Thermal effects on optical amplification in 16-core MCFs

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We investigate the impact of thermal effects, due to the quantum defect in the optical amplification process, on the performance of 16-core Yb-doped multicore fibres designed for high-power lasing and amplification applications.
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1. Introduction

Multicore fibres (MCFs) are a cutting-edge technology posited as the best candidate to replace conventional fibres in lasers and optical amplifiers, due to their potential of delivering a single higher-power beam by combining several lower power beams coherently, which can allow to overcome the threshold power limit caused by the onset of nonlinearities and transverse mode instabilities (TMI) [1] in high-power applications.

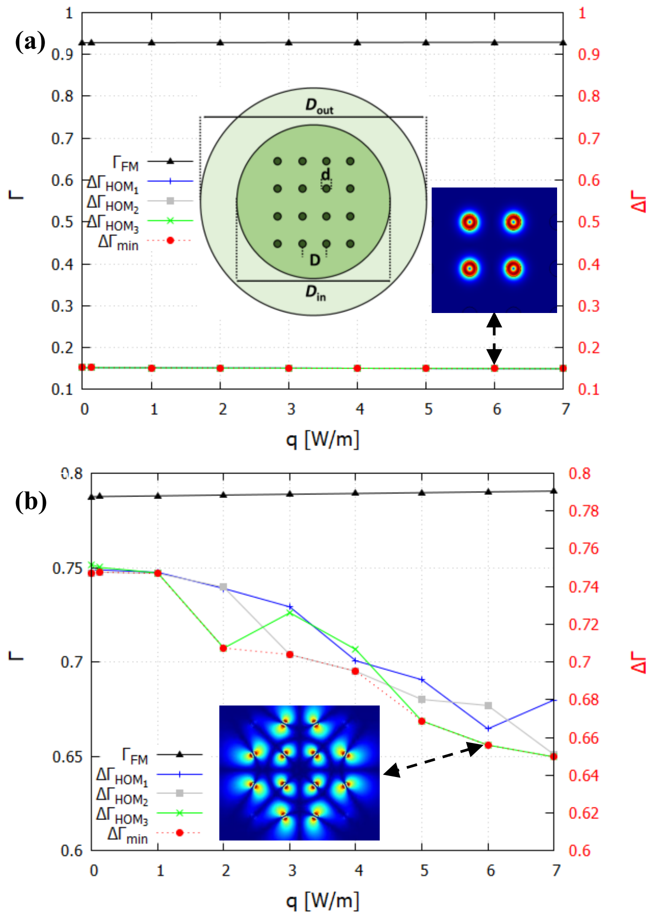

Fig. 1. FM core overlap integral $\mathbf{\Gamma_{FM}}$ and overlap difference $\mathbf{\Delta\Gamma_{HOM,i}}$ between FM and three HOMs with effective index closest to FM (minimum $\mathbf{\Delta\Gamma_{min}}$), as a function of uniform heat load **q**, with pitch **D**=55 mm and core diameters (a) **d**=19 µm and (b) **d**=12 µm.

However, the effect on all doped active cores of a uniformly applied heat load **q**, originated by the quantum defect in the amplification process, leads to interaction between optically uncoupled cores, which can result in spurious mode coupling [2] that causes detrimental effects on system performance.

2. Results and Discussion

In this work, we analyse a multicore fibre with 16 Yb-doped silica cores in a 4×4 configuration (as shown in the inset of Fig. 1(a)) by finite-element method (FEM) simulations at a signal wavelength of 1032 nm. The silica inner cladding diameter $\mathbf{D_{in}}$, the acrylate polymer outer cladding diameter $\mathbf{D_{out}}$ and core-to-core distance (pitch) **D** were set to 420 µm, 600 µm, and 55 µm, while the core/inner-cladding/outer-cladding refractive indices were 1.45/1.4487/1.37, respectively. Fig. 1(a) shows fundamental mode (FM) core overlap $\mathbf{\Gamma_{FM}}$ and overlap difference $\mathbf{\Delta\Gamma_{HOM,i}}$ between FM and the three higher-order modes (HOMs) whose effective index is closest to FM, for a core diameter **d**=19 µm. From previous results, we drew two main criteria for single-mode fibre operation: a high $\mathbf{\Gamma_{FM}}$ value and at the same time a minimum $\mathbf{\Delta\Gamma_{min}}$ value above 0.3, which fails for **d**=19 µm. However, we show that by adjusting **d** we can achieve overall effective monomodality, e.g. as shown in Fig. 1(b) for **d**=12 µm. More insight will be given at presentation time.

3. Conclusions

We applied a uniform heat load to the active cores of a multicore fibre, in order to evaluate the optical field distributions and **ΔΓ** through a thermal-optical FEM model. Results show that by adjusting the core diameter between 12 µm and 19 µm, the minimum **ΔΓ** can be managed to achieve single-mode operation. **ΔΓ** curve slopes tend to flatten for **d**>14 µm, as HOMs become more confined into the cores, which causes a negative impact on the optical beam quality.

References

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