**Advances and Potential Opportunities in OAM Carrying Twisted Light Communication and its Application**

Abstract

Twisted light allows a new degree of flexibility for optical or quantum information capacity increase, in addition to bringing unique insight into structured light-matter interactions. The wide adoption of Orbital Angular Momentum (OAM) equipment is impracticable due to the size, cost, and low reaction time of today's optical elements. OAM-carrying beams have aroused the interest of evaluators across a wide range of fields. Analyzing multiple current methodologies also develops a way for creating twisted light beams with OAM characteristics. This research work summarizes a variety of approaches for generating OAM conveying twisted light signals, including adding, and discussing recent advances in passive and adjustable microcavities for on-chip vortex emission and lasing based on whispering gallery mode. Analyzers also discussed the effect of data transfer rate on wireless communications based on OAM and twisted light. Also, it compares OAM applications such as fiber optics and wireless communication. In this study, an effective methodology for OAM Twisted Light Communication is used and provides improved results for the same.

KEYWORDS: OAM; Twisted Light; Wireless Communication; spin angular momentum (SAM); X-waves.

1. **INTRODUCTION**

The exponential growth of data has led to an ever-increasing desire to attain high channel capacity and efficient spectrum utilization in communication systems. Long-distance high-speed photonic communication is critical for a future quantum internet on a global scale [1]. Larger capacity wireless communication can be possible with a broader bandwidth at a higher carrier. However, wireless bandwidth is limited, and components that operate at higher frequency bands are always more expensive. As a result, it is desirable to make full use of the current wireless spectrum. Since Allen revealed light's OAM as a separate dimension in 1992 [2], OAM-carrying beams have piqued attention in a variety of domains. Allen made the point that this OAM was a natural characteristic of all helically phased beams and could thus be easily created in a normal optics lab. What makes their discovery even more astounding is that heliocentrically phased light fields had been studied for years without any identification of or reference to their angular momentum [3]. The phase singularity and helical wavefront of OAM beams distinguish them. Light's OAM has recently risen to prominence as a possible contender for quantum and classical information systems. OAM's discrete, unbounded state-space offers not only dramatically greater data speeds but also increased eavesdropping tolerance in quantum communication. In different study fields, OAM beams, characterized by wave head phase helical, were of considerable interest [4].

Object movements lead to several types of momentum. An object moving in a straight line is linear momentum. Likewise, when the object spinning (spin angular momentum, SAM) determines photon polarization, or Orbital angular momentum (OAM) is imparted when an object circles around with an axis. OAM is responsible for the distribution of photons in the spatial phase. OAM beams can be generated in a variety of ways [5]. Spatial and fiber generating methods are the two broad groups of such methods. Spiral phase plates, Spatial light modulators, diffractive phase holograms, cylindrical lens pairs, metamaterials, photonic integrated circuits, and q-plates are all used to aid spatial approaches. Each spatial strategy has its own set of benefits and drawbacks [6][7].

The investigation of these underlying natures has allowed electromagnetic waves to expand in many applications. Transmission of data for communication purposes, bypassing time and space limits, and reducing the distance between humans are only a few of the critical applications for electromagnetic waves [8]. Electromagnetic waves are commonly utilized to transmit data in communications through varied physical qualities. Among other benefits, optical communications have demonstrated significant capacity at an insignificant compared bandwidth due to a high optical carrier frequency, minimal transmission lines, an unregulated optical spectrum, and a lack of electromagnetic interference [9][10]. All of the products included include the manufacture of OAM, OAM multiplexing, OAM detection, OAM transmission, OAM demultiplexing, OAM processing, and. Increased aggregate and spectral efficiency of both free-space and fiber-optical communication would be a valuable aim of twisted optical communication compatible with already advanced freedom levels [11].

It also introduces OAM and OAM-based wireless communications as a fundamental theory in this Study. The main aspects of OAM and its broad applications are explored. Design of different computer techniques for generating, propagating, processing, and detecting OAM-carrying twisted light beams, assess the impact of the data transmission rates on twisted light wireless OAM-based communications and simulation results [12].

