



Engineering and
Physical Sciences
Research Council



InFoMM
Industrially Focused
Mathematical Modelling

A New Method of Modelling Tuneable Lasers with Functional Composition

Brady Metherall

October 2019

Laser Overview



- The word laser was originally an acronym for Light Amplification by Stimulated Emission of Radiation
- The defining feature of laser light is coherence, where the peaks and trough overlap causing very strong constructive interference
- 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,

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

Generalization

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

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