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Analysis Of Linearly Polarized Modes

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Introduction

- This paper is an analysis of the propagation mode of step index fiber optic
- To obtain the propagation modes of electromagnetic waves the characteristics of the optical fiber has been changed
- Analytical method of this analysis is based on finite element method
- This study is required for further investigation of states of polarization and analysis of electric field distribution

Basic equations

- Snell's law: $n_1 \sin\phi_1 = n_2 \sin\phi_2$
- Wave equation: $A(r,t) = \mathrm{Re}\{\bar{A}(r)\exp(j\omega t)\}$
- The equation of electric field: $$\nabla^2 E + \nabla\left(\frac{\nabla\varepsilon_r}{\varepsilon_r}\cdot E\right) + k^2 E = 0$$ $$\nabla^2 E + +k^2 E = 0$$
- The equation for magnetic field: $$\nabla^2 H + \frac{\nabla\varepsilon_r}{\varepsilon_r}\times(\nabla\times H) + k^2 H = 0$$ $$\nabla^2 H + n^2 k_0^2 H = 0$$
- The Helmholtz's equation for the electric and magnetic fields can be summarized as

$$\nabla_\perp^2 E + (k^2 - \beta^2)E = 0$$

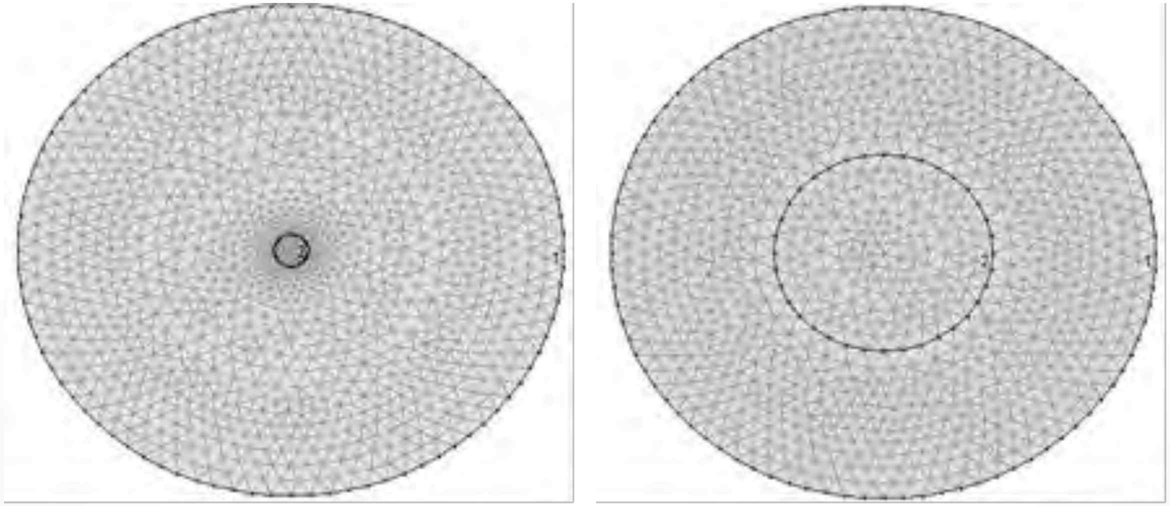
$$\nabla_\perp^2 E + k_0^2(\varepsilon_r - n_{eff}^2)E = 0$$

$$\nabla_\perp^2 H + (k^2 - \beta^2)H = 0$$

$$\nabla_\perp^2 H + k_0^2(\varepsilon_r - n_{eff}^2)H = 0$$

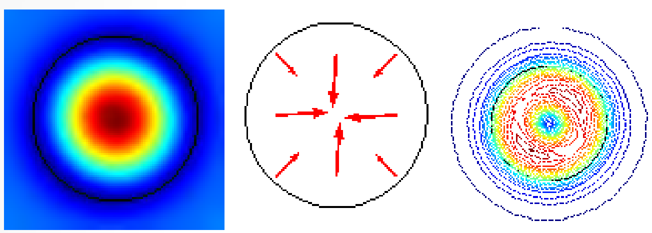
The propagation of electromagnetic field

