Engineering and Physical Sciences Research Council

InFoMM Industrially Focused Mathematical Modelling

A New Method of Modelling Tuneable Lasers with Functional Composition

Brady Metherall

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Laser Overview

- The word laser was originally an acronym for Light Amplification by Stimulated Emission of Radiation [1]
- The defining feature of laser light is coherence, where the peaks and trough overlap causing very strong constructive interference [2]
- Typical lasers, such as Helium-Neon gas lasers or laser pointers, are monochromatic (operate at a single wavelength—have a very narrow bandwidth)

Tuneable Lasers

Tuneable lasers

- have a much wider bandwidth (up to ~ 100 nm)
- lase continuously at all of these wavelengths
- have applications in spectroscopy and high resolution imaging

Nonlinear Optics

The standard equation for studying nonlinear optics is the generalized nonlinear Schrödinger equation,

$$\frac{\partial A}{\partial z} = \underbrace{-i\frac{\beta_2}{2}\frac{\partial^2 A}{\partial T^2}}_{\text{Dispersion}} + \underbrace{i\gamma|A|^2 A}_{\text{Nonlinearity}} + \underbrace{\underbrace{\frac{1}{2}g(A)A}_{\text{Gain}} - \underbrace{\alpha A}_{\text{Loss}}}_{\text{Generalization}}. \tag{1}$$

- Derived from the nonlinear wave equation
- Uses comoving coordinates so that the reference frame propagates with the pulse at the group velocity

$$T = t - \frac{z}{v_g}$$

References

[1] A. K. Aziz, M. Schneider, and A. Werschulz, "A Finite Element Method for the Tricomi Problem," *Numerische Mathematik*, vol. 35, pp. 13–20, 1980.

[2] J. A. Trangenstein, "A Finite Element Method for the Tricomi Problem in the Elliptic Region," *SIAM Journal on Numerical Analysis*, vol. 14, no. 6, pp. 1066–1077, 1977.