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Intensity Stability Comparison Between Different Colors of Laser Pointer

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Abstract: Different source of light can be used as a main light source in an open path optical method. Sunlight, tungsten lamp, LED, laser, mercury vapor lamp and halogen are the example of the light source. It is important to test the stability of the light source used to avoid inaccuracy in the measurement. The purpose of this project is to determine which color of laser has higher stability. Once the light is switched on, the intensity of the light source changes slowly until it comes to a stable state. Each color has different counts of intensity and stability. Different set of laser pointer is used in this project which included blue, violet, red and green color. An open path optical method is used in the experiment. A different color of laser pointer will be used as a light source while spectrometer will act as a detector. The stability for each color of laser pointer is reported in this paper where the standard deviation for each color is calculated to determined which color have a higher stability. Results shows that standard deviation for green color has the smallest value among these four colors where the standard deviation is 15.97. Color with smaller standard deviation has the highest stability.

Keywords: Optical, sensor, stability, color, laser pointer

1. Introduction

1.1 Light Source

Emission of electromagnetic radiation comes from wide variety of sources and it is generally categorized based on the specific spectrum of wavelength generated by the source itself. Visible light is a form of electromagnetic radiation. It comprises only a tiny portion of the entire electromagnetic spectrum of radiation. Basically, light source can be classified into two types where the first type is a light that transmit a continuous wave while the other type is transmits modulated light. Continuous wave usually requires an external modulator at the optical output [2]. Z.L. Yuan et al. (2016) stated that a modulated type does not need any external modulator as the output [3]. Figure 1 presents a spectral distribution curves demonstrating the relative amounts of energy versus wavelength of different sources including noon sunlight, white LED, tungsten lamp, mercury vapor lamp and bar code scanning laser. Result from this graph proves that each light source shows the different energy level on certain wavelength.

The word laser is stand for Light Amplification by Stimulated Emission of Radiation. Laser eliminates drawbacks for a pinhole illuminated by a mercury vapor lamp point that used as a source of monochromatic light [4-5]. The intensity of light that pass through can be increase due to the energized substance in the laser. Some photons are travelling through the excited medium state and interact with electrons. Single and aligned beams of light emitted from the laser with a different wavelength of light will emits depends on the color emitted by laser itself. [1].

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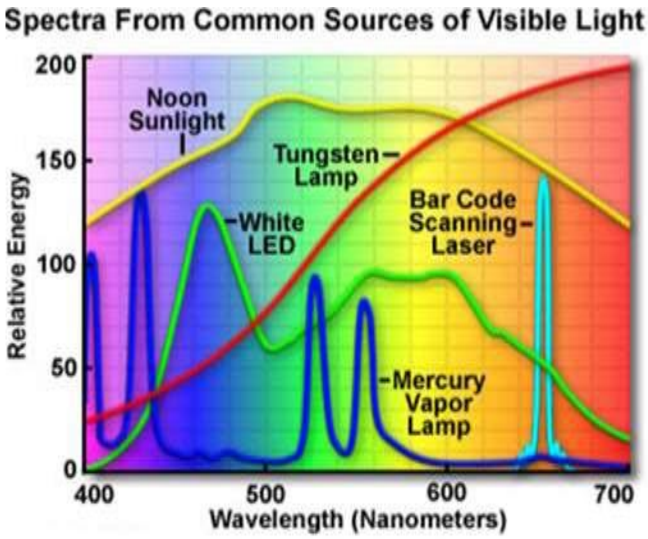

Fig. 1 - Relative energy vs. wavelength for spectra from common sources of visible light

1.2 Optical Measurement System

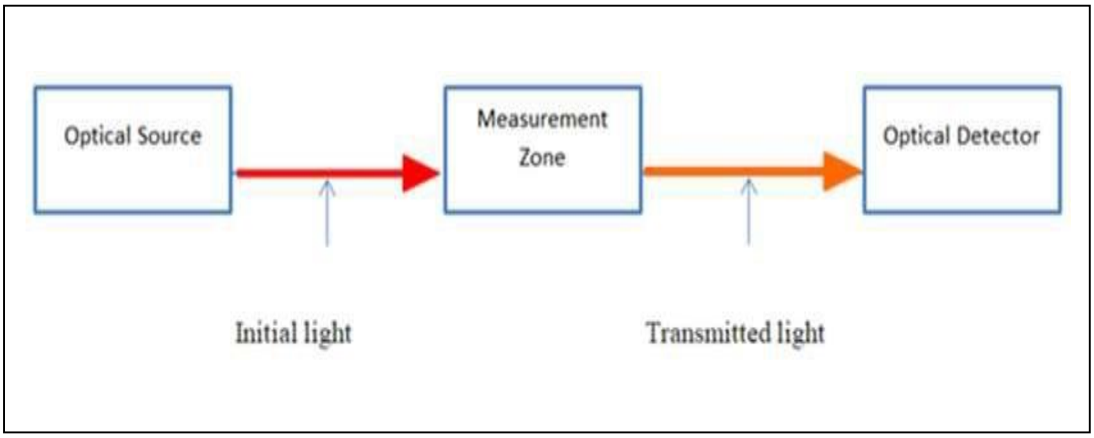

Fig. 2 - Basic working principle of optical sensor

Figure 2 shows a basic working principle of an optical sensor. In 1960, the application of optical system was invented after the invention of laser light. It becomes the ultimate choice in making use for sensing, data communications and many more. Through the great evaluation of optical sensing technology, the optical sensor nowadays can measure nearly all of the physical quantities such as pressure, displacements, vibration, force radiation, temperature, humidity and concentration of chemical species [6]. A light ray is converted into an electronic signal then the measured physical quantity is translated into a form that is readable by the detector.

2. Methodology

A series of diode pumped solid state (DPSS) laser pointer in green, red, violet and blue color manufactured by Roithner Laser Technick GmbH are chosen. Each of it comes in <5mW power and it is automated power control [7]. The output power of this laser pointer is classified by the American National Standards Institute and usually the stated unit is miliwatts(mW) [8]. The schematic diagram of the laser pointer used is shown in Figure 3.

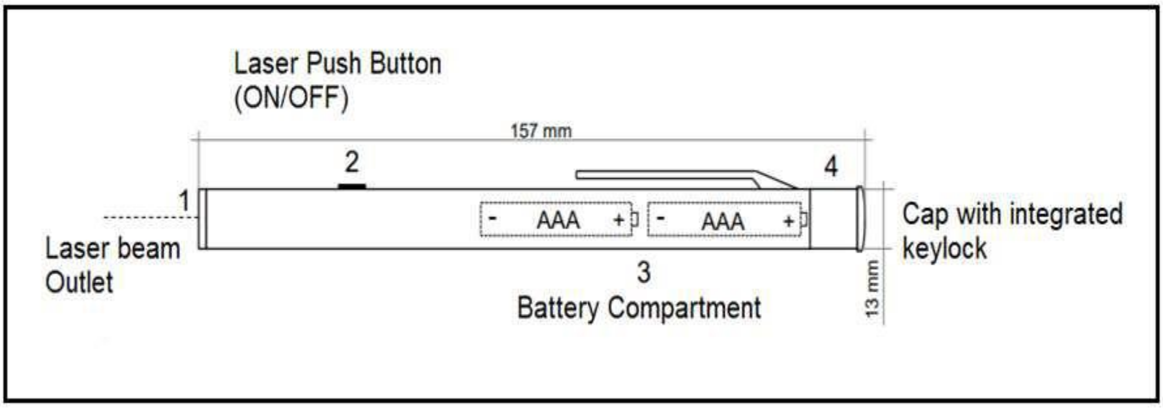

Fig. 3 - Schematic diagram of a laser pointer

An open path optical technique is used in order to conduct the experiment. A battery-operated laser pointer is used as a light source and spectrometer as a detector. In this stability test, the light source used is placed at one of the ends of a chamber and another end is attached with fiber optic as shown in Figure 4.

A polyethylene water pipeline with 100cm in length and 6 inches' diameter is used a chamber. A black color is painted inside the chamber to reduce the reflection of the light inside the chamber. The chamber is used in order to protect the laser light from being interrupted by light changes such as the shadow from human movement and light from outside. The transmitted light is read by a spectrometer that is connected using a fiber optic cable. A laptop installed with SpectraSuite software is used to record the intensity reading. An integration time is set to 1 s and the light source is switched on for 15minutes. The same procedure is used for each laser pointer.

