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The Effect of elliptical core on producing modal birefringence (low and high) in the single-mode optical fiber

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Abstract:

In this applied theory study presents the results of theoretical investigation of the normalized Birefringence produced in a single - mode optical fiber, when this fiber produced under high accuracy manufacturing process to uses it in long - haul communication field.

We suppose (by implying some experimental thesis) that the fiber core contains a slight ellipticity lies between the range (e_s = (1-10.01) percent), when the ellipticity comes from a manufacturing process imperfection.

We find the induced birefringence is small, then could not affect on the state of the guided light, but it may causes a limited fluctuation in it in a long fiber distanced.

In the other hand when we introduce a large ellipticity (e_L = (15-91) percent), intentionally to enhancing the internal geometrical Birefringence. We find that the induced birefringence did not satisfied the minimum required value to design polarization maintaining fibers, this mean that the geometric contribution alone could not design such a fiber without introduce the other kind called "stress birefringence".

Key words: The single mode optical fiber, polarization maintaining.

1.introduction:

The monofilament – the (modern pattern) is a generated media for Birefringent , which is inadvertently due to the lack of circular symmetry of the cross section. In addition to the asymmetric stress, which allows the fiber to support two semi-polarized two-phase polarization modes (phase-Velocity) with slightly difference [1]. Therefore, the state of polarization at the end of the fiber will not be retained as it was at the input. The irregular distribution of the binary refraction will make the problem worse, so the polarization situation cannot be predicted at the exit, and for optical systems, the special kind of fiber is "conservative polarization" (Polarization Maintaining) is preferred. This type, symbolized by PM, represents a class of monofilament - a pattern that has linear fracture. If the falling light is linearly polarized in parallel to the Optic Axis, this state of polarization will be maintained by this type of evidence even if the fiber moves with the influence of an external action [2]

2.MODES DISTRIBUTION ALONG NONCIRCULAR CORE)

that spread of the two predominant dominant type compounds in the cardiac heart is the two axes so that the vehicle (HE11even (= HE11y)) propagates the pattern along the long axis (y-axis), while the vehicle (HE11odd (= HE11x) Short (to be x-axis) [3]. Thus, the presence of roundness (and the approximate shape will assign new binary refraction axes, which is in turn generate linear impedance (added to the existing impedance due to impurities or industrial defects) depend on the degree of ellipsoid (e) [4].

Several formulas were proposed to calculate this type of binary refraction. If I want to calculate the bifurcation that is created by chance, which is the result of defects that arise during manufacturing, then a small percentage of ellipsoid will be assumed, thus calculating the binary-geometric refraction using the following relationship [5]:

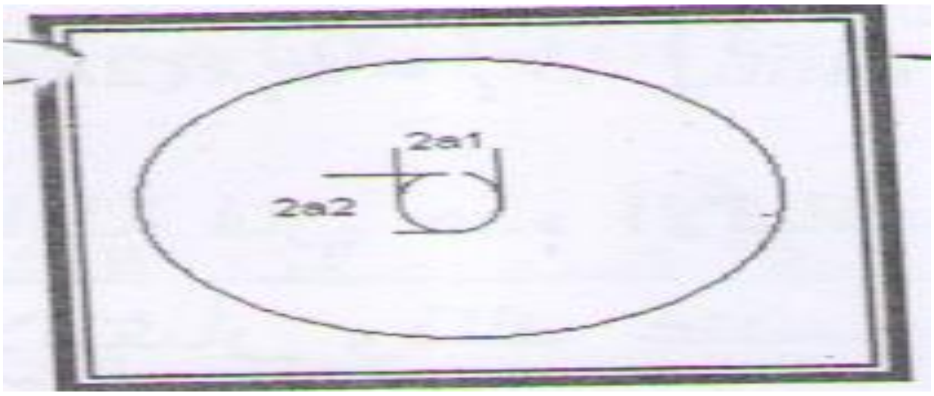


Figure (1) A non-circular heart of the visual tract showing the large and small diameter (2a2, 2a1), respectively.

$$B = 2\sqrt{2}\pi e_s^2 \delta^2 \frac{c_1}{V_c} \dots\dots\dots\dots..(1)$$

$$\left\{ e_s^2 = 1 - \left(\frac{a_2}{a_1}\right)^2 , \delta = {dn}/{n_{av}} , dn = n_1 - n_2 , n_{av} = \frac{n_1 + n_2}{2} \right\}$$

Where a1 (a2) represents the large and small diameter of the oval shape of the cross-section of the cross-section, respectively, (c1) is a constant based on the calibrated frequency value as (c1 = 0.06), when the operation is in the basic mode. The above equation assumes that fiber manufacturing processes are of high accuracy include precise thinning of the protective layers and accuracy during roll-out for transport purposes. In order to avoid the fine bending and sprains that may arise during these stages, the fibers manufactured with that precision are used for purposes requiring low bifurcation Such as optical communications, Faraday phenomenon applications, circular polarization applications, etc.