- Optical fibers
  - o core- 8 μm and 50 μm
  - o cladding - 125 μm
  - o Refractive index of core – 1.4457
  - o Refractive index of cladding – 1.4378
  - o Core –pure silica
  - o Cladding – doped silica

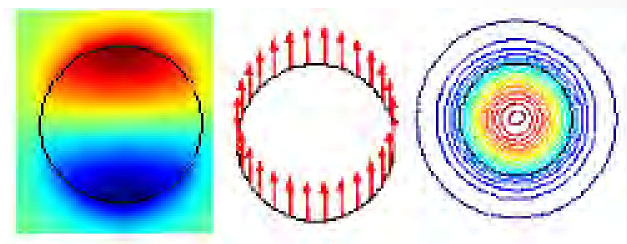


Finite element mesh for single mode and multimode fiber optic

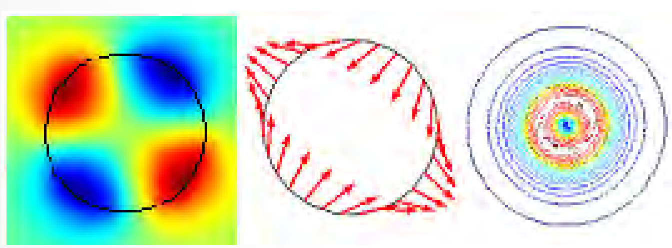
Classification of LP_{nm} modes for single mode optical fiber and the distribution of electric and magnetic field