* 1. **Structured Ultrafast Pulses with Time-Dependent Orbital Angular Momentum**

Ultrashort pulses of coherent, structured light fields with custom spatial and temporal properties, such as intensity, phase, and angular momentum – are opening excellent opportunities to control the primary electronic response of matter. Topological light beams carrying angular momentum are particularly interesting, as interaction with matter is different, introducing a mechanical motion to nanostructures, and affecting fundamental excitation rules [13]. There are two types of light angular momentum: spin motion (SAM), which is connected to the polarization of light, and orbit angular momentum (OAM), which is related to the spatial profile of the electromagnetic wave's phase. While angular momentum can be transmitted frequently via visible/infrared (IR) beams, this becomes significantly more difficult in the extreme ultraviolet (EUV) & X-ray regimes [14]. Through asymmetric frequencies up-conversion of an intensive IR ultrafast laser pulse using high harmonic generation (HHG), a robust technique for imprinting SAM and OAM onto the EUV regime has developed, resulting in structured nanosecond pulses with controllable angular momentum features [9]. The creation of EUV self-torqued beams is illustrated in Figure 1.

* 1. **Type of light beams can be used to generate OAM beams**

Numerous light beams are employed to generate OAM beams using various approaches and systems. Let us consider various efficient strategies for the creation of light with orbital angular momentum.

* + 1. **Bessel beams**

A Bessel beam is a pulse whose intensity is determined by a first-order Basis vectors function. Bessel beams are useful for simulating electromagnetic, acoustic, gravity, or matter waves. A Bessel beam that is not diffractive is a true Bessel beam. This means that it does not scatter or active attitude as it propagates, which is the opposite of how light behaves in general when focused on a small space. Additionally, basis vector beams are self-healing, meaning they can be partially hindered at one point and reconstitute farther along the principal route [15]. As with a plane wave, unrestricted Basis vector beams cannot be generated because of the infinite energy required. However, acceptable approximations are possible, and it is crucial in a broad range of optical applications due to their low or zero scattering over a short distance. Bessel beams are often mimicked in practice by concentrating a Gaussian beam with an axicon viewpoint, employing axisymmetric dispersion gratings, or by introducing a tiny annular aperture into the far field. Spiral diffraction gratings can be used to create high-order Bessel beams [16].

Diagram

Description automatically generatedWhile Bessel beams maintain their needed crisp focus for just a very short stretch of the beam and are partially obscured by the tweezed interstitial particles, it is extremely effective for optical tweezing. In comparison, particle manipulation through acoustical tweezers was done using a Bessel beam, which distributes and creates a radiation force because of the acoustical relative motion between a ripple and a particle traveling along its path [17]. A Bessel beam is a technical term that refers to a reaction to Bessel's derivative that arises from distinct Laplace and Max solutions in circular dimensions. While crucial cut-off Bessel beams have an amplitude at their inputs, a high order Base vector beams HOBB seems to have a transverse phase discontinuity along its route with no magnitude [18]. Additionally, Hoffman is plausible even in the absence of a vortex. X-waves were superpositions of Lowpass filter beams traveling at a constant velocity greater than the speed of light. Euler beams and parameterization lasers are two additional non-diffractive beam forms that share the same properties as Basis vectors beams but have a separate transverse structure [19].

FIGURE 1 Generation of EUV harmonic beams with self-torque (time-dependent OAM) [9]

* + 1. **Bessel gauss beams**

Analytically the angular momentum density of BBs in the nonparaxial regime using a rigorous vectorial approach. In the paraxial limit, the results replicate the well-known angular momentum formulas developed first for LG beams and then generalized to any plane-wave beam with spiral wavefronts. Indeed, the spin angular density of BBs is comparable to that of multi-ringed LG beams, i.e., p > 0, which is unsurprising given that BBs can be thought of as the limiting situation for LG beams having increased radial mode index p [20]. However, when nonparaxiality is considered, large fluctuations in the local rotational motion occur. Additionally, experimentally generated high-order Basis vector beams are easier to create than multi-ringed LG beams [21]. The mechanical transmission of OAM to confined nanoparticles in optical tweezers is shown experimentally for the first time, to the knowledge, using an increased Bessel beam. The rotation rate is quantified in terms of its linear dependency on the light beam's orbital angular momentum content [22].

* + 1. **Hermite Gaussian beams**

There are three distinct forms of refractive error (inhomogeneity) Hermite-Gaussian (HG) beam their complex strength in the Rayleigh diffraction zone is given by the complicated issue of a degree Hermite polynomial (n, 0). The initial beams are an optical vortex with circularly symmetric topology charges n that has been transmitted through a cylindrical lens. The optical vortex that is emitted separates into n first optically swirls, each with an annular amplitude of n for every photon. The second category of laser is a Hermite Gaussian (HG) beam of order (n, 0), which is created by passing an irregular beam through a conical lens, imprinting an OAM onto the previous HG beam. OAM is determined as the sum of the vortex and spherical distortion elements of such a beam and can be rather large. The OAM of these aHG beams is precisely described by a formula. HG beams are formed by distributing Gauss beams that include optical vortices via a cylindrical lens. As seen in, there exist distinct intensity nulls singularities at the double focal distance of a cylindrical lens along a straight line inclined by 4 to the Geometrical axes. The number of destructors equals the Frequency of the optical vortex n precisely [23].

1. **LITERATURE SURVEY**

This section comprises the previous work and evaluation regarding the OAM in twisted light communication. Various OAM generating theorems, processes, and application aspects by the authors and their results are summarized below.

Abhyankar et.al., (2021) [19] depicted that to improve the overall aggregate capacity and spectrum efficiency of data communications networks, optical vortices conveying orbital angular momentum (OAM) are being investigated. Increased total transmission capacity and spectrum effectiveness through N-dimensional multiplexing are achieved by using OAM carrying vortex beams. Its limitless orthogonal modes enable effective multiplexing and demultiplexing of OAM carrying beams. An analysis of Gaussian vortex beam intensity profiles and phase structures. For mutually opposed levels of the topology charge of OAM, the phase structures spiral in both directions.

Ji et al., (2020) [20] suggested that light's orbital angular momentum (OAM) can be used to increase optical communication network capacity. But direct photocatalytic detection of multiple OAM modes is still unknown. This has led to a loss of phase information in most investigations of electrical responses to electromagnetic fields. It developed a tungsten ditelluride (WTe2) photodetector with precisely manufactured electrode geometries to directly characterize the fundamental charge of OAM light. This orbital photo conductive phenomenon, denoted by a quantization OAM model number, is characterized by a circuit winding entirely around the optical beam axis. Their discovery paves the door for on-chip detection of optical OAM modes, which can enable the development of next-generation photonic circuits.

Ramesh et al., (2020) [21] depicted that an increasing number of applications have been spawned by the research of Orbital Angular Momentum (OAM) including broadcasting in diverse ways. Newton, Maxwell, and Einstein, among others, have all made significant contributions to the understanding of light. Even yet, it continues to amaze us with its many different lights uses. To create twisted light, a helical or twisting structure was used to impact OAM. On the other hand, OAM is a physical feature of electromagnetic waves that tells us about the quantum properties of a photon. A thorough review of OAM's fundamentals and detailed application in wireless network communications was conducted as part of this research work, and the findings revealed promising prospects in OAM-Carrying twisted light.

Chen et al., (2019) [22] stated that many sectors, including telecommunications, are interested in OAM because of its potential to free up capacity in the crowded bandwidth of commercial communication networks. OAM beams feature a helical phase front and an electrostatic force with a discontinuity along with the axial Centre. It is possible to have an unlimited number of diagonal OAM modes in a focused strand, and each medium is part of a full orthogonal basis. This study reviews and contrasts optically, radio, and acoustic methods for OAM generation and detection. It subsequently depicts OAM in communication technologies such as free-space optical, optical fiber, radio, and acoustic. Finally, it investigated particle manipulation for imaging targets using OAM beams.

