Spatial and Spectral High-Speed Optical Fibre Characterization

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We built a high-speed fibre characterisation apparatus which can measure a complete linear description of the fibre, as a set of spectrally-resolved mode transmission matrices (MTM). These matrices map every input spatial and polarisation mode, to every output spatial/polarisation mode as a function of optical frequency. The apparatus uses an LCoS-based spatial light modulator to excite the desired input spatial/polarisation modes, and a swept-frequency laser source, high-speed InGaAs camera (*Xenics Cheetah 640×512 - 1700 fps*) in combination with custom electronics and CPU-accelerated off-axis digital holography [1]. Figure (1) shows an experimentally measured spectral MTM of an OM1 multi-mode fibre MMF (62.5um diameter core, graded-index), supporting 22 near-degenerate mode-groups (253 spatial modes per polarisation) at 1300nm, across 80nm with a spectral resolution of 15GHz (∼84pm). The measurement was performed by sweeping the waveleght of the laser at 100nm/s@80nm, triggering the camera at 1.1kHz for a total of 945 frames. The field and modal coefficients extraction is performed in real-time at a rate of 3.8KHz for an Intel i9-9980XE@3GHz PC.

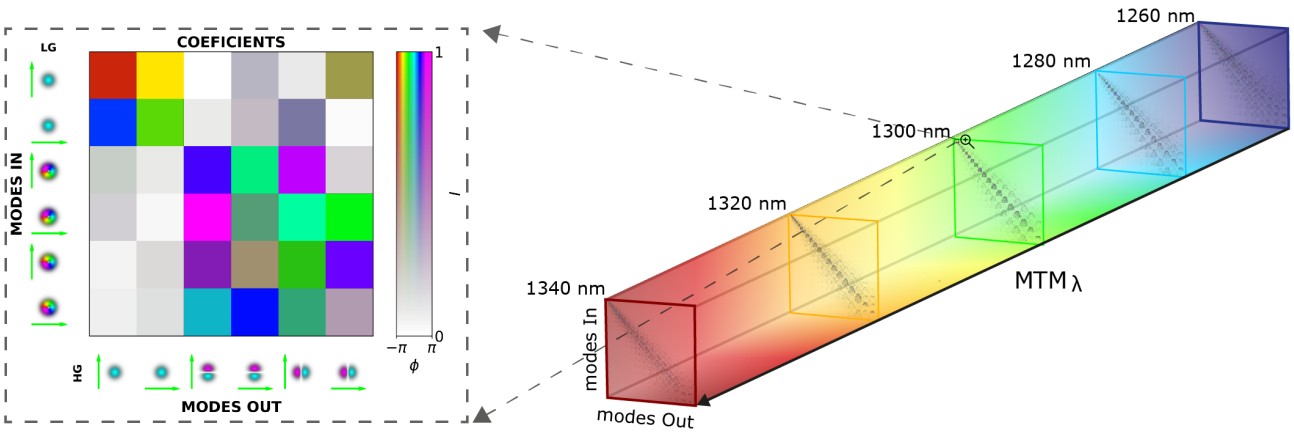

Figure 1: Full Spatial and spectral MMF characterization ($\lambda \times modeIn \times modeOut$), zooming in at the first 6×6 complex coefficients at λ =1300nm

This high-speed field acquisition system process frames four times faster than the speed of camera acquisition, which is not only useful for rapid fibre characterisation but also has potential for real-time imaging through multimode optical fibres.

[1] J. Carpenter, *digHolo: High-speed library for off-axis digital holography and Hermite-Gaussian decomposition*, arXiv:2204.02348, 2002.