In order to be used in applications that require linear polarization, the binary refractive (in process) manufacturing of optical fibers (PM) is to be enhanced by increasing the frequency of these fibers to become large (eL) and increasing their calibrated frequency The binary-geometric fractions are calculated using the following formula [5]:

$$B_{G_L} = c_2\delta^2 \dots\dots..(2)$$

$$\{c_2 = \left[\frac{(4\pi)^2}{2n}\right]\left[(V_x + 2)^{-3} - \left(V_y + 2\right)^{-3}\right], V_i = d_i(2n\delta)^{\frac{1}{2}}, i = x, y\}$$

According to this equation, this fiber (which has eL) will only allow one frequency to propagate when it is (C2 ≅1). The binary fractions are calculated by each of the two previous equations can be counted as internal binary fractions for each of the two previous designs.

3.(THE USED FIBER PARAMETERS VALUES)

The operating wave length is: 1.30μm. Our choice of this wavelength was to exploit the second window for low attenuation as well as to reduce signal distortion by using the absolute value of both the physical dispersion and the dispersion of the waveguide. As for the fiber indices, their values were chosen according to the following criteria:

With regard to the heart and cortex regions, the latter should give greater importance than expected, due to its important role in monofilament fibers. The favorite article to use as a heart is In order to understand the requirement of "Weakly Guiding" for fiber optic communication systems, the refractive index of the material used as a cortex should reach (n2 = 1.452), based on the exporters [6] and [7], optical stress coefficients (Pukels) have the following values:

(P_{11} = 0.113, p_{12} = 0.252, v_p = 0.17)

The optical elasticity coefficients are calculated based on the precise concentrations of the materials used in the correction and using the following relationship [8]:

$\alpha(d) = d\alpha_d + (1-d)\alpha_{silica}$ ………… (4)

Where αsilica = 5 * 10-7 / Co), (αd) is the coefficient of the expansion of the molar concentration (d).

And thus will reach the coefficient of expansion of the cortex and heart:

($\alpha_{cl} = 7.7 * 10^{-7} / C^o$, $\alpha_{co} = 1.07 * 10^{-6} / C^o$) respectively. As for half the diameter of both the heart and the crust are determined on the following basis:

Regarding to the heart, it satisfies the requirement calibrated cut frequency of the measured pieces (Vc≤22.405) to propagate by the basic pattern alone, and to compensate this value and the value of the previous operating wave length by the following equation [8]:

$$a \leq \frac{2.405\lambda_c}{2\pi(n_1^2 - n_2^2)^{1/2}} \ldots\ldots\ldots\ldots\ldots.(4)$$

We get upper limit for the heart radius (α≤ 44.61μm), the value was selected (α ≤ 44.61μm) of this fiber based on the standard specifications indicated in the source [8], and to determine the appropriate radius of the cortex (b) for this value we by substituting in the the following equation [9]:

$$\frac{cladding\ diameter}{core\ diameter} \geq 5 \ \ldots\ldots\ldots..(5)$$

The above equation aims to reduce absorption loss, and we chose the value (b = 62.5μm) based on the same reference [8] above. When the above-mentioned fiber indications are attenuated based on the study [10] to be less than 0.2 dB / Km.

4.Results and Discussion

Equation (1) was used to calculate the values expected to be generated for biodegradable refraction when the ground section of the elliptic heart was contained in the elliptical, which can be applied in the ellipsoid states located in a finely constructed optical fiber designed for use in optical communication, assuming that the long radius (a1) of the heart is located on the axis (y), while the short (a2) is located on the axis (x) and the ellipsoid is practically proportional between the following two values:

(e_s = (1 - 10.01) percent)

The results (shown in Table (1)) showed a bio degradable refractive value ranging from:

{B_{1s} (L_{b1s} = 7748.99m - 77.39m) = 1.68 * 10^{-10} - 1.68 * 10^{-8}}

Table (1) Results of double (high and low) refraction calculations generated by elliptical effect: (a) minor, (b) large, heart