Li et al., (2019) [23] suggested the cascade system with the HOBBIT system of an acoustic optic deflector (AOD). The AOD driving frequency controls the OAM mode. This technology offers a rapid and constant BG beam adjustment solution for OAM carriers.

Zhang et al. (2018) [24] suggested a visible indoor light communication system based on OAM suggested and demonstrated. The sender uses theta-modulation to encode and broadcast information encoded by the OAM across green, red, and blue free space networks, with the help of a white LED. With the pattern recognition process based upon the controlled machine learning, the receivers demultiplex and decode green, red, and blue OAM superimposed modes.

Wang et al., (2018) [25] investigated the transport of water-air-water data through OAM, known as wireless optical communication, underwater (UWOC). An OAM-based optical wireless connection between air and water necessitates an accurate harmonization between the transmitter and the recipient. Asymmetry induced by variations in the water level would lead to poor reception of the OAM ray beam. The output or decoded OAM intensity distribution is adequately matched when a responses correction approach is used to determine the optimum water surface heigh.

Basar et al., (2018) [26] considered a new dimension for index modulation named orthogonal OMA. The ability of OAM-IM, as demonstrated by theoretical BEP derivatives and computer simulations, has revealed that IM-based solutions can improve even non-fading communication circumstances.

Zhou et al., (2018) [27] constructed and demonstrated a programmable and controllable twisted light laser capable of transporting OAM on a combined free-space and fiber platform. Instead of a conventional FP cavity, a ring resonator is employed. The exciting, twisted beam single laser is facilitated by a ring resonator equipped with space lighting modulators (SLMs) as well as a band-pass filter (BPF). The OAM value used in the experiment is between -10 and +10, and the absorption spectrum around 1530 and 1565 nanometer for the whole C-band is altered. The findings obtained demonstrate that a customizable and tunable twisting light laser with acceptable operational performance has been successfully developed.

Mao et al., (2017) [28] suggested that the Archimedean spiral is used to generate broadband orbital rotational motion (OAM) carrying beams. The antenna's mechanism is theoretically studied and then confirmed numerically and physically. According to the results, a spiral-based antenna can successfully create OAM carrying beams across a wide frequency spectrum. It's worth noting that adjusting the operating frequency can affect the pattern number of radiated beams. It investigated and demonstrated single-arm spiraling antennas (SASA), multi-arm spirals antennas (MASA), and compressed multi-arm spiraling antennas (CMSA) (CMASA). With its simplicity, vast capacity, and reconfigurability, the suggested technique can create an OAM carrying beam in microwave radio bands.

Willner et al., (2015) [29] stated that in recent years, interest in orbital angular momentum (OAM), which characterizes the “phase twist” (helical phase arrangement) of light rays, has grown. This is because coaxially propagated OAM beams with differing azimuthal OAM states were mutually perpendicular, and inter-beam crosstalk can be reduced. In this way, various OAM states might be employed as carriers for numerous data streams, thus enhancing system capacity. It examines current advancements in OAM beams generation/detection, multiple access, and possible applications in free-space optical, fiber-optic, and RF communications. Features of OAM beams also are examined. Table 1 demonstrates the summarized table of the Literature review.

