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STUDY ON IMPROVING THE EFFICIENCY OF FIBER OPTIC COMMUNICATION SYSTEM

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ABSTRACT

In today's scenario data traffic is high, this demands more bandwidth. To find a solution to the problem this article surveys various literatures and presents the studies about the increasing data capacity through a nonlinear optical fiber using orbital angular momentum (OAM) where OAM conserved in soliton motion. To achieve less brittle nature of fibers micro structured polymer fibers are recommended with low dispersion.

Indexing terms/Keywords

Optical fiber; OAM; solitons; effective communication;

Academic Discipline And Sub-Disciplines

Physics; Mathematics; Nonlinear dynamics; Partial differencial equations;

SUBJECT CLASSIFICATION

Physics subject classification

TYPE (METHOD/APPROACH)

Literary Analysis

INTRODUCTION

In many applications such as optical manipulation to quantum information processing light beams with a helical phase front has orbital angular momentum has been deployed in late 1990's. Jian Wang et.al demonstrated that four light beams with different values of orbital angular momentum and encoded with 42.834 Gbits quadrature amplitude modulation (16-QAM) signals can be multiplexed and demultiplexed, allowing a 1.37 Tbits aggregated rate and 25.6 bits Hz spectral efficiency when combined with polarization multiplexing[1]. They showed scalability in three-dimensional domain using two groups of concentric rings of eight polarization-multiplexed orbital angular momentum beams, achieving a high data capacity and spectral efficiency[2-4]. These demonstrations suggest that orbital angular momentum could be a useful degree of freedom for increasing the capacity of free-space communications. The same authors also explained the application of OAM for analog signal transmission.

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Figure 1(a) shows the generation of input analog signal-carrying Gaussian beams with planar phase fronts changed to analog signal- carrying OAM beams by spiral phase masks and multiplexing of multiple analog signal-carrying OAM beams. Different Gaussian beams with the same optical carrier wavelength are indistinguishable from each other. OAM beams are orthogonal to each other by using the property; it is possible to combine different analog signal-carrying OAM beams together for collinear OAM multiplexing analog-signal transmissions. At the receiver side, as shown in Fig. 1(b), analog signal-carrying OAM beams are once again converted by inverse spiral phase masks to Gaussian-like beams for detection.

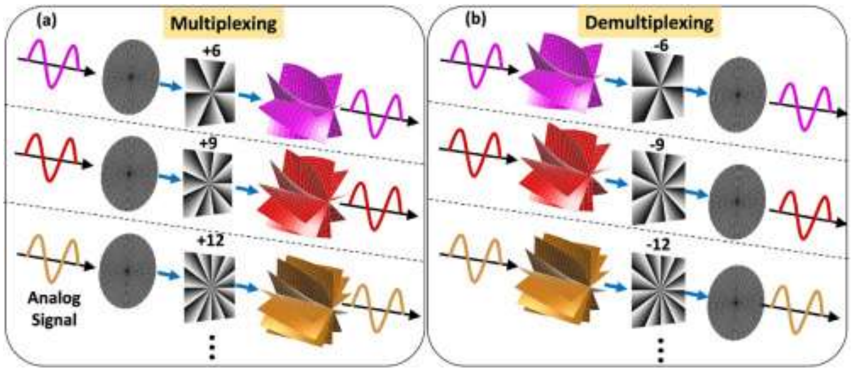

Figure 1

The experimental setup uses external cavity laser (ECL) operating at 1550 nm is fed into a Mach – Zehnder modulator (MZM) which is driven by a sinusoidal Radio Frequency signal which flows at a higher frequency of 3 GHz frequency to carry the analog signal[5]. The signal is divided into two ways, coupled to free space by two collimators, and projected onto two phase-only Spatial Light Modulators, which are loaded with complex phase patterns [6-7]. Complex phase patterns generates OAM signals. Linearly polarized light is generated by the polarizer (Pol.) and half-wave plate (HWP) before SLM [8]. Then the produced 8-analog signal-carrying OAM beams are united together by a beam splitter (BS) for OAM multiplexing analog-signal transmissions [9-10]. For the OAM demultiplexing, another SLM loaded with changeable specific complex phase spiral-phase pattern is used to convert OAM beams to Gaussian-like beams. Finally, the converted beam is sent to a photodetector (PD) and then measured by an electric spectrum analyzer (ESA) [11]. The dynamics of the light signal through a fibre is modelled as given below.

