

Self Focusing in Multicore Fiber Designs

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Self focusing is the ultimate power limit of single mode fiber amplifiers. It can be mitigated in bulk systems, as the propagation length in the crystals can be made shorter than the self focusing length, but this approach is not an option in fiber amplifiers. We analyzed the self focusing properties of multicore fibers. According to our calculations it should be possible to significantly scale the self focusing limit using the waveguide properties of the fiber to avoid the collapse of the beam to a single point.

At first glance it might seem like the self focusing scales simply with the number of cores. However, the cores in multicore fibers are often at least slightly coupled. This gives rise to supermodes, which might be prone to the same self focusing limits as free space intensity distributions.

We simulated different multicore designs using COMSOL to obtain the eigenmodes and then used a custom FFT based propagation algorithm to simulate self focusing. We assumed a signal at 1064nm and a nonlinear refractive index of $n_2=2.2 \cdot 10^{-20} \text{ m}^2/\text{W}$. To decrease oscillations of the mode area during propagation, we slowly increased the power up to the final value along the first half of the propagation. We analyzed different modes (in phase and out of phase mode) and fiber designs. We obtained the best results with a circular 6 core design (6 μm core diameter, 15 μm core to core distance, NA=0.076). In this case self focusing can be mitigated to approximately 6 times the single core limit. This is shown in Fig. 1, which shows the mode area after 2mm propagation and for comparison 6 times the effective mode area of as comparable single core fiber. At the self focusing limit the supermode collapses, in Fig. 1 this point is reached for an effective mode area of $100 \mu\text{m}^2$ due to the chosen grid size.

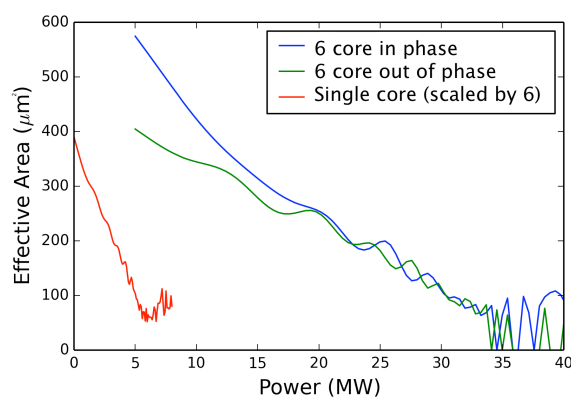


Fig. 1. Comparison of the 6 core supermodes (in phase and out of phase) effective mode area with a single core of the same size and NA as a function of total power. To simplify comparison 6 times the effective mode area of the single core fiber is shown.