**Table 1. Summarize Table of LOR**

|  |  |  |  |
| --- | --- | --- | --- |
| **Ref No.** | **Author** | **Technique** | **Outcome** |
| [9] | Abhyankar et.al., (2021) | N-dimensional multiplexing | The simulation findings demonstrate a ring-shaped intensity distribution and phase structures. |
| [10] | Ji et al., (2020) | orbital photo galvanic effect, driven by the helical phase gradient | paves the way for the development of on-chip identification of optical OAM waveforms |
| [11] | Ramesh et al., (2020) | OAM that influences a helical or twisted structure | OAM basics and uses in wired and wireless communication for faster internet |
| [12] | Chen et al., (2019) | holographic grating with anti-helical phase factor transmission function | Technical challenges relating to optical amplifiers in communications, more specifically free-space optical communication and optical fiber communications. |
| [13] | Li et al., (2019) | AOD optical system based on the HOBBIT log-polar transform | provides a method for quick and continuous OAM-carrying BG beam tuning |
| [14] | Zhang et al., (2018) | RGB OAM decoding using machine learning and pattern recognition | transmission of color pictures and audio across a 6-meter indoor line with a quality of more than 96 percent |
| [15] | Wang et al., (2018) | Adaptive water-air-water data transfer based on OAM | demonstrate the positive performance of a feedback-assisted water-air-water twisting light data information transition. |
| [16] | Basar et al., (2018) | Mode division multiplexing (MDM) based on orbital angular momentum (OAM) | showed that IM-based systems can enhance non-fading communication settings |
| [17] | Zhou et al., (2018) | ring resonator with SLMs and a band-pass filter (BPF). | The development of a customizable and controlled twisting light laser with advantageous operating characteristics |
| [18] | Mao et al., (2017) | Spiral Antenna Strategy with Multiple Arms | presents a low-cost approach for producing OAM-carrying beam in the microwave frequency bands |
| [19] | Willner et al., (2015) | Multiplexing/Demultiplexing Using Photonic Integrated Circuits | carriers for multiplexing and delivering several data streams, possibly boosting system capacity |

1. **BACKGROUND STUDY**

A relatively discovery of the concept that OAM beams with helical phase dependence are carrying, and OAM applications in communication systems still represent a nascent area that must be explored, including possible opportunities and technical hurdles. A few significant issues should be noted. In its fundamental form, the OAM-born beam has a twisting speed helical phase front that is dependent on the model number, so that it is orthogonal and can be differentiated from other OAM forms by different mode numbers. Although other mode groups are orthogonal and can be utilized for mode multiplexing (e.g., Hermit–Gaussian modes), OAM's circular symmetry can offer the conceivable advantage. Many free-space data connection demonstrations try to use OAM modes as these modes have circular symmetry and are compatible with optical components available on the market. Therefore, OAM can be employed rather than a necessarily "superior" sort of modal set as a technical comfort for effective multiplexing. Many of the proven OAM multiplexing communication systems involve bulky and costly components that are not necessarily suited for OAM operation. As with many prior developments in optical communication, OAM deployment would benefit enormously from the future enabled devices and subsystems (e.g., transmitters, (de)multiplexers, etc.). This is especially true in terms of the integration of tremendous opportunities for cost and size reduction and performance improvement [30].

1. **PROBLEM FORMULATION**

Twisted light, with its helical spatial phases geometry and OAM, cleared the way for advancements in optic manipulation and communication. The reconfigurable and controllable laser excitation of twisted light is of tremendous interest. This work is currently looking at the twisted optical vortex. A screw dislocation is an optical vortex in the quantized orbital angular momentum-carrying light field and experiences zero intensity at its center because of the cancellation of twisting throughout the propagation axis. The vortex shows as a black patch in the center bordered by white along the propagation axis when viewed in a perpendicular, a dazzling concentric ring of light. The optical vortices are formed using computer-made holograms and for twisting, SLM is included by altering the BPF and adjusting the phase pattern put on the SLM. The current count would be a twisting light laser with a programmable OAM and wavelength tunability. The work also incorporates the optimization techniques for generating a nanophotonic design of the light beam. In the work, a Global optimization algorithm is incorporated which combines the annealing algorithm and the genetic algorithm.

1. **RESEARCH METHODOLOGY**

The proposed system contains a laser beam source, a beam splitter, A holographic mask, a spatial light modulator (SLM), a phase shift device, an OAM chip, and a voltage source as shown in Figure 2.

