Supercontinuum generation in higher order modes of microstructured optical fibre

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Declaration

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Samuel Legge

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Abstract

The focus of this thesis is the observation and characterisation of supercontinuum generation within multimode microstructured optical fibre and the development of the techniques required to both create and measure the generated supercontinua. In addition, the nonlinear effects of light in silica are reviewed, and the experimental results from supercontinua generated with a low number of solitons add novel scientific weight to recent theories on dispersive wave and soliton interactions in microstructured optical fibre.

The supercontinua generated in various hexagonal core and elliptical core microstructured optical fibres when pumped with femtosecond pulses sourced from a Ti:Sapphire laser system are observed. The electromagnetic mode excited within the core is selected by an offset to the incident beam position on the fibre end face through a precise coupling system under computer control. A novel experimental measurement technique was developed to simultaneously characterise the electromagnetic mode output of these fibres in spectral and spatial domains.

This technique revealed previously unobserved complexity in the mode structure of the supercontinuum output from microstructured optical fibre. In the generated dispersive wave, it was found that the electromagnetic mode structure was orientated in a hexagonal higher order mode structure with each orientation producing a slightly varied wavelength of light.

From this work, and by selectively coupling into higher order modes, it was discovered that the creation of a “sparse supercontinuum” with a low number of solitons was possible while still maintaining strong nonlinear effects. This work allowed experimental soliton and dispersive wave pairs matched in higher order modes to be compared to the recent theories on dispersive wave trapping and the group index matching between these light pulses.

To aid in the understanding of this data the full vector solutions for the electromagnetic modes in all fibres used were simulated using finite element frequency domain analysis, providing both the mode field structure and the effective mode index and dispersion for all modes in each fibre.

A polarisation study was performed on the output of the higher order electromagnetic modes confirming the expected simulated vector modes and using the rotation direction of the field pattern with polarisation rotation to determine the specific mode generated.

This thesis comprises significant work that expands the scientific knowledge in the fields of supercontinuum generation, nonlinear optics and higher order electromagnetic modes in microstructured optical fibres through both simulation and experimental measurement and analysis.

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