^*$$

We have two NLSE, and the terms on the right-hand side act as a perturbation and are responsible for nonlinear interactions between the two solitons. The equations we derived can be used to study mathematically the interactions.

I don't want here to consider calculations (if you are interested.... let me know for a possible homework).

Here I want to investigate numerically soliton interactions

Numerical solutions of the NLSE are quite instructive and allow exploration of different amplitudes and different phases associated with a soliton pair by using the following form at the input of the fiber:

$$F(0,t) = \operatorname{sech}(t - q_0) + r \operatorname{sech}[r(t + q_0)] \exp(i\theta)$$

where r is relative amplitude, $\theta = 2\psi_0$ is the initial phase difference, and $2q_0$ is the initial separation between the two solitons.

Cases:

$\theta = 0$, $r = 1$ $\qquad$ $q_0 = 10$, $q_0 = 3.5$

$\theta = \pi/2$, $r = 1$ $\qquad$ No effects $\qquad$ Effects

$\theta = 0$, $r = 1.1$

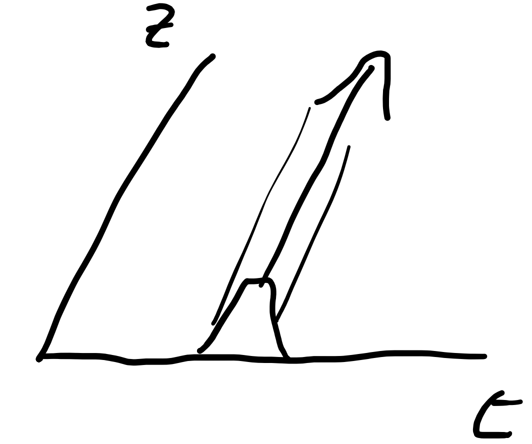
In the case of equal amplitude solitons ($r = 1$), the two solitons attract each other in the in-phase case ($\theta = 0$) and collide periodically along the fiber. For $\theta = \pi/2$ the solitons repel each other, and their spacing increases monotonically with distance.

The last case shows the effect of slightly different ~~sol~~ soliton amplitudes by chosing $r = 1.1$ and $\theta = 0$. Two in-phase solitons oscillate periodically but never collide or move far away from each other.

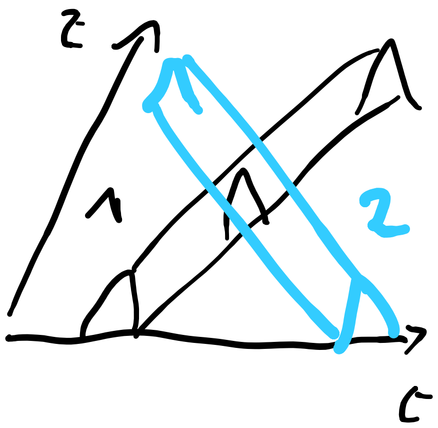
The periodic collapse of two solitons is not desirable from a practical standpoint: interference.

One way to avoid the collapse is to increase soliton separation.

Soliton Collision

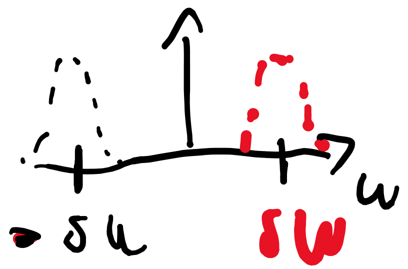


zero-velocity soliton



walking soliton

$$F_N = F \cdot \exp(\pm i\,\delta\omega\, t)$$



I have shown to you numerically the elastic collisions of walking solitons of the NLSE. This dynamics confirms the particle-like behavior of the solitons.