Table(1-b)

e_L	B_{1L}	L_{b1L}(m)	V_y	C_2
15.00%	1.45E-07	8.95168	2.37248	9.08E-03
19.00%	2.33E-07	5.57565	2.38916	1.46E-02
23.00%	3.42E-07	3.80192	2.41025	2.14E-02
27.00%	4.72E-07	2.75631	2.43611	2.95E-02
31.00%	6.22E-07	2.0887	2.46718	3.89E-02
35.00%	7.94E-07	1.63665	2.50402	4.96E-02
39.00%	9.87E-07	1.31647	2.54735	6.17E-02
43.00%	1.20E-06	1.08148	2.5981	7.51E-02
47.00%	1.44E-06	0.90397	2.65744	8.99E-02
51.00%	1.70E-06	0.76664	2.72693	0.10599
55.00%	1.97E-06	0.65825	2.80859	0.12344
59.00%	2.28E-06	0.57126	2.90516	0.14223
63.00%	2.60E-06	0.50043	3.02041	0.16237
67.00%	2.94E-06	0.44204	3.1597	0.18381
71.00%	3.30E-06	0.39341	3.33092	0.20654
75.00%	3.69E-06	0.35255	3.54627	0.23047
79.00%	4.09E-06	0.31801	3.82582	0.2555
83.00%	4.50E-06	0.2887	4.20543	0.28145
87.00%	4.93E-06	0.26381	4.75739	0.30799
91.00%	5.35E-06	0.24287	5.65748	0.33455

Table (1-a)

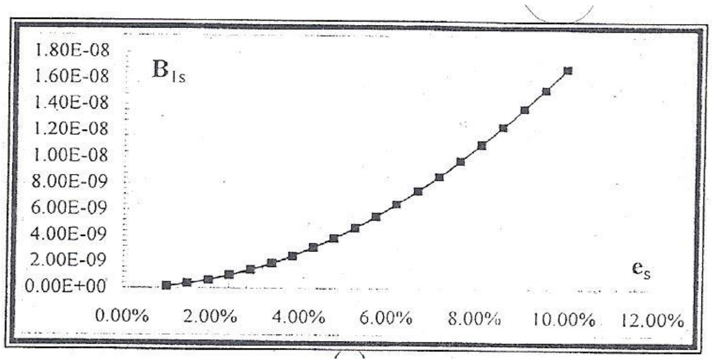
These values are very low, which means that the effect of this binary refraction on the state of polarization of the two basic type composites will be limited as long as the strike length satisfies the condition: (Lb≥50m) as indicated by Okamoto (K.) and his group [3]. In contrast, the practical value reached by Kaminow (I. P.) [5] (which adopted the equation used by him) is:

= 4.5 * 10^{-9}}){B(L_b = 140m:

It corresponds to elliptical of (e_s≈7.5 percent), and the lowest elliptical is practically manufactured, indicating that this factor is has limited impact on relatively short distances such as interconnection networks in data, ships, trains, spacecraft and other uses, should be taken into account in large-distance applications such as marine access and connectivity between remote cities and other uses. On the other hand, if the techniques of production can be improved to the lowest value used for (es), the values for the binary refraction will be greatly reduced, and the remaining elliptical will return either to possible errors occurring when the fiber is encapsulated or to those that occur when the fiber is rolled in transport rollers , Which generate precise curvature and twisting. When calculating the calibrated frequency at this operation and these values of the fiber dimensions using the relationship

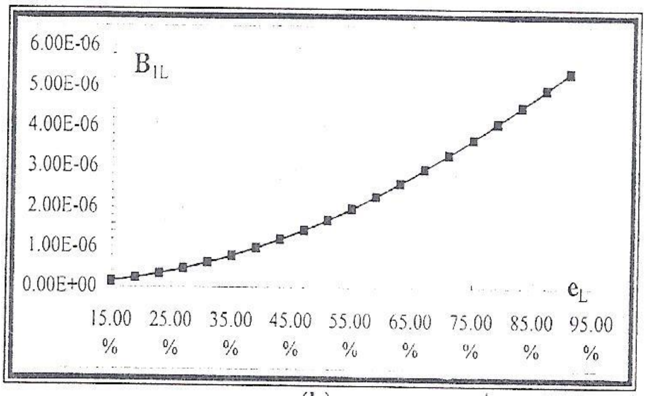
$V = ka\sqrt{(n_1^2 - n_2^2)}$ [11] , we see that the calibrated frequency dispersed on the longitudinal V_{xs} didn't exceed the frequency of the part V_c shows the almost complete partial correlation between the ellipsoid (ES) and the binary refraction (E). (B1s) arising from them.

Figure (2) The relationship between the binary refraction generated by the slight ellipsoid effect in the heart and the values of the ellipsoid.



In the same program, the B1L (deliberately generated) refractive index was calculated in the high ellipsoid heart between values (eL = (15 - 91) percent), using equation (2) for high ellipticity, The assumption is that the long and short diameter is in the same coordinate order. The results showed that a measured geometric fracture was produced between:

{B1L(Lb1L = 8.95 - 0.24m)=1.45 *10^{-7}-5.33 * 10^{-6}}They are medium-high values. Figure (3) illustrates the almost complete positive relationship (Corresponding to figure (2)) between this great binary and elliptic refraction.