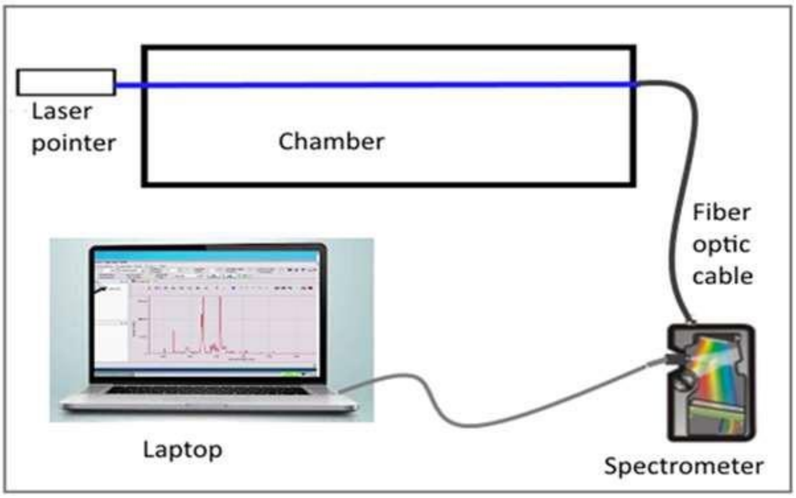

Fig. 4 - Experimental setup for laser stability test

3. Results and Discussion

Laser pointers emit collimated visible light beams at different wavelength due to the multiple laser elements [9]. Red, blue, violet and green colors of laser pointer are tested, and the results are shown in Figure 5. Basically, the wavelength range of red color is commonly detected at 620-750nm, blue color at 450-495nm, violet color at 380- 450nm and green color at 520-560nm [13-15]. Based on the graph, green and blue laser shows the most stable intensity among these four colors. This graph shows that; each laser pointer takes a few minutes to become stable. At first 5 minutes, the fluctuations of the line are quite high. For clearer viewer, the line is zoomed in and replotted for the first 5 minutes as shown in Figure 6. Laser pointers start to achieve stable state at 250s.