Laser beam

Holographic Masks

SLM

Phase Change

OAM Chip

Parameter Optimization using global optimization algorithm

Voltage source

Optical Vertices

Twisted light Modulation

* 1. **Holographic Mask (HM)**

Optical vortices can exist naturally or be made in a variety of methods, including manipulating the laser cavity with mode converters or using a simple process involving computer-generated holograms. The item is rebuilt, and the vortex appears in the output beam when a beam with the reference wave in the experiment irradiates this Hologram.

(1)

where H is hologram transmission function, are formalizable wavefunctions, = are the polar coordinates, *k* is the spatial frequency indicating the tilting angle of the waves, and m indicates the no. of phase windings around the dark spot.

* 1. **Spatial Light Modulator (SLM)**

A spatial light modulator is a device that modifies the amplitude, phase, or polarization of light waves in time and space. With SLM devices, optical signal processing has provided significant solutions for converting data into spatially modulated coherent optical signals, allowing the successful deployment of digital holograms. The SLM is an electrically configurable instrument capable of adjusting the light to a fixed space pattern (pixel). It can generally be used to regulate the incident light phase and/or amplitude. SLM thus can easily achieve phase, amplitude, or a phase-amplitude combination [30].

* 1. **OAM chips**

These chips are used to generate the OAM effect in the electromagnetic wave for twisting the laser for data transmission. The OAM chips are used as both means, to generate a twisting effect or to detect the effect on the receiver side. This chip works on the orbital angular momentum effect. In this, the dark side of the twisted beam is used to transmit data because the dark side is safe from the atmospheric turbulences.

* 1. **Optimization Technique**

For the optimization of parameters’ performance, a global optimization algorithm is considered, which is an integration of a genetic algorithm (GA) and simulated annealing (SA) algorithm. GA and SA are two of the most prominent approaches for optimization. GA is a robust biological theory optimization method. SA developed in the field of materials and is frequently used for the optimization of numerical parameters from simulation of the solid materials ringing process. SA is emulating such a procedure and generally finding the best worldwide solution more dependable. It requires no derivative calculation and is an algorithm like GA, which is zero-order. However, SA depends heavily on initial temperature or factors. If initial variables are not selected correctly, it cannot be the same as GA [31].

FIGURE 2 Proposed Methodology in pictorial representation

The preceding findings infer that the advantages and disadvantages of GA and SA are complementary. Hence the merits of the two methods should be combined with a hybrid GA-SA algorithm to prevent the drawbacks. Initial beginning parameters are not sensitive to GA. The ideal solution can be iterated quickly in the vicinity; SA can take over. Because of the good initial GA parameters, SA needs a few iterations to reach the best solution. Apart from that effect of atmospheric turbulence is also considered for optimization and is supposed an idea for minimizing the turbulence effect.

The recommended approach of optimization begins with the GA process and subsequently the SA process. The criterion for the GA process is either that a specific number of generations of GA are achieved or that the objective functions are negligibly improved. The complete flow chart of the combined algorithm is given below in Figure 3.

Diagram

Description automatically generated

FIGURE 3 Flowchart of Combine GA-SA algorithm

1. **RESULT & DISCUSSION**

Using MATLAB, this part calculates the amplitude and phase of a structural beam with a value of Z using eq. no. 2, which displays phase modulation [32].

ϴ = a(bØ) (2)

ϴ symbolizes phase modulation, where a, b, & c represent positive real numbers.

The given equation number 2 depicts GB: Gaussian type beam due to a Gaussian seed with radical variation shown in eq.no. 3.

R(ϼ) = ϼ2 (3)

Where function R(ρ) provides control over the radial symmetry

Here, R(ϼ) is the radial function and two types of seed beams: a gaussian beam and a Laguerre -gauss type beam (LGB) and a Gaussian Beam.

Gaussian Beam (GB)= (4)

Here, A is the normalization constant, r is the radial distance having coordinates r = (x, y) from the propagation axis and is beam waist. LGB with LG Seed Equation (5) is expressed as

(5)

Graphical user interface

Description automatically generatedIn equation number 5 ‘n’ is the radial index that defines the order of the Laguerre polynomial and thus the number of intensity rings. Based on the above calculations the propagation of the beam with the controlled intensity is determined at different amplitudes and phases [33]. The results of structural beam simulations with varying amplitudes and phases are shown below.