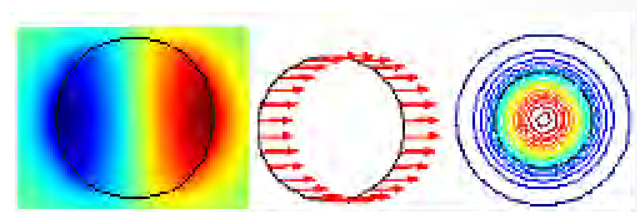
Fundamental mode



LP_{01} Electric transverse mode

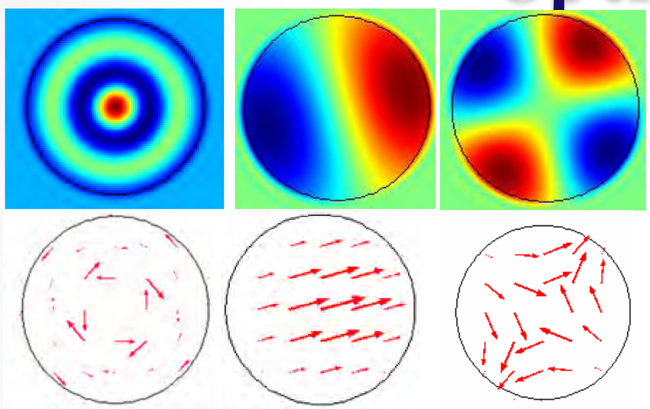


LP_{02} mode

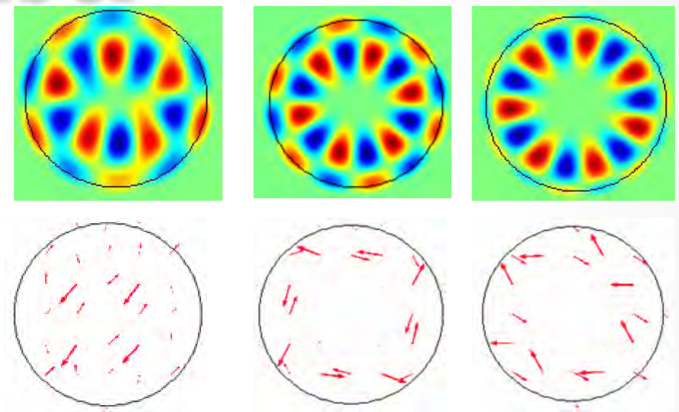


LP_{01}Magnetic transverse mode

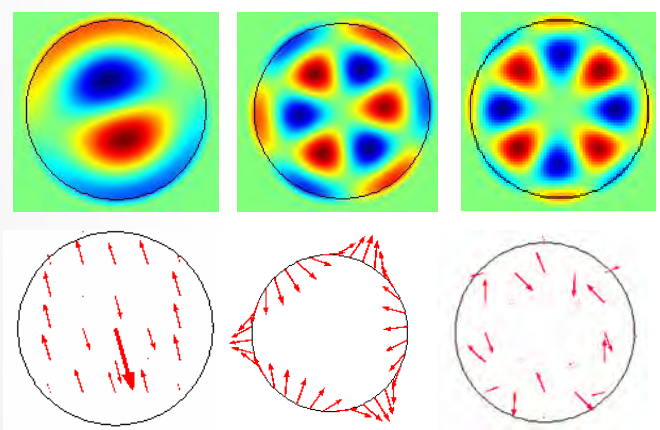
Classification of LP_{nm} modes and distribution of electric field for multimode optical fiber



