

# Light Propagation in Multicore Photonic Crystal Fibers

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This project is focused on light propagation in multicore fibers, especially nonlinear coupling, which is useful for all optical switching and other in-fiber photonic applications. In the first stage of this work, we studied linear propagation and inter-core coupling. Secondly, we checked simultaneous propagation as a proof for fundamental modes in such fibers. Additionally one example of nonlinear effects is demonstrated.

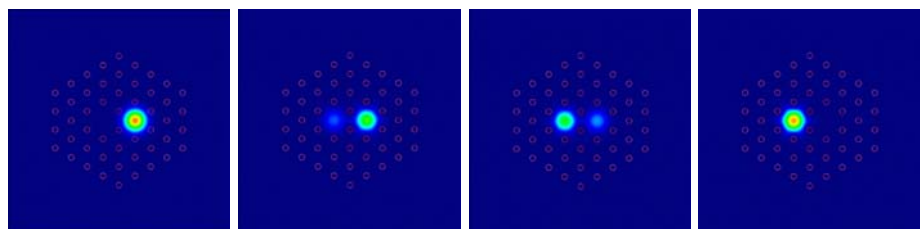
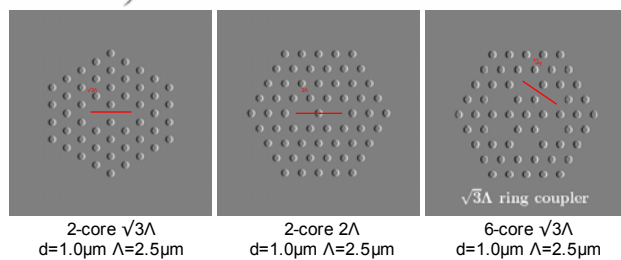
## ☆ Inter-core linear coupling simulation

(using fast Fourier transform and finite-difference scheme)

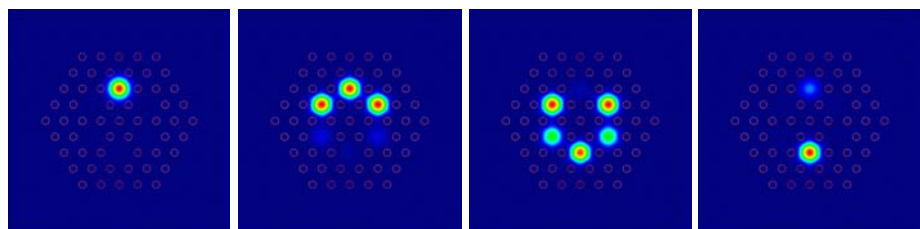
Maxwell's equivalent propagation equation

$$(\vec{k} \cdot \vec{\nabla}) \vec{H} = -\frac{i}{2} \Delta \vec{H} - \frac{i}{2} \left( \frac{n^2 \omega^2}{c^2} - |\vec{k}|^2 \right) \vec{H} - \frac{1}{n} [(\vec{\nabla} n) \cdot \vec{H}] \vec{k} - \frac{i}{n} (\vec{\nabla} n) \times (\vec{\nabla} \times \vec{H})$$

Different fibers with different hole diameters ( $d$ ) or pitches (hole spacing  $\Lambda$ ) have different propagation characteristics.



linear coupling process in a 2-core  $\sqrt{3}\Lambda$  coupler (simulated)



linear coupling process in a 6-core  $\sqrt{3}\Lambda$  ring coupler (simulated)