* **Result 1**

Diagram, schematic

Description automatically generatedThis result simulates the starting stage for a Structural Beam. The findings section shows the measurements obtained by the integrated usage of a Gaussian type of beam caused by a Gaussian seed having radical variation. At first, the transverse amplitude of a Gaussian form beam is measured experimentally at various propagation lengths. This is done to independently regulate the symmetry of the beam's transverse intensity and OAM content. The structural beam simulations are depicted in Figure 4.

Chart

Description automatically generated

FIGURE 4 Structural Beam Simulation

* **Result 2**

Amplitude & phase for the structural beam at z=0.013 is generated. GB: Due to the radical fluctuation in the Gaussian seed employed in eq. 4, a Gaussian type of beam is produced. The results of the LGB simulation generated by Equation 5 are displayed. The numerical values correspond to the estimated z and experimental transverse intensity values for Gaussian-type beams at various propagation distances. Moreover, there is a Gaussian beam at various propagation wavelengths, which are measured relative to the lens's image plane. Figure 5 (a) shows Amplitude at z=0.013 and Figure 5(b) shows phase at z=0.013.

FIGURE 5 (a) Amplitude at z=0.014 and (b) Phase at z=0.014

* **Result 3**

Graphical user interface

Description automatically generatedGraphical user interface

Description automatically generatedAmplitude & phase for a structural beam with z=0.014 using an equation with Eq. No. - 1. GB: Gaussian type beam as a result of radical fluctuation in a Gaussian seed Eq. 2. LG Seed Equation generates a Laguerre – Gauss type beam. The results of the simulation using Eq. No. 3 is displayed. The numerical values represent the computed z using equation Eq No.4. The transversal effectiveness of Gauss-type beams is measured experimentally at various propagation lengths. For the simulated measurements, the Numerical Value is derived using Equation 4. Figure 6 (a) shows Amplitude at z=0.014 and Figure 6(b) shows phase at z=0.014.

Diagram, schematic

Description automatically generated

Figure 6. (a) Amplitude at z=0.014 and (b) Phase at z=0.014

* **Result 4**

Amplitude & phase for a structural beam with z=0.015 using an equation with Eq. No. - 1. Due to radical fluctuation in a Gaussian seed, a Gaussian-type beam is produced. LGB: Laguerre – Gauss type beam created by the LG Seed Equation. The results of the simulation created by Equation 3 are displayed. The numerical numbers represent the determined value of z using the equation. Number 4 Equation, the transverse intensity of a Gaussian-type beam is measured experimentally throughout a range of propagation lengths. For simulated measurements, the Numerical Value is determined using Eq No. 4. Our approach is notable in that the produced beam inherits the seed beam's propagation qualities. As a result, it is envisaged that, in comparison to paraxial-type beams, non-diffracting-type beams would retain their transverse form during propagation. Figure 7 (a) shows Amplitude at z=0.015 and figure 7(b) shows phase at z=0.015.

Diagram, schematic

Description automatically generated

Figure 7 (a). Amplitude at z=0.015 and (b) Phase at z=0.015

* **Result 5**

Graphical user interface

Description automatically generatedAmplitude and phase for the structural beam with z=0.016 using an equation with Equation Number - 1. Due to radical fluctuation in a Gaussian seed, a Gaussian-type beam is produced. LGB: Laguerre – Gauss beam created using the LG Seed Equation. The results of the simulation created by Equation 3 are displayed. The numerical numbers represent the computed value of z using Equation 4. The transverse intensity of a Gaussian-type beam is measured experimentally throughout a range of propagation lengths. The Numerical Value is calculated with Equation Number 4 for the simulated measurements. Figure 8 (a) shows Amplitude at z=0.016 and figure 8 (b) shows phase at z=0.016.