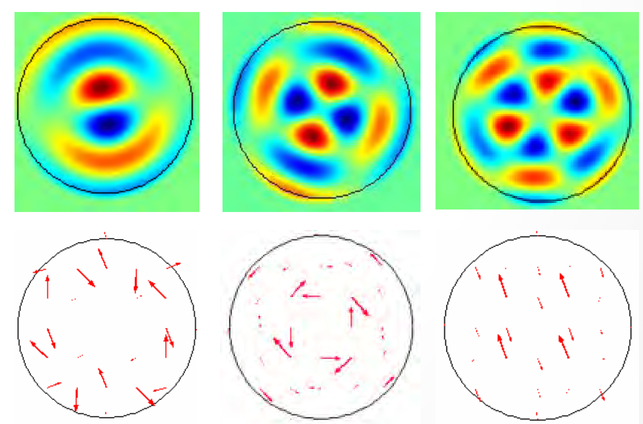
LP_{01}, LP_{11}, LP_{21}



LP_{52}, LP_{62}, LP_{72}

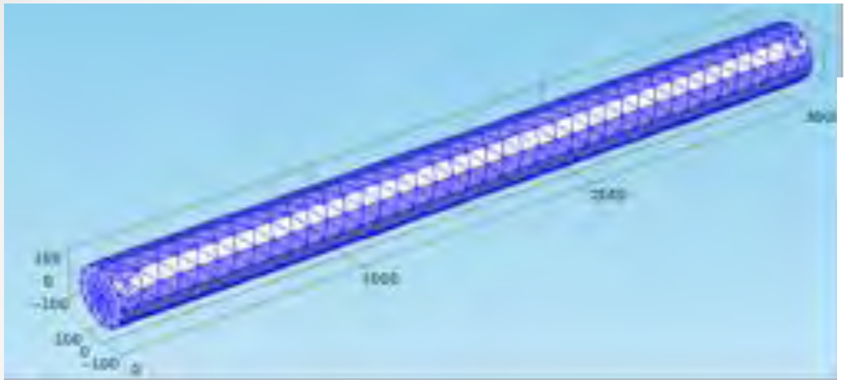


LP_{12}, LP_{32}, LP_{42}

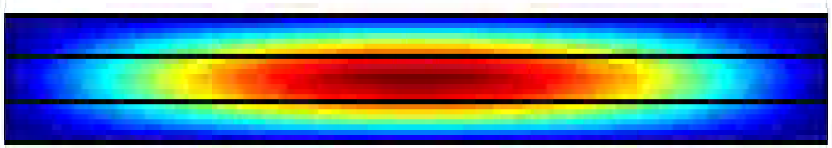


LP_{13}, LP_{23}, LP_{33}

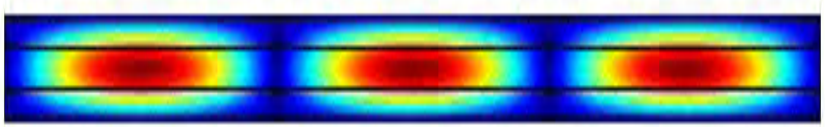
The propagation of electromagnetic wave through a transversal optical fiber.