Maxwell's equations [12] for electromagnetic wave propagation through medium are given by

$$\vec{\nabla} \times \vec{H} = \vec{j} + \frac{\partial \vec{D}}{\partial t} \quad - (1.1)$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad - (1.2)$$

$$\vec{\nabla} \cdot \vec{D} = \rho \quad - (1.3)$$

$$\vec{\nabla} \times \vec{B} = 0 \quad - (1.4)$$

The material equations accompanying Maxwell's equations are:

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P} \quad - (1.5)$$

$$\vec{B} = \mu_0 \vec{H} + \vec{M} \quad - (1.6)$$

Here, $\vec{E}$ and $\vec{H}$ are the electric and magnetic fields, $\vec{D}$ the displacement vector, $\vec{B}$ the magnetic flux, $\vec{j}$ the current density of free carriers, ρ is the free charge density, $\vec{P}$ is the polarization, and $\vec{M}$ is the magnetization. By taking the curl of eq. (1.2) and considering for optical fibres, (with magnetisation $\vec{M} = 0$, current density $\vec{j} = 0$, charge density $\rho = 0$, the displacement vector $\vec{D} = \varepsilon_0 \varepsilon_r \vec{E}$), we obtain the wave equation driven by the polarization in the medium

$$(\nabla - \frac{1}{{C_0}^2}\frac{\partial^2}{\partial t^2})\vec{E} = \mu_0 \frac{\partial^2 \vec{P}}{\partial t^2} \quad - (1.7)$$

In a linear, isotropic, homogeneous & loss less medium the electric field of that EM wave is given by

$$\vec{E}(z,t) = |\vec{E}| cos\,(\omega t - kz) \quad - (1.8)$$

Here, ω is the frequency, k is the wave number $(k = \frac{\omega}{c} = \frac{n\omega}{\varepsilon_0})$, n is the refractive index, c is the velocity of light in medium, and the group velocity $v_g = \frac{1}{k'}$. If we have lossless medium then the value of n is not a complex number.

The absolute value of the group velocity can become much larger than the velocity of light in vacuum. Therefore, the Tachyon motion of the peak of such a signal does not contradict special relativity.
When the electric and magnetic fields rotate continuously around the beam axis during the propagation circular polarization arises in an electromagnetic wave. The circular polarization is left or right depending on the field rotation [13-14]. Photons transfers a spin angular momentum when light beam is circularly polarized, where the reduced Planck constant and the sign is positive for Left and negative for Right circular polarizations. This SAM is focused along the ray axis (parallel if positive, antiparallel if negative [15].

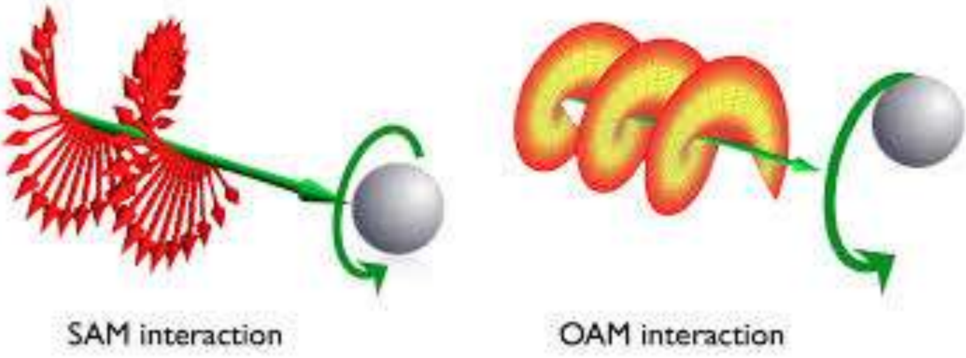

Fig.2

Emma Wisniewski-Barker proposed that the plane of polarization gets rotated, when linearly polarized light is diffused through a rotating window [16-17]. A degree of difference in phase between the positive and negative modes is detected as a rotation of the transmitted picture due to orbital angular momentum (OAM) and this rotation angle does not exceed the scale of the spatial features in the beam profile [18].

