Light Intensity Measurement On Sun-Earth System Model Using Logger Pro Light Sensor

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Abstract. The measurement of light on the Sun-earth system model has been done using a logger pro and light sensor. The purpose of this research is investigating the relationship between Sun declination with the Sunlight intensity on variety earth model latitude. By Lambert’s Cosine Law, the light intensity that falls on a certain angle can be calculated. On the summer solstice, the highest light energy that was measured on earth model surface occurred on 23.5 degrees north latitude. It was 129.264 candela. The highest light intensity on 23.5 degrees south latitude was 125.907 candela. It has happened on the winter solstice. The light intensity on the equator reaches the maximum compared to the other latitude on the vernal equinox and autumn equinox. There were 115.982 and 111.121 candela, respectively.

1. Introduction

Dynamically, the earth is revolving the Sun. Besides the revolution motion, the ground is also making the rotational motion. The day and night phenomena on the planet are caused by the rotational movement of the earth [1]. The astronomer and geographer dispart the earth coordinate system into longitude and latitude. A line (half circle) of longitude is called a meridian. Zero degrees of longitude is located at the “Royal Greenwich Observatory” in England. The sun rays propagate from the solar surface then fall onto the earth surface. At the equator, the light intensity that comes from the sun will be higher than other latitudes. The higher flexibility of the earth’s surface, the less power of the Sun’s light will be received [2].
This concept is difficult for students to understand, so it requires teaching aids to visualize the process of changing light intensity by varying the latitude and declination of the Sun. The Sun-earth system model can be an inexpensive and easy experimental alternative by using a vernier light sensor and logger pro application in the laboratory [3,10]. To solve the student’s misconception in astronomy, active learning strategies are a great tool to be applied [5]. By using a light sensor and varying the latitude of the globe (the earth model) will be obtained the value of light intensity from the light source in the form of a flashlight (the sun model). From the experiment, it can be obtained a phenomenon from the relationship of the Sun’s declination with the measured light intensity of the Sun in particular latitude of the earth.

The amount of emitted energy as light in a particular direction is called light intensity and is expressed in candela (cd), can be represented as

$$I = \frac{\Phi}{\omega}$$

(1)

where $\Phi$ is the unit light flux in the lumen and $\omega$ is the steradian angles of space.

The earth rotates on its axis, due to the earth’s rotation causing a difference in light intensity somewhere. In optics, Lambert Cosine Law said that the received light intensity per unit area reaches a maximum if the beam of light falls perpendicular to the surface [4]. If the light intensity of an extended source obeys Lambert’s Cosine Law, then for all wavelength intervals the light intensity at some angle $\theta$ concerning the normal to the surface varies as the cosine of the corner. The similarities of Lambert's Cosine Law by the follows:

$$I = I_{source} \cos \theta$$

(2)

**Figure 1.** Light intensity per unit area

Figure 1 shows the light intensity (energy per unit area) with the angle of incidence to the earth’s surface. Lower edges (higher latitudes) result in the same power spread out over a larger area and in a lower intensity [8]. If the element of space is $A$. The light intensity in the direction of $A$ is given by $I \cos \theta$, light energy per unit area by the following:
The earth is round so that the light power received per unit area at the equator will be higher, as in the northern and southern of the planet and the lowest region is the pole [5]. Latitude has a function to determine the division of climate on earth. The division of the Sun's atmosphere is carried out by the amount or least of the Sun's rays or based on the location or position of the Sun against the earth's surface [7,11].

The declination is the distance or height of the celestial equator to celestial bodies. The declination trajectory is parallel to the equatorial path [6]. Declination is measured along the arc of a time cycle through a celestial body, starting from the celestial equator towards the north pole of the sky (positive) or the south pole of the atmosphere (negative) until the celestial body is observed [12].

2. Method

2.1 Materials and tools

The equipment used consists of: a ruler with 0.05 cm accuracy, arc, vernier light sensor, lab quest, logger pro application for data collection from vernier light sensor, and laptop with 32/64 bit specifications with 2 GB RAM. Globe with diameter 13 cm as a model of the earth, the flashlight as a model source of light from the Sun and stative.

2.2 Research procedure

Experiments were carried out in a dark place so that the resulting light was not interfering with an outside light source. The light source is not too close to the globe, to avoid focusing light at only one point. The distance between the world and the light source is 2 meters. The position of the light source is aligned vertically with the center of the world. Furthermore, the world is not positioned close to the wall because it can affect the light to be measured mixed with the light reflected from the wall.

\[
\frac{I \cos \theta}{A \cos \theta} = \frac{I}{A}
\]  

(3)

The equipment is arranged according to Figure 2. The sensor is positioned at each latitude on the globe is perpendicular to its surface. Measure the angle formed between the light source and the measured light. Repeat for each position of equinox and solstice. The value of the measured light

![Figure 2. Research procedure](image-url)
intensity experimentally obtained from the data logger pro. Whereas to get the value of the power of the measuring light, in theory using the equation of the Lambert's Cosine Law, so used equation (2).

By the value of the source intensity at the equinox, the position is taken from the data of the light intensity at an angle of 0 degrees. Summer solstice position is taken from the data of light intensity at an angle of 23.5 degrees north latitude, and winter solstice position is taken from the data of light energy at an angle of 23.5 degrees south latitude [9-14].

3. Results and Discussions

Research on the determination of light intensity on the Sun-earth system model has produced light intensity values at each latitude. This research also results from a light intensity relationship curve with a scope at four positions of the earth towards the Sun. This can be seen in figure 3.

![Figure 3. The relationship between light intensity and latitude.](image)

The curve is analyzed by logger pro, the x-axis as latitude, and the y-axis as the value of light intensity. There is four earth’s position relative to the Sun. It can be seen that in the area of the autumn equinox and vernal equinox, the difference in value is not too significant, because in both conditions the location of the Sun and latitude at the north pole and south pole are equal [13]. Whereas for summer solstice and winter solstice have opposite views. In the summer solstice, the location of the Sun is at 23.5 degrees north latitude, while the winter solstice position of the Sun is at 23.5 degrees south latitude.

| Latitude (degrees) | Autumn Equinox (cd) | Vernal Equinox (cd) | Summer Solstice (cd) | Winter Solstice (cd) |
|--------------------|--------------------|--------------------|----------------------|----------------------|
| SL -90             | 13.633             | 13.633             | 9.629                | 20.107               |
| -75                | 29.754             | 32.088             | 9.629                | 77.089               |

Table 1. The value of light intensity in each latitude
On the summer solstice, the highest light intensity that was measured on earth model surface occurred on 23.5 north latitude. It was 129.264 candela. The highest light intensity on 23.5 south latitude was 125.907 candela. It has happened on the winter solstice. In the summer solstice, the northern earth has summer, while the Confederate planet has winter. In the north of the land, it has the longest day and otherwise. This can be seen from the curves and tables, the summer solstice where the intensity of the Sun's light is higher in the northern latitudes. In winter solstice, the north earth has winter, and the north planet has the shortest day [15].

This experiment is natural to do at school, and the teacher only needs simple equipment to give simulation to students about the division of seasons in each country based on the latitude of the country. From this experiment can be made censor-assisted teaching aids to support learning in school laboratories. In addition to season division, students can analyze the length of time or day in each place based on the Sun's position, so that students can participate in the group based on an active learning process.

4. Conclusion

Based on the research that has been done, it can be concluded that the value of Sun's light intensity varies at each latitude. The declination angle of the Sun affects the climate division that depends on the Sunlight intensity. It can also be stated as the light intensity depends on the position of the Sun to the earth surface. The Sun position in one year has four kinds of changes, namely summer solstice, winter solstice, vernal equinox, and autumn equinox.

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