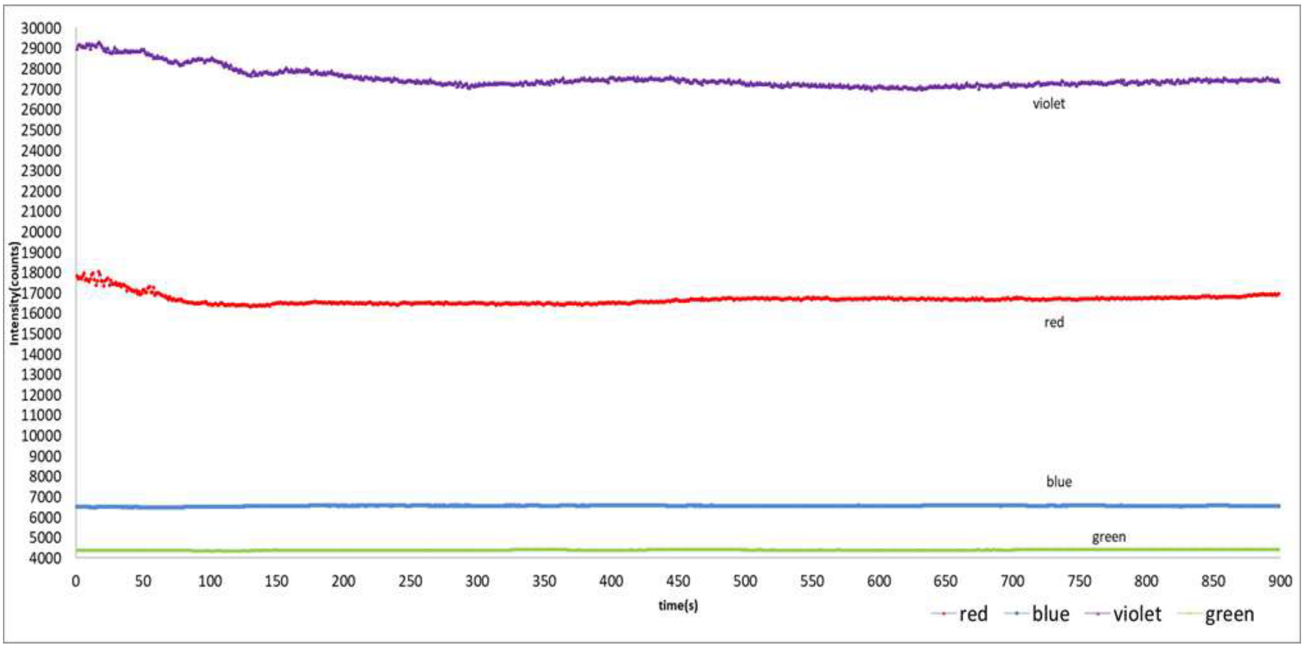

Fig. 5 - Graph of intensity vs time for 15 minutes

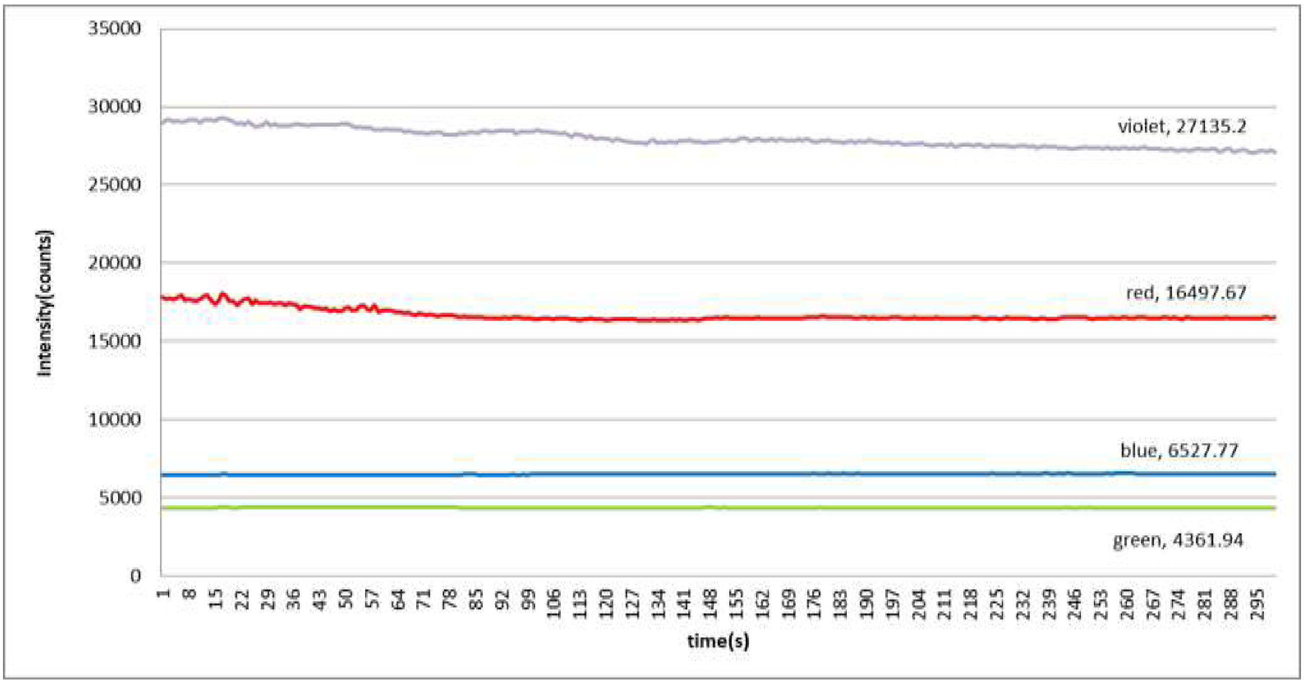

Fig. 6 - Graph of intensity vs time for first 5 minutes

Third graph is plotted by averaging 10 points at the last 10minutes and labelled as Figure 7. This is due to the last 10 minutes shows the intensity is in stable state. Based on this graph, it clearly shows that green color is the most stable between red, blue and violet. Standard deviation value is calculated for each line and recorded in Table 1. From the table, green color has a smallest standard deviation value. It means that, this green color laser has the smallest fluctuation and noise.