W. J. Firth and D. V. Skryabin predicted a new kind of concentric circles like profile solitary wave in nonlinear optical media, with finite orbital angular momentum [19]. During propagation these divide into a number of fundamental solitons. They move tangential to the ring, demonstrating conservation of orbital angular momentum in soliton motion [20].
Martijn A. van Eijkelenborg proposed microstructured polymer optical fibre working effectively for single moded at optical wavelengths. These polymer based fibres may be deployed for applications in data communication networks because of its low-cost manufacturability and the chemical flexibility of the polymers [21-22].

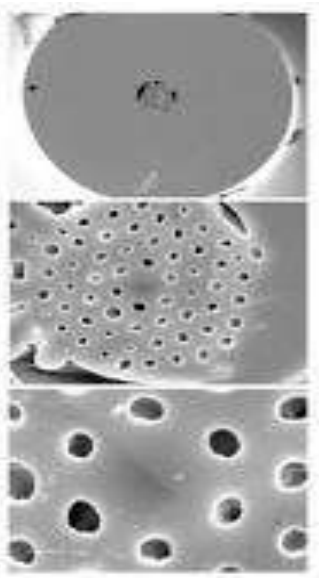

Fig. 3 Electron micrographs of the microstructured polymer optical fibre (MPOF) [21]

Observations recorded are “MPOF was made by drawing on a polymer fibre draw tower at a rate of 10 m/min at a temperature of approximately 175°C and to an outer diameter of 250 µm. These fibres have potential for applications in telecommunication networks, because of the following advantages such as low-cost, low-loss transmission fibre as well as for fibre-optic components. In addition, MPOF can be manufactured at a cheaper price. The major advantage of MPOFs are the variety of fibre cross-sections produced is much less restricted, and the choice of availability of material properties is much greater”.

CONCLUSION:

To meet the high demand for data traffic, it is found from the study that transmission of data as OAM s through micro structured polymer fibers will serve to increase the data capacity through a nonlinear optical fiber as well as less brittle in nature. From the dynamics of EM waves through nonlinear media it is also found there is conservation of orbital angular momentum in soliton motion.

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Degree/ Diploma	Specialization	Class	% of Marks	Name of the Institution	F / P / D *	University	Month & Year of Passing
Ph.D.	Nonlinear Dynamics	Highly commended	Highly commended	Govt. Arts College, Coimbatore	P	Bharathiar University	June 16
M.Phil.,	Nonlinear Dynamics	First	63	Govt. Arts College, Coimbatore	P	Bharathiar University	Dec 08
M.Sc.,	Physics	First	87	Govt. Arts College, Coimbatore	F	Bharathiar University	Apr 04
B.Sc.,	Physics	First	86	Govt. Arts College, Coimbatore	F	Bharathiar University	Apr 02
HSC	Science & Maths	First	78	CSI HSS, CBE	F	TN State Board	Apr 99
SSLC	Science & Maths	First	80	MSSD HSS, CBE	F	TN State Board	Apr 97

* Note : - F / P / D **– Full-Time (F), Part-Time (P), D – Distance Education**

10 Professional / Teaching / Research Experience (Starting from Present Experience)

S. No	Name of the post held	Name of the Employer / Institution	Period of Employment				Teaching/ Industrial/ Research
			From Date	To Date	Years	Months	
1	Asst. Professor(III)	Jansons Institute of Technology	19.07.10	Till date	6	1	Teaching
2	Sr. Lecturer/ HOD	Kalaivani College of Technology	01.06.09	07.07.10	1	2	Teaching
3	Lecturer	Karpagam College of Engineering	02.08.07	19.05.09	1	10	Teaching
4	Lecturer	VLB Janakiammal College of Arts and Science	01.09.04	03.07.07	2	11	Teaching
				Total	**12**	**0**	**Teaching**

11 Publications:

- **2 Books**
- **1 National journal Paper (Published)**
  - The non-simplicity of simple pendulum, IJAR, Vol:4, Issue:8, P:78-80, Aug 2014.
- **3 International Journal Paper (Published)**
  - Origin of Electromagnetic Breatherlike Soliton Propagation in a Ferromagnetic Medium, IJNS, Vol.21, No.3, P.170-180, Jun 2016.
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- **1 international Journal papers (under review).**
  - Propagation of electromagnetic oscillating soliton in a ferromagnetic medium, J.Mag.Mag.Materials, submitted on July 16.