## ☆ Simulation result: coupling length vs. $d/\Lambda$

Gaussian beam ( $\lambda=1.0\mu\text{m}$ ) launched into right core

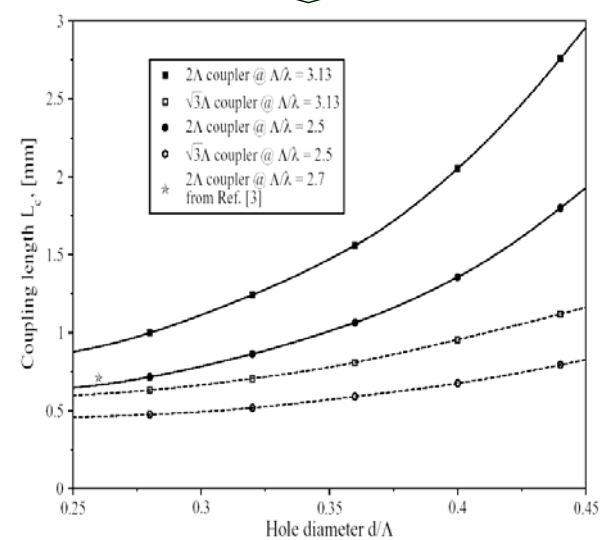
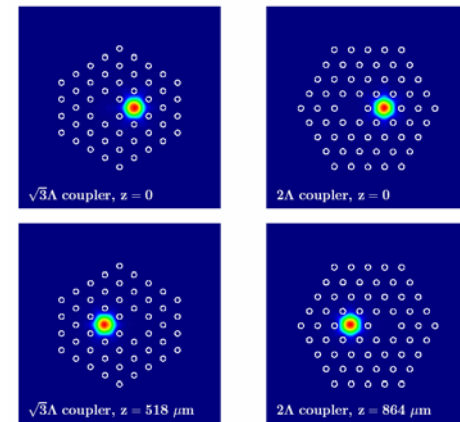
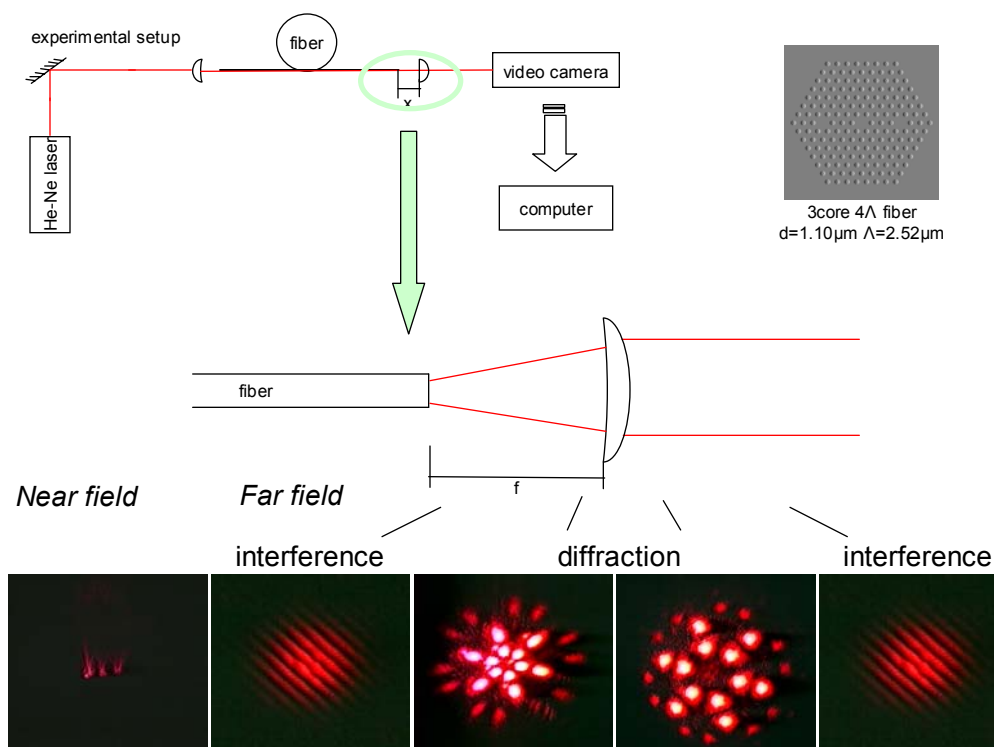


Fig. 3. Calculated values for the coupling length for various fiber geometries.  
coupling length vs. structural parameters

## ☆ Experimental results of simultaneous propagation in all cores of the fiber



real fiber image of 3 cores (fiber tip at the focal point of microscope objective 100x)

Theory indicates that fibers with ratio  $d/\Lambda > 0.45$  carry higher order confined modes. This picture of interference gives proof that the cores in testing fibers with  $d/\Lambda = 0.4365 < 0.45$  are single mode at  $\lambda_0 = 632.8\text{nm}$ .  
calculated distance between adjacent cores  $d = \lambda_0 / \Delta y = 9.112\mu\text{m}$   
actual distance  $4\Lambda = 10.08\mu\text{m}$

## ☆ An example of nonlinear effects in microstructure fibers: Supercontinuum Generation

