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Red Sunrise, Blue Sky, and Red Sunset: the Light Refraction of Earth Atmosphere

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ABSTRACT

The red sunrise, red sunset, and blue sky were common nature phenomena. Why sunrise and sunset are red color, and why daytime sky is blue? This paper used earth atmosphere refraction principles to explain the sky and sun color. The "energy attract force equation" was considered to explain the sun light offset at the outer atmosphere acted by earth mass, which may be better for understand the Relativity Theory. The conclusion will be benefit for the telescope application, satellites communication, astronomy observation, and other atmosphere optical applications.

Indexing terms/Keywords

Atmosphere, Earth, Refraction, Color.

Academic Discipline And Sub-Disciplines

Physics, Atmosphere Optics.

SUBJECT CLASSIFICATION

Theory Physics Subject Classification

TYPE (METHOD/APPROACH)

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INTRODUCTION

The sunrise was red color and that was same with sunset color. Why sunrise and sunset was red color, while the noon sun was near white color? And the historical classical "Why sky is blue?" were common questions. Until recently, The answer was refer to scattering [1] of sun light through atmosphere of earth to show the blue sky. When the sun's radiation enters the earth's atmosphere, it is scattered by mainly oxygen and nitrogen molecules, that scattering is known as Rayleigh scattering. Although the scattering was one of the atmosphere actions on sun light to explain the blue sky, the refraction of sun light by atmosphere should be introduced to explain these questions.

This letter used the refraction principle, that sun lights refracted by outer spherical atmosphere, which can successfully to explain the red sunrise, blue sky, and red sunset nature light color phenomena. Before the sun light enters the spherical atmosphere, it was refracted at the spherical atmosphere interface. The sun lights enter atmosphere at different angles, and were refracted to different color and different direction light before scattering by the inner atmosphere. So the red sun and blue sky was due to the refraction of sun light by atmosphere. When you watch the sky at day time, the refracted blue light focus on you and you see the blue sky. The "energy attract force equation" can explain the refraction phenomena of sun light at outer atmosphere of earth. The phenomena that sun light refraction by atmosphere and explained by "energy attract force equation" will help to better understand the Relativity Theory. And that will benefit for the telescope application, satellites communication, and astronomy observation.

RESULTS AND DISSCUSION

The question of the sky color was answered in physics common level text [1] and advanced book [2]. When the sun's radiation enters the earth's atmosphere, it is scattered by mainly oxygen and nitrogen molecules. This scattering is known as Rayleigh scattering, and the scattered energy is proportional to $1/\lambda^4$. On a very clear day, the skylight seen at zenith when the sun is well above the horizon is this scattered radiation which result as the "Rayleigh sky" [3]. This paper introduces refraction concept to further explain the sky and sun color.

Refraction [4] is the change in direction of a wave due to a change in its transmission medium, which observed when a wave passes from one medium to another at any angle other than 0° from the normal, and with a given refractive index to a medium with another at an oblique angle. At the boundary between the media, the wave's phase velocity is altered, usually causing a change in direction. Its wavelength increases or decreases but its frequency remains constant. The refractive index n of an optical medium is a dimensionless number that describes how light, or any other radiation, propagates through that medium. It is defined as $n=c/v$. (c the speed of light in vacuum, v the speed of light in the substance). [5]

This paper one side recognized the important actions of scattering of atmosphere on sun light, the other side to introduce refraction principle to explain the red sunrise, red sunset, and blue sky phenomena. Refraction principle has been observed by using triangular prism under an angle of incident light. For example, the rainbow show there exist refraction phenomena in atmosphere. The atmosphere gave sphere refraction on sun light to show the red sun and blue sky.

The outer part of earth atmosphere have vacuum, ionized or ozone layers, which interface of atmosphere may have the refraction index (n), that might be different with the n of inner atmosphere layers. When the sun lights enter through atmosphere, sun lights were refracted by this vacuum/atmosphere interface, before scattered by the inner atmosphere. Sun light has multicolor spectra, different wavelength lights have different refraction index. Atmosphere of earth has Exosphere (>700 km), Thermosphere (80 to 700 km,), Mesosphere (50 to 80 km), Stratosphere (12 to 50 km), Troposphere (0 to 12 km) [6-9]. The outer sphere atmosphere contains the ionosphere and ozone layer, which refraction index was different with that of the inner air layers. Ionized layer may be $n>1$. Then the sun light will be refