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DISPERSION ANALYSIS IN AN OPTICAL FIBER

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ABSTRACT:
An optical fibre is a cylinder-shaped dielectric waveguide. If the angle of incidence onto the core cladding interface is greater than the critical angle Θc, it confines electromagnetic energy in the form of light within its surface and directs light by multiple internal reflections. Both digital and analogue transmission through optical fibres is distorted by the transmitted optical signal's dispersion. Dispersion mechanisms within the fibre cause the transmitted light pulses to broaden as they travel through the channel when optical fibre transmission is being used extensively and incorporates some type of digital modulation.

Keywords: Dispersion; MATLAB; single-mode fiber; multimode fiber;

1. INTRODUCTION:
As a light pulse travels down the fibre, it spreads out in time, which is known as dispersion. Model dispersion, material dispersion, and waveguide dispersion are all types of dispersion in optical fibre. The refractive index of fibre optic materials varies with wavelength, which leads to material dispersion. Light moves more slowly with a higher index. Light is distributed between the core and cladding of the waveguide, which causes waveguide dispersion. [6]
Dispersion reduces the length of time a signal spends travelling across optical fibres, similar to attenuation. Dispersion, in contrast to attenuation, distorts rather than weakens the signal. A pulse that lasts one nanosecond at the transmitter will last ten nanoseconds at the receiver, for instance. As a result, signals are not correctly encoded and received.[6]
The straightforward fitting of the curve is used to calculate the waveguide dispersion. By adjusting the wavelength in relation to various types of dispersion, including material dispersion, waveguide dispersion, and total dispersion, the dispersion analysis for single mode fibre is conducted. [8,9]

2. DISPERSION IN OPTICAL FIBER:
As far as we are aware, dispersion is a phenomena that occurs when light travels from one medium to another. Light of different wavelengths will bend at various angles and cause dispersion.
One common illustration is how a transparent prism would divide white light into a spectrum of colours, with red light bent at the lowest angle and blue light bent at the greatest angle. As a result, red light is at the top of the spectrum while blue light is at the bottom. We just use our secondary understanding of light dispersion to support our explanation [14]. To fully comprehend dispersion and how it applies to fibre optics, more research must be done. [10]

- **Modal dispersion:** Various modes spread out at various group velocities
- **Material dispersion**: The medium's medium's index of refraction varies with wavelength
- **Waveguide dispersion**: A waveguide's changing refractive index causes varying delays for different wavelengths.
- If the waveguide is birefringent, polarisation mode dispersion will occur.

Combining material and waveguide dispersion in a way that results in zero chromatic dispersion at a desired operating wavelength is a practical application of both (normally between 1530 and 1620 nm). Since material dispersion is typically unpleasant to change due to desirable inherent features of the chosen material for optical fibre, this can be accomplished by altering waveguide dispersion (most likely silica). The following figure illustrates how nonzero dispersion-shifted fiber's material, waveguide, and chromatic dispersion fluctuate with wavelength and exhibits zero chromatic dispersion at 1.5 micrometre wavelength.[1,2,7]

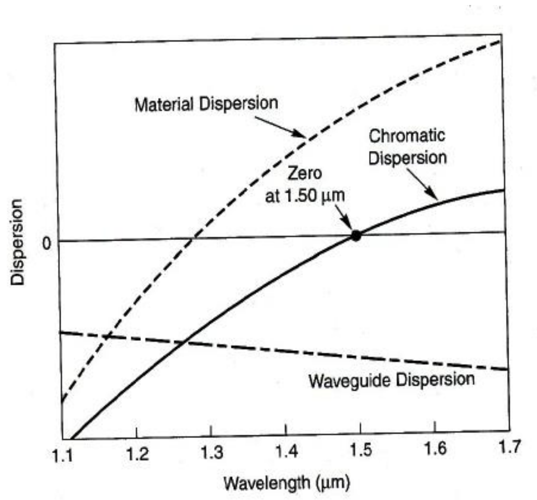

Figure 1- Combine waveguide and material dispersion.

3. MEASUREMENT METHODOLOGY-

Measurements of dispersion reveal how optical signals are distorted as they travel across optical fibres. The capacity of the fibre for conveying information is constrained by delay distortion, which, for instance, causes the spreading of transmitted light pulses. We implement the system using MATLAB , the optical fiber toolbox.