Based on both graph (Figure 6 and 7), light with high counts of intensity shows the less stable compared to light with low light intensity. As reported by Kai Jiang etc, every color has different carbon dots emission that causes the different brightness for each color [18-20].

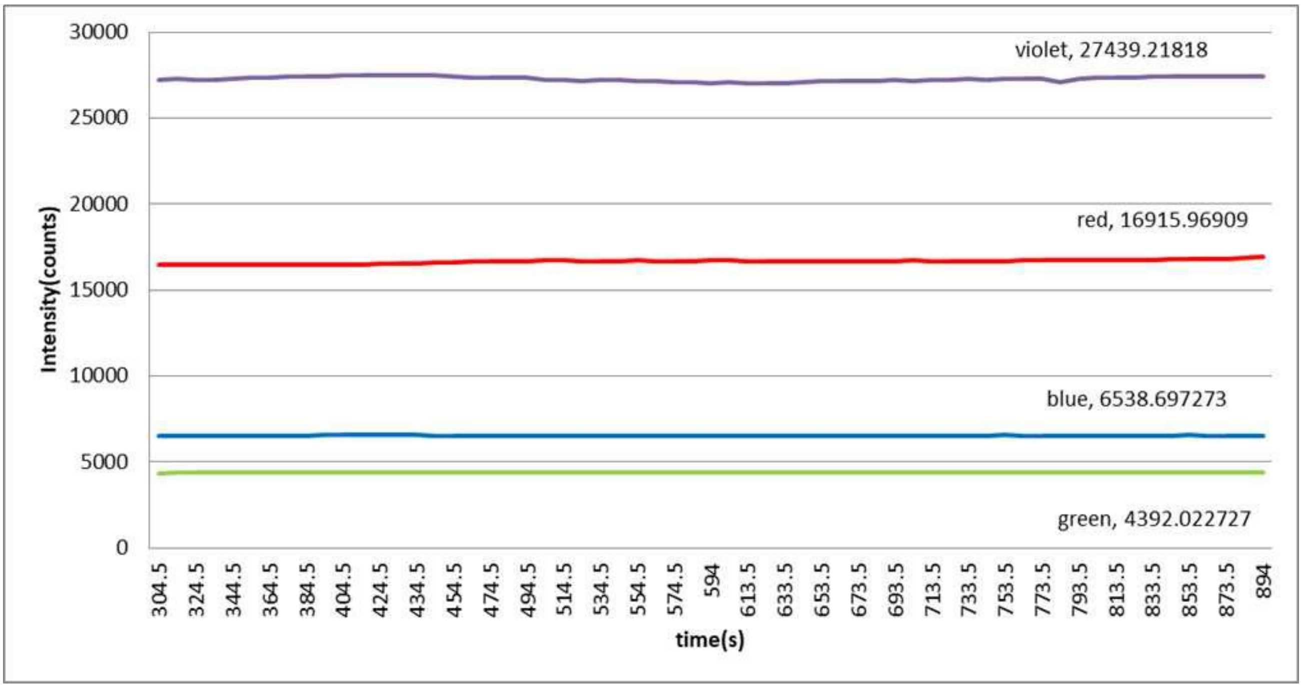

Fig. 7 - Graph of intensity vs time (average for every 10s in last 10min)

Table 1 - Standard deviation

Laser Pointer	Standard Deviation
Red	248.6560825
Blue	24.14286516
Violet	489.2540039
Green	15.97231794

From the results, green color is chosen to become the most stable laser pointer. The intensity that detected by a spectrometer shows that, green laser pointer has the lowest count of intensity compared to other colour. According to Yan Qi, 2010, green color also has long-term reliability and stability due to the low power density and thermal effect [10]. A high and low temperature does not affect the performance of green laser itself. In addition, due to the Rayleigh scattering and airborne dust, green laser is visible at night and in low light condition [10]. It is commonly used by worldwide astronomers in order to conduct a lecture in astronomy [11].

4. Conclusion

Despite being used as a visual aid to a particular feature, laser pointer also suitable to be used as a light source for an optical system. It is known as portable hardware and can operate using battery [12]. Besides, it is small in size, easy to hold and affordable. The stability of the light source plays an important role in optical system where the stability will affect the result [16-17]. From this paper, green color laser pointer with the lowest standard deviation value 15.97 is the most stable compared to red, blue and violet laser pointers.

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