Figure(3)The relationship between the binary refraction generated by the large elliptic effect in the heart and the values of those large elliptical.

In comparing the behavior of each of the previous forms with some of them, we find that in the small case of ellipsoid, especially in the primary values, the relationship tends to bend compared to the shape of the large case, The relationship gradually becomes "linearly linear" rather than "curved". In this binary fracture, the possibility of additional patterns is assumed. Assuming that the two orthogonal HE11s are spread on one of the axes (x, y), we find that when the large ellipsoid has a value of (eL = 22.75 percent) (Vy ≥Vc), indicating that the pattern associated with this vehicle can exceed the calibration frequency at this ellipsoid, thus generating unwanted propagation patterns (which may be leaked) once these values exceed Elliptical. Figure (4) shows the relationship between the measured frequency and this type of elliptical.

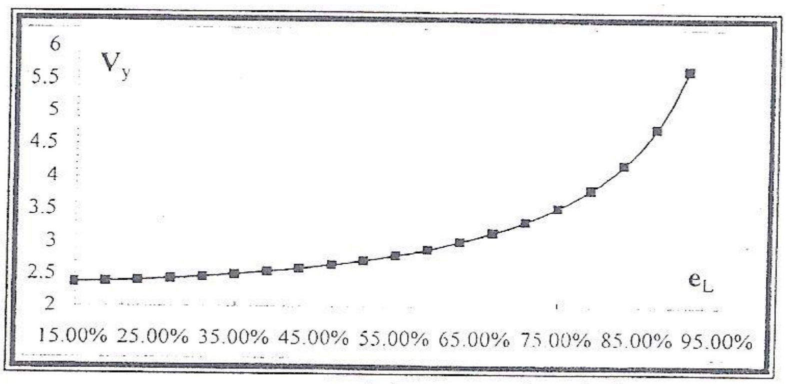
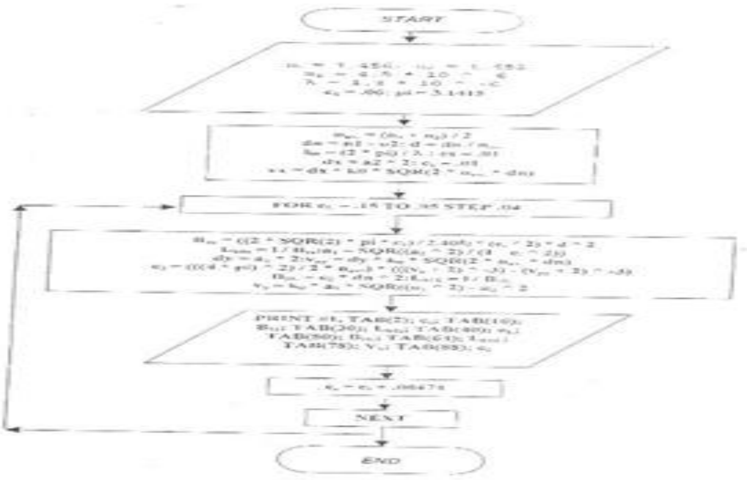


Figure (4) The relationship between the frequency of the cross sections along the long axis and the large elliptical

(λ_c <1.174μm), which theoretically negates the possibility of other types of diffuse light, but in practice this is possible only when the beam of light used is wide So that wavelengths exist shorter than the previous cut wave length. This fiber achieves the high binary break target with a potential increase in loss through leaked patterns. If a narrow beam light source can be used, this loss will be exceeded. Typically, this fiber, despite its high loss, is preferred for short-distance applications, pressure sensors or temperature. Table (1-b) shows the results of this program, while Figure 5 shows the BIOS of the program designed and implemented using Q-BASIC \ V -4.5.

Figure (5) The traffic diagram of the program used in binary refraction calculations (B1), which is composed of both the heart and the cortex.



5. Conclusions:

The presence of ellipsoid in the heart of the visual fiber of the monophysic type is accidental (unintentional) due to defects in the manufacturing, and considering that the manufacturing technology is so high that the ellipsoid ranges between: (es = (1-10.01) percent), will lead to the formation of refraction Is a binary with very low values to low, respectively, which means that this effect on the use of fiber is limited in short distances. In the case of the introduction of elliptical high intentionally ranging between (eL = (15 - 91) percent), and for specific uses of the fiber, then the binary-calibrated fracture will have values between the medium and the high, and at these values of the binary refraction, On the polarization (PM) because the highest stroke length will not achieve the condition (Lb <1mm), indicating that the presumed engineering effect of the heart rotor will not only produce the desired type, which necessitates the introduction of a material effect of " "(Anisotropy stress), along with the geometrical effect used, to match the axes of both Nexarine binary.

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