Diagram, schematic

Description automatically generatedDiagram, schematic

Description automatically generated

Figure 8. (a) Amplitude at z=0.016 and (b) Phase at z=0.016

Figure 9. (a) Amplitude at z=0.017 and (b) Phase at z=0.017

* **Result 6**

Graphical user interface

Description automatically generatedAmplitude & phase for the structural beam with z=0.017 using an equation with Eq. No. - 1. GB: Gaussian type beam due to a Gaussian seed with radical variation equation number 2. LGB: Laguerre – Gauss type beam generated with LG Seed Equation. Simulation generated with equation number 3 results is shown. The numeric values indicate the computed value of z using Equation 4. The transverse intensity of a Gaussian-type beam is experimentally determined at a variety of propagation lengths. For the simulated measurements, the Numerical Value is derived using Equation No. 4. Although the seed beams do not include OAM, the resultant beam does and inherits the seed beam's propagation attributes. As a result, the suggested technique has the added advantage of allowing for the control of propagation behavior nonetheless, the final beam has the required quantity of OAM and retains the seed beam's propagation qualities. As a result, this technique has the added advantage of allowing for the control of propagation behavior. Figure 9(a) shows Amplitude at z=0.017 and figure 9(b) shows phase at z=0.017.

* **Result 7**

Graphical user interface

Description automatically generatedDiagram, schematic

Description automatically generatedDiagram, schematic

Description automatically generatedGraphical user interface

Description automatically generatedAmplitude and phase for the structural beam with z=0.018 using an equation with equation number 1. Gaussian type beam through a Gaussian seed with radical variation equation number. 2. LGB: Laguerre – Gauss type beam generated with LG Seed Equation. Simulation generated with equation number 3 results is shown. The numerical values represent the predicted z by equation 4. Simulated observations of transversal intensity and for a Gaussian pattern ```` n beam at various propagation lengths are measured. The Numerical Value is calculated with equation number 4 for the simulated measurements. Figure 10 (a) shows Amplitude at z=0.018 and figure 10 (b) shows phase at z=0.018.

Figure 11. (a) Amplitude at z=0.019 and (b) Phase at z=0.019

Figure 10. (a) Amplitude at z=0.018 and (b) Phase at z=0.018

* **Result 8**

The amplitude and phase of a structural beam having z=0.019 are calculated using an equation similar to equation 1. GB: Gaussian type beam as a result of a Gaussian seed involving radical variation equation 2. LGB: Beam of the Laguerre – Gaussian type formed using the LG Seed Equation. Simulation generated with equation Number 3 results is shown. The numerical values represent the computed z according to equation 4. Simulated observations of transversal intensity also for a Gaussian class beam at various propagation lengths are recorded. For the simulated measurements, the Numerical Value is computed using Equation Number 4. The numerical numbers represent the computed z. Figure 11 (a) shows Amplitude at z=0.019 and figure 11 (b) shows phase at zssss=0.019.

1. **Conclusion and Future Scope**

This research effort pioneered a technique for independently controlling the uniformity of the beam's transverse amplitude and its OAM content. OAM has been actively investigated in recent years in a wide variety of sectors of application, most notably communications. Numerous studies have demonstrated the feasibility of multiplexing a series of coherent OAM modes on the very same channel to achieve great spectral efficiency. Additionally, this study discovered a straightforward equation for modulating the angular range of a seed beam while maintaining the OAM. There are several research avenues for fiber-based OAM transmission and distribution systems, as well as some researchers are continuing to develop improvements to fiber structure and optoelectronic filters in order to improve the all-fiber system's support for OAM mode. In general, fiber-based OAM transmitting and generating systems have significant opportunities for improvement. Simultaneously, the fiber system possesses the considerable potential for supporting OAM modes. An improved methodology is provided in this research work and the implementation is done over MATLAB which shows the Amplitude and Phase at the different values in the result section. Implementing the provided methods would improve the betterment of OAM which is still a hot topic and have a high potential for both theories and applications.

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