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Semiconductor laser beam bending

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Abstract: This study is about a single-component cylindrical structured lens with a gradient curve that was used for bending laser beams. It operates under atmospheric conditions and bends the laser beam independently of temperature, pressure, polarity, polarization, magnetic field, electric field, radioactivity, and gravity. A single-piece cylindrical lens that can bend laser beams was developed. Lenses are made of transparent, tinted, or colored glass and are used to undermine or absorb the energy of laser beams. This study is not a work of a plasma filamentation, nor is related to a self-accelerating wave packet. Rather, it focuses on bending the laser beam as required. The dimensions of the light-bending curvatures vary depending on the source and the lens. This is an application of laser beam bending. The dimensions of the captured images are 500 $\times$ 700 mm.

Key words: Laser, bending, lens, light

1. Introduction

There have been various studies conducted on the bending of light. Some of them have been discussed in experimental studies in which the light was bent as it passed through high gravitational fields and magnetic fields [1,2]. Different studies and theorems that focus on the bending of light have been provided [3].

Disregarding the effect of light diffraction, rays of light tend to propagate along a straight path. All the winding paths are used to gather as much light as possible through mirrors, lenses, and waveguides of light. Therefore, many researchers have conducted their studies in various environments in which light is bent, even in a vacuum [4].

Kaminer and his colleagues revealed that through the full solution of Maxwell's wave equations, light could turn to the right or left and by itself in circular orbits without diffraction [5–8]. It is possible to identify this behavior in sound and water waves in detail, similar to the equations that account for these light waves. Light waves in the form of a special shape without acceleration have been proposed [9].

The studies conducted during the last decade have shown experimentally that Airy wave packets could bend themselves without acceleration [10–14]. These are defined as self-accelerating Airy wave beams. These studies also proposed that these waves could be used in different ways in optical micromanipulation [15], plasma guidance [16,17], and routing surface plasmon polaritons [18–20]. It was also found that, like Airy beams, Bessel waves have the same feature [18–21]. Due to the force of gravity, Airy beams move in their path along parabolic

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trajectories. They spread in the form of paraxial approximation in wide angles, without keeping their features and shapes [21,22].

In the studies conducted about accelerating beams and paraxial regimes, the real solutions of nonparaxial Airy beams are Maxwell's wave equation solutions [22,23]. In another study, "caustic-design" accelerating beams could not keep their shapes like nonparaxial regime nondiffracting paraxial Airy beams, and these were defined as caustic methods [24–26]. In another study conducted by Kaminer et al., through the full solution of Maxwell equations, the researchers obtained nonparaxial accelerating beams that keep their shapes. In their later studies, they revealed that these beams would be self-accelerating Airy beams [7–11].

Several studies found that through the filamentation of ultraintense Airy beam waves in air, Airy wave packets could lead to the generation of curved plasma channels [27]. The use of ultraintense Airy beams curved plasma channels and self-bending, filamentation, and femtosecond laser pulses, and their features were described [27–33]. Moreover, the behavior of tailored-beam ultrashort laser beams and the fact that these waves can bend in various ways were also stated [34]. Early studies also provided information on ultrafast laser filamentation, Gaussian form [34], flat-top shape [35], Bessel shape [36–38], and cavity wave form (hollow ring beams) [39,40].

Nonlinear behaviors [41,42], Helmholtz beams [43], convex trajectories [44], and optical routing [45] have also been discussed. Several studies have been conducted on nonspreading wave packets for the cubic Schrodinger equation with a bounded potential [46], asymptotic expansions for Riesz fractional derivatives of Airy functions and applications [47], stationary nonlinear Airy beams [48], and the dynamic control of the collapse of a vortex Airy beam [49].

The current study, unlike the aforementioned studies, was conducted simply using a lens under atmospheric conditions. The scale of laser beam bending can be adjusted as desired. It is not the self-bending that occurs due to the conditions. The radius of the bending light can be in meters. The details of this experiment are provided below. In this experimental study, contrary to the known expansion of a laser beam along its path, it was observed that the laser beam contracts, which can also be observed in fluid mechanics.

2. Laser bending experiment

The experiment was conducted in the laboratory at room temperature and atmospheric pressure. It was observed that the differences in the shapes were due to the various lenses used, and because laser light exhibits unusual behavior.

