PQS Project

Meeting 2022-01-21 1:30pm

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Project 1

- **Attempting to analytically solve the NLSE for a PQS**
- Assume the effect of nonlinearity is only a change in propagation constant, not intensity
- Look for solutions of the form $u(z)\exp(i\mu z)$ satisfying

$$\mu u + \frac{|\beta_4|}{24}\frac{d^4 u}{d\tau^4} + \gamma u^3 = 0$$

$$\underbrace{u'''' + 4\sigma^4 u}_{L} + \underbrace{\Gamma u^3}_{N} = 0, \qquad \sigma^4 := \frac{6\mu}{|\beta_4|}, \Gamma := \frac{24\gamma}{|\beta_4|}$$

Project 1

- In the tails, $u^3 \ll u$, so consider a perturbation of the linear part of the ODE

1. Let $u^{(0)}$ be a solution to $L\left[u^{(0)}\right] = 0$, up to first order of $1/\cosh, 1/\sinh$
2. Then define $u^{(1)}$ such that $L\left[u^{(1)}\right] + N\left[u^{(0)}\right] = 0$ up to third orders of $1/\cosh^3, 1/\sinh^3$
3. Repeat for higher orders to (hopefully) converge on a solution

Project 1

For $u^{(0)} = A\dfrac{\cos \sigma x}{\cosh \sigma x} + B\dfrac{\sin \sigma x}{\sinh \sigma x}$ and $u^{(1)} = \sum_{k=0}^{3} C_k \left(\dfrac{\cos \sigma x}{\cosh \sigma x}\right)^{3-k} \left(\dfrac{\sin \sigma x}{\sinh \sigma x}\right)^{k}$

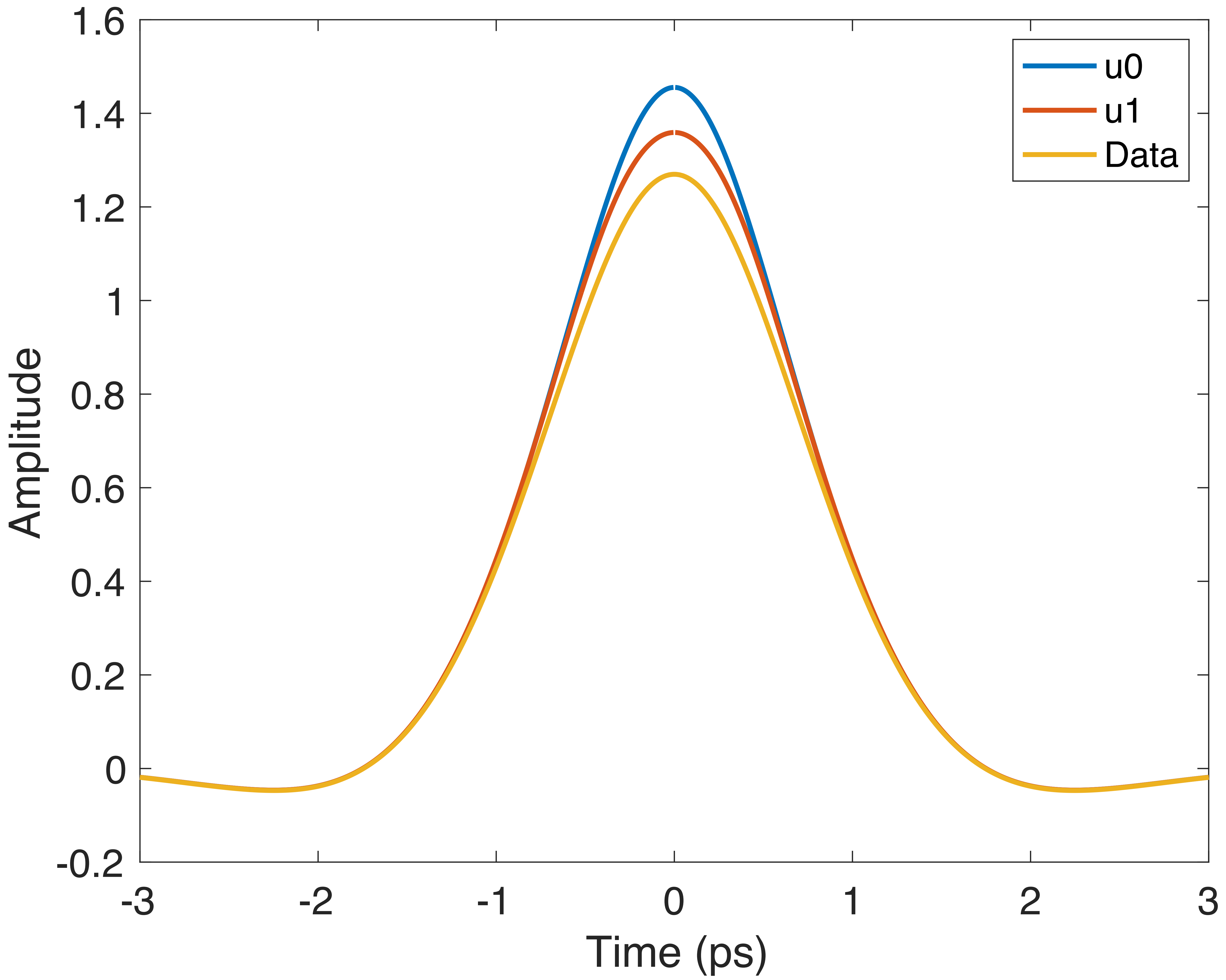
we get

$$\begin{aligned} C_0 &= \frac{9}{1280}\varphi \\ C_1 &= -\frac{3}{640}\varphi \\ C_2 &= \frac{9}{1280}\varphi \\ C_3 &= -\frac{1}{640}\varphi \end{aligned}, \quad \varphi := \frac{(A+B)^3}{\sigma^4}\Gamma$$