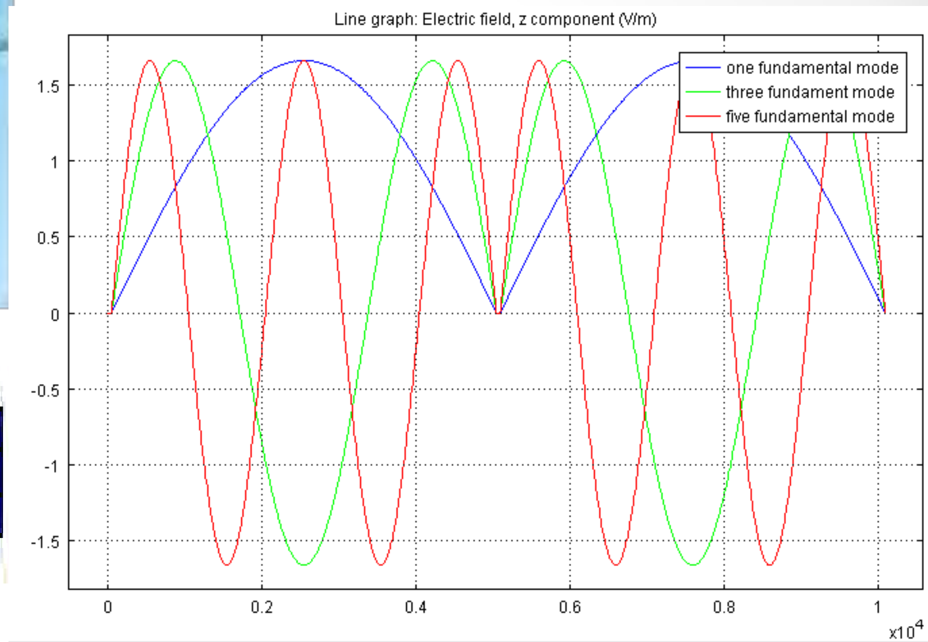
The 3-D optical fiber



The electrical field distribution
One fundamental mode

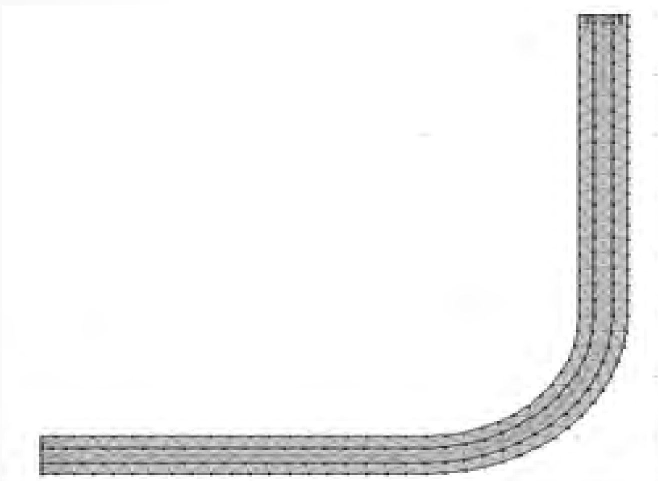


The electrical field distribution.
Three fundamental modes



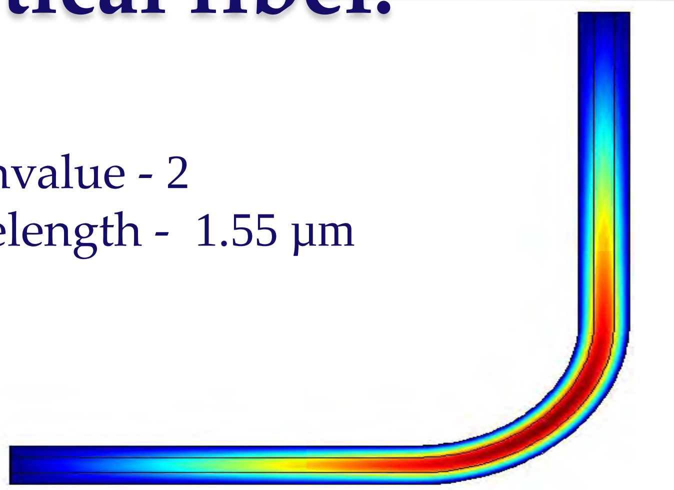
Line graph for electric field distribution along the z axis

The propagation of electromagnetic wave through a curved optical fiber.



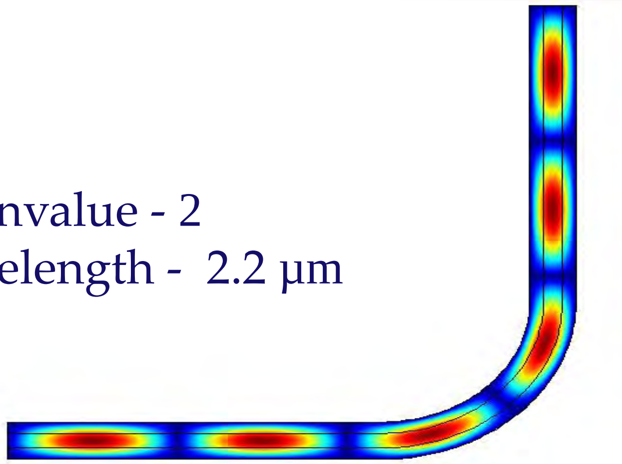
The mesh for the multimode curved optical fiber