In the experiment, a continuous wave laser was employed as an optical source, with the output power of a 1–5 mW Class III semiconductor laser diode operating with two standard 1.5 V AAA batteries. This laser source is an electronic component manufactured commercially for general applications.

Different shapes were obtained by using different lenses. A 10 megapixel resolution camera was used to take photos of the shapes. The distance between the laser source and the optical lens ranged from 4 to 400 mm and the distance between the optical lens and the plane was 4500 mm. The captured images are the final images spreading in the atmosphere after passing through the lens and being emitted into the atmosphere. The images in Figures 1–7 were obtained via the aforementioned lens. Red and green lasers were used as sources. Two different laser sources were tested on the lens.

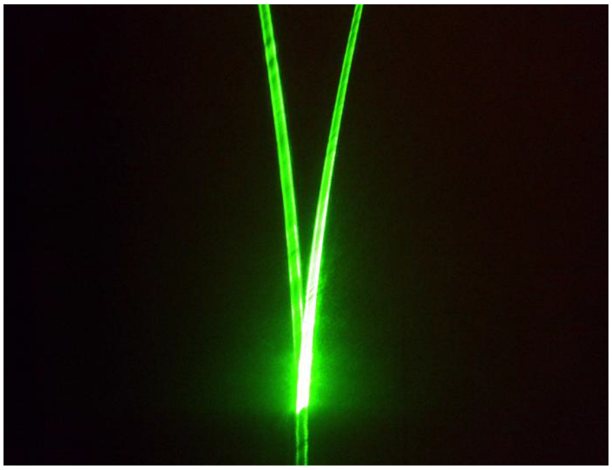

Figure 1. Bending of green laser light in two opposite ways (dimensions of the photo: 500 × 700 mm).

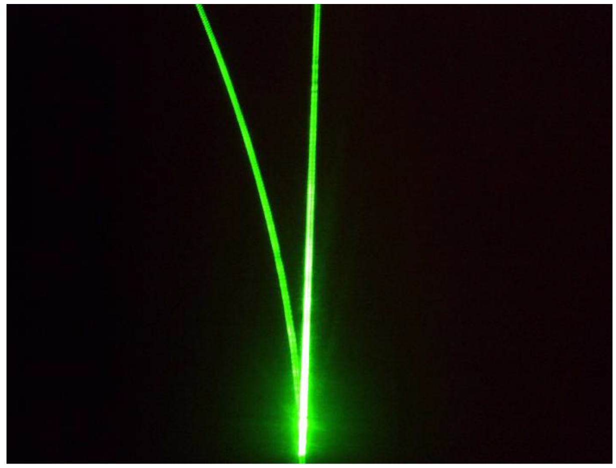

Figure 2. Bending of green laser light in straight and left directions (dimensions of the photo: 500 × 700 mm).

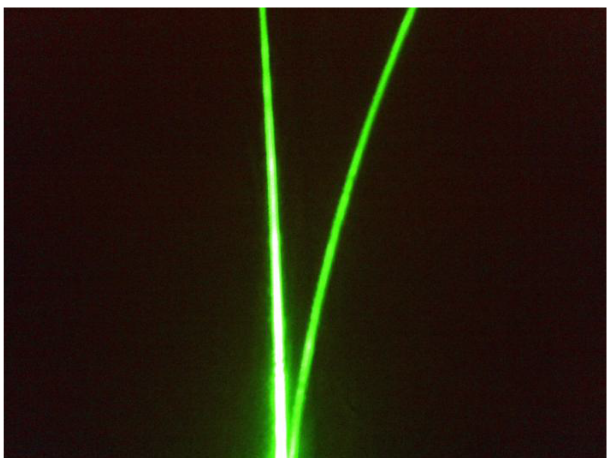

Figure 3. Bending of green laser light in straight and right directions (dimensions of the photo: 500 × 700 mm).

