P2-30 Propagation of a nondiffracting light beam

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Abstract

In this paper, we present a special light beam which propagates keeping its narrow beam width for a long range. Some experimental results of atmospheric propagation of this beam at 500m distance are shown comparing with a conventional collimated beam and a focused beam. The results and related analyses show that the new beam is much less influenced by atmospheric turbulence than other beams.

Introduction

Light beam propagation in the atmosphere is significantly influenced by the atmosphere. Major effects by the atmosphere are absorption, scattering and turbulence. The subject of this paper is the effect of atmospheric turbulence.

A light beam with very narrow width which is sized enough smaller than the spatial coherence length should propagate in the atmosphere with less influence from atmospheric turbulence. However, a light beam of visible wavelength, e.g., with 1cm diameter expands its beam width by diffraction about 10cm at only 1km and about 20cm at 2km, both of which are much larger than the coherence length. Recently, a long range nondiffracting light beam which propagates long distances in free-space almost keeping its narrow beam width, has been presented by the author.

Concept of the Long range Nondiffracting Beam

A long range nondiffracting beam (LRNB) can be produced by controlling the wavefront of light emission. When a concave spherical wavefront is distorted negatively, i.e., the curvature of the wavefront is reduced with radial distance, a long-range nonspreading beam is generated in the central core of the original emitting beam. A simple way to produce this beam is to use a Galilean-type telescope which eyepiece has a spherical aberration. By controlling the separation between objective and eyepiece of the telescope, a concave wavefront can be produced, and furthermore, owing to the spherical aberration of the eyepiece, the new type of nondiffracting beam, i.e., LRNB is generated.[1]

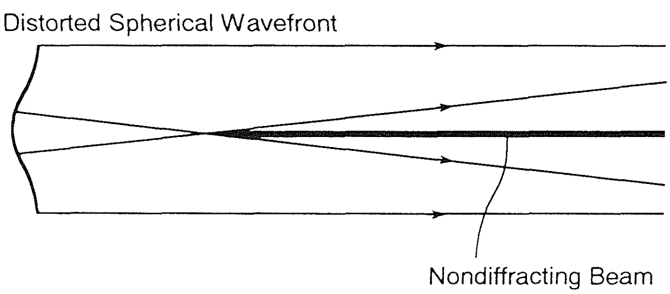

Fig. 1 (a) Concept of LRNB generation.

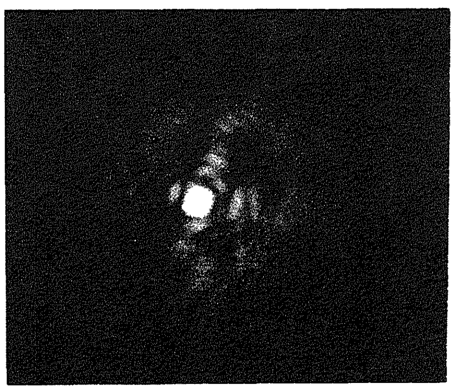

Fig. 1 (b) Actually observed LRNB at 500m distance.

The concept of generation of the LRNB is shown in Fig. 1 (a). The bright beam spot is created in the central region and propagates almost keeping its narrow beam width for a long-range. For example, when a 10cm diameter telescope is used, a near nonspreading beam of order mm width can be generated for a range of 100m ~ a few km. Actually observed LRNB is shown in Fig. 1 (b). For longer ranges, larger diameter telescopes can be available.

Light beams Propagation Experiment

Three kind of light beams were used for the propagation experiment in the atmosphere. They are the LRNB, a conventional collimated beam and a focused beam. As the light source, a compact cw Nd:YAG laser (2nd harmonic: $\lambda = 0.53\mu m$) was used. The original laser beam was expanded and truncated to produce almost uniform amplitude distribution in the beam aperture. A transmitting telescope of 10cm diameter was used for transmission of the laser beam and another telescope of 5cm diameter with a PM (photo multiplier) tube was used for reception.

The atmospheric propagation experiment was done with a 500m propagation path-length, i.e., the laser beams were transmitted horizontally and received at ground level over a distance of 500m. Fig. 2 (a) (a'), (b) and (c) show light intensity variations observed at 500m distance of the main lobe of the LRNB, its side lobes, a conventional collimated beam and a beam focused at 500m, respectively.

The results show that the LRNB is much less influenced by atmospheric turbulence than other beams, and related analyses suggest that the LRNB can apply to many fields. (See reference 2 for details.)

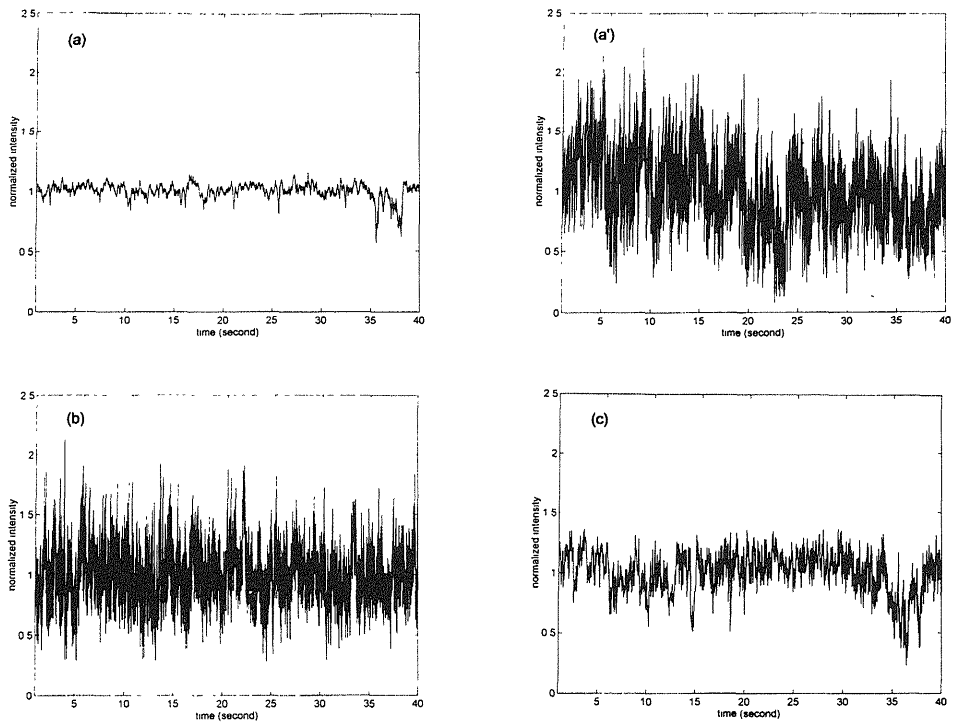

Fig. 2 Measured light intensity variations.

References

1. T. Aruga, Appl. Opt. 36, 3762(1997).
2. T. Aruga, S. W. Li, S. Yoshikado, M. Takabe and R. Li, Appl. Opt. 38, 3152(1999).