Eigenvalue - 2
Wavelength - 1.55 μm



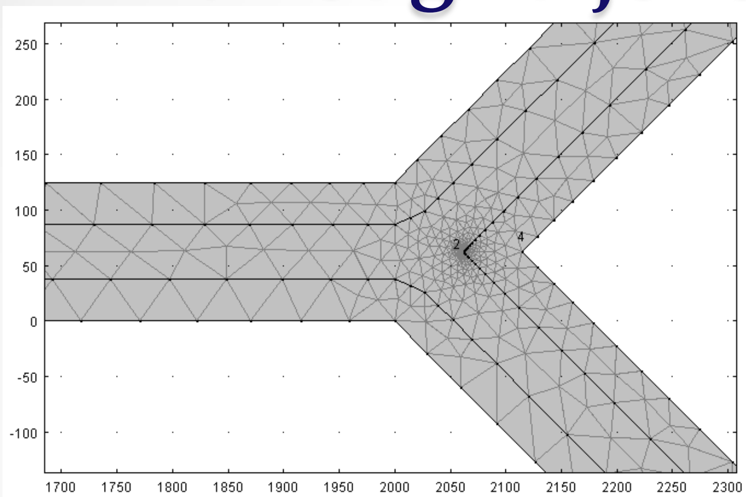
The electric field .
One fundamental LP

Eigenvalue - 2
Wavelength - 2.2 μm

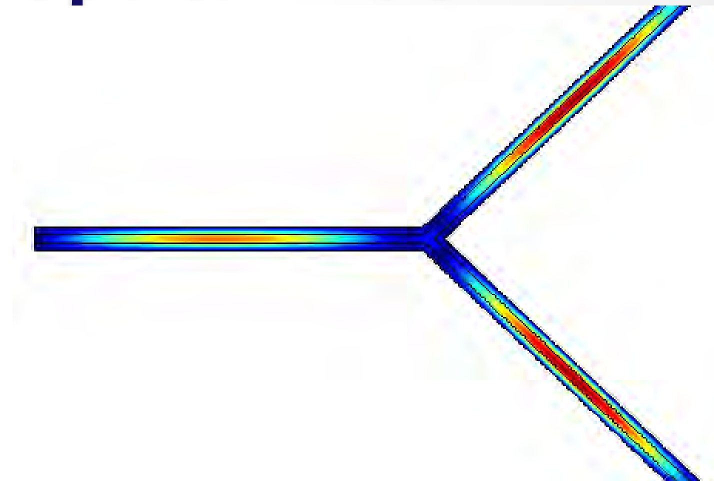


The electric field
Six fundamental LP

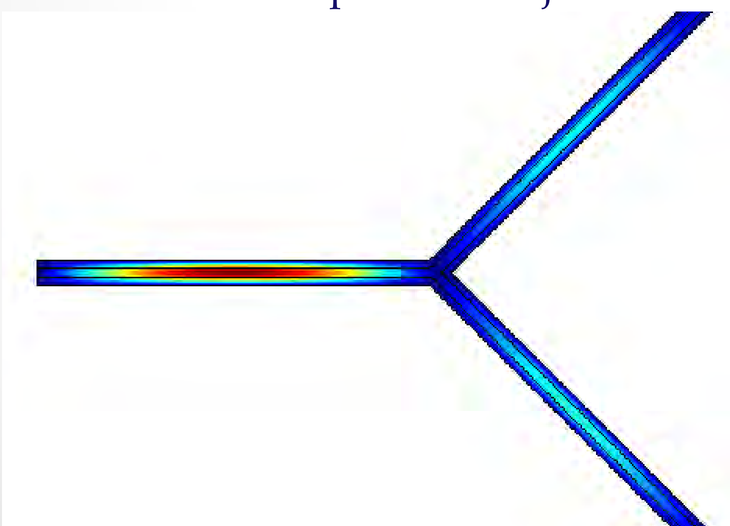
The propagation of electromagnetic wave through a jonction optical fiber



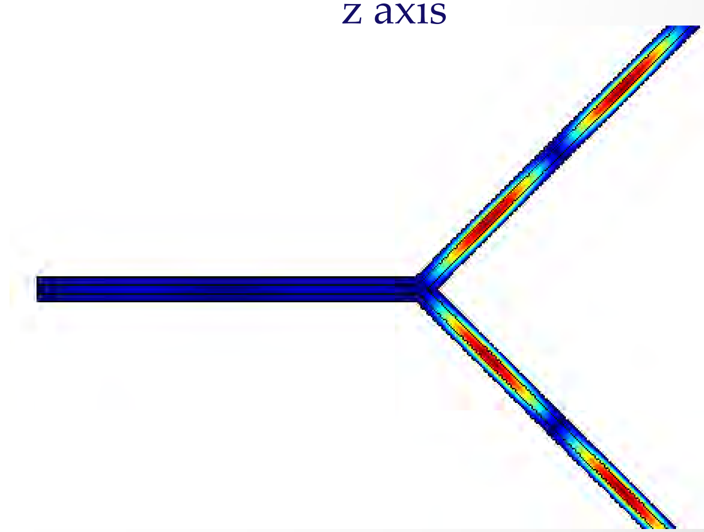
The mesh of optical fiber junction



Second step of electrical field distribution along z axis



First step of electrical field distribution along z axis



Last step of electrical field distribution along z axis

Conclusion

- According to the simulation through the single-mode fiber, the wave is transmitted in one linearly polarizated mode
- Through the multimode fiber more light waves can pass, but each with its particular linearly polarized mode
- These simulations will be developed to simulate Faraday Effect, Kerr Effect and Pockels Effect