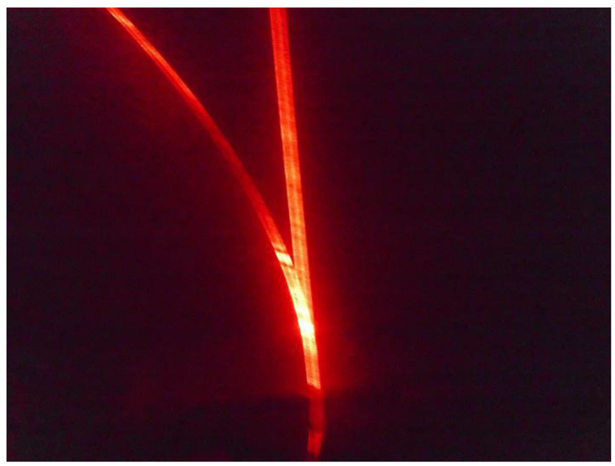

Figure 4. Bending of red laser light in straight and left directions (dimensions of the photo: 500 × 700 mm).

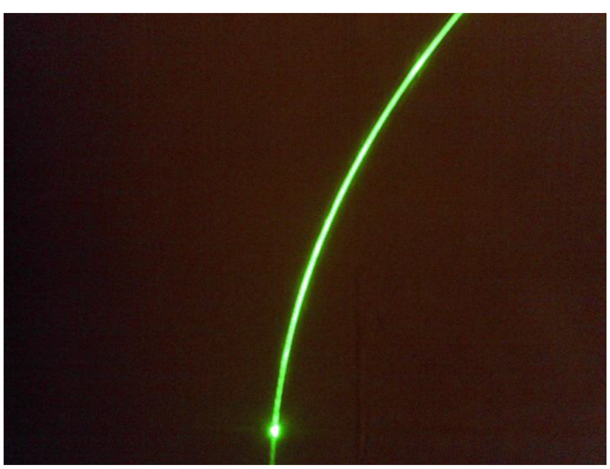

Figure 5. Bending of green laser light towards the right (dimensions of the photo: 500 × 700 mm).

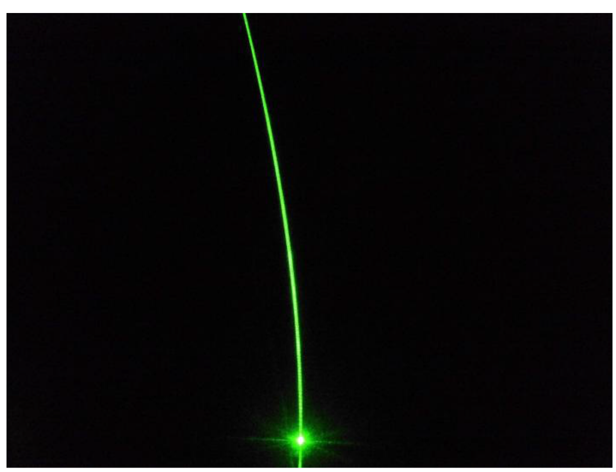

Figure 6. Bending of green laser light towards the left (dimensions of the photo: 500 × 700 mm).

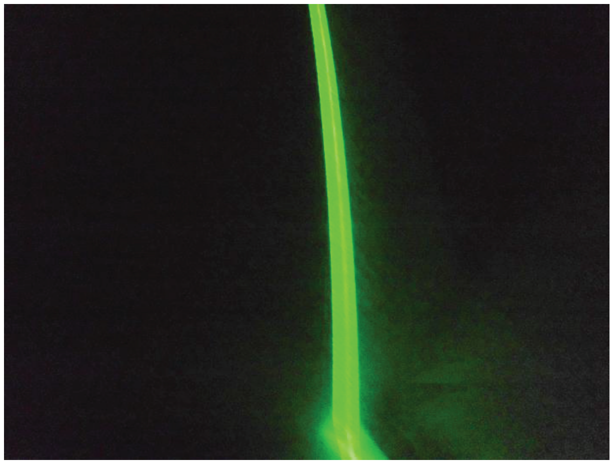

Figure 7. Bending of green laser light towards the left (dimensions of the photo: 500 × 700 mm).

3. Conclusion

In this experimental study, semiconductor laser diodes and LEDs were used as light sources. Specifications for the lens used are provided above. Apart from these components, there were no other parts made of special materials. While it is commonly assumed that a laser beam expands along its path, it is clearly shown in Figure 7 that, contrary to common assumptions, the beam contracts. Due to some technical reasons, we are unable provide other details of the experiment. Here we share the results with our colleagues. In the experiment, only the observed cases are discussed. The authors would like to discuss the findings of the experiment with other scientists interested in this issue and look forward to their support, suggestions, and criticism.

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