Functions for quick, automatic guided mode calculations in basic optical fibres are provided by the Optical Fibre Toolbox (OFT). Designed with tapered microfibres in mind (also known as nano-fibres). For both weak and strong guidance scenarios, exact answers are given. Dispersion of the material is considered.

The main feature is

- To locate the guided modes.
- Determine each mode's effective refractive index for the specified diameter and wavelength or in the presence of changeable diameter or wavelength (modal dispersion).
- Determine the modes' electric and magnetic fields (only two-layer modes).
- Locate phase-matching fibre spots for harmonic production.

By directly fitting the curve, the waveguide dispersion is calculated. By adjusting the wavelength in relation to various types of dispersion, such as material dispersion, waveguide dispersion, and total dispersion, one may analyse the dispersion of single-mode fibre.

4. RESULTS:

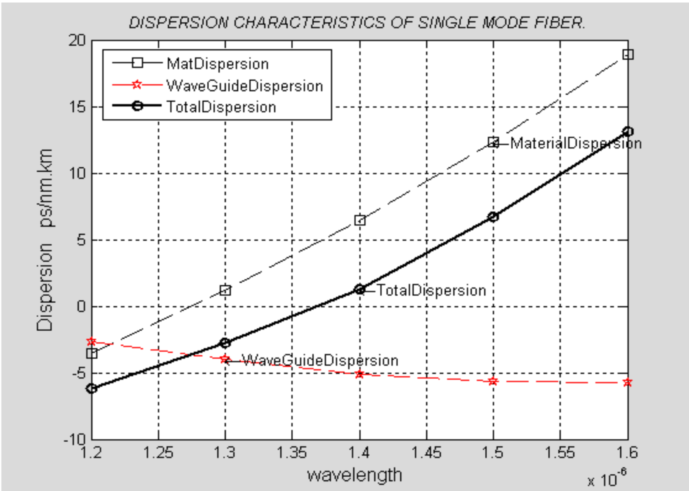

Figure 2 - Dispersion characteristics for singlemode fiber

Table 1- Dispersion characteristics in singlemode fiber

Sr. No.	Wavelength in µm	Dispersion for single mode fiber in ps/nm.km		
		Material Dispersion	Waveguide Dispersion	Total Dispersion
1	1.2	- 3.5	- 2.68	- 6.2
2	1.25	- 1.15	- 3.35	- 4.5
3	1.3	1.2	- 4	- 2.8
4	1.35	3.82	- 4.6	- 0.76
5	1.4	6.3	- 5	1.27
6	1.45	9.37	- 5.4	4
7	1.5	12.3	- 5.62	6.68
8	1.55	15.6	- 5.7	9.9
9	1.6	19	- 5.8	13.16

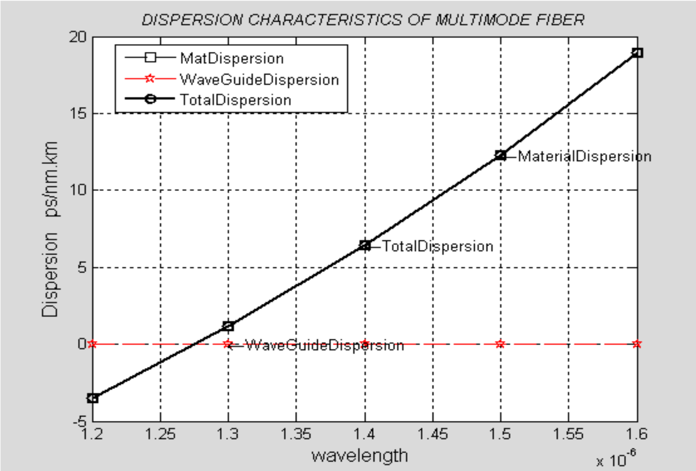

Figure 3- Dispersion characteristics for multimode fiber

CONCLUSION:

The figures above show that waveguide dispersion in single mode fibre is not zero. However, waveguide dispersion in multimode fibre is zero. Material dispersion and waveguide dispersion are included in total dispersion. Additionally, it can be shown that at 1.27 mm, there is no material dispersion. Chromatic dispersion differs between optical fibres that are single mode and multimode.

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