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Numerical simulation of multimode nonlinear optics: The nonlinear Schrödinger equation

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Two recent developments have driven the interest in large core optical fibres: the exponentially growing demand for data transmission, which can be accommodated in optical fibres by exploiting spatial degrees of freedom in addition to the traditional wavelength, polarisation, and amplitude/phase encoding of data, and the rapid advances in available laser powers, which necessitate large core transmission fibres to avoid damage.

Numerical modelling of such systems requires a tool that can simulate the propagation of laser pulses at high powers including all relevant nonlinear and linear effects that act within and between different bound modes of an optical fibre: Kerr and Raman effects, self-steepening, even multiphoton and tunnelling ionisation in gas-filled hollow-core fibres, as well as mode-dependent chromatic dispersion and propagation losses. One such tool is the multimode nonlinear Schrödinger equation (MM-NLSE).

In this talk, I will discuss the MM-NLSE and the pulse propagation effects that it can describe. I will present various examples where we have used the MM-NLSE to model experiments, highlighting the simplifications that apply in different situations such as supercontinuum generation in multimode waveguides, intermodal wavelength conversion for optical communications, passive mode locking in fibre lasers, or high harmonic generation in gas-filled capillaries.