Project 1

- Using our current best estimates for A, B:

- Next step is to continue the process with fifth order terms



Project 2

- There is a preference for PQS to form at a particular frequency and particular group velocity
  - These PQS are members of a larger family, traveling at other speeds
- **Can we use a frequency shift (such as from an acousto-optic modulator) to nudge the soliton into these other forms?**

Project 2

- Using MATLAB, simulate how the PQS evolves as it passes through the laser
- Determine how the magnitude of the frequency shift affects the output of the laser

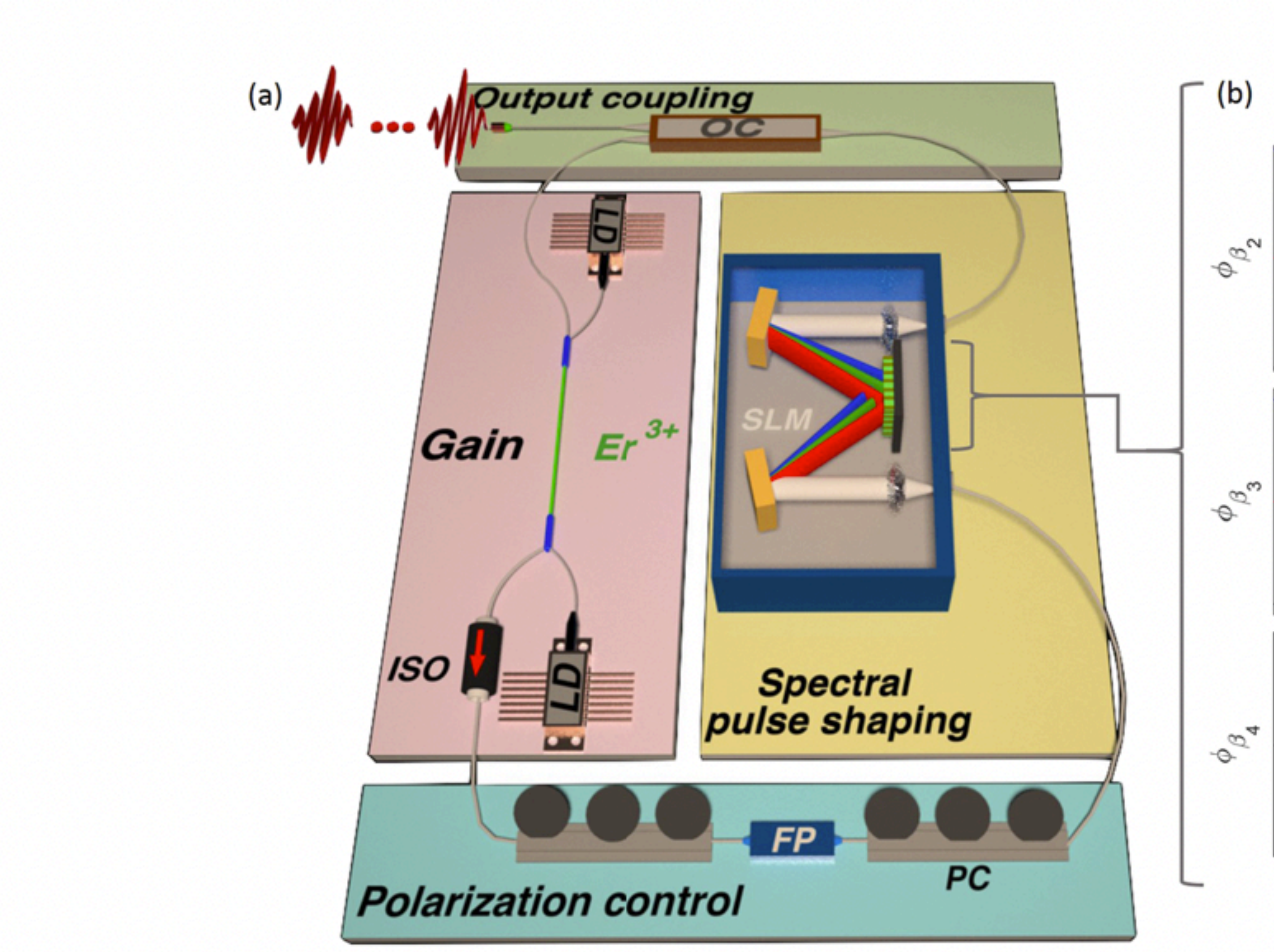


FIG. 10. Principle of operation of the PQS laser. (a) Schematic of the mode-locked fiber laser cavity: izer; PC, polarization controller; SLM, spatial light-modulator; and OC, output coupler. The combinati (SA) that allows for the mode-locking of the laser. (b) Conceptual illustration of the quadratic (top ro phase imparted by the cavity (solid black line) and the spectral pulse-shaper (solid blue line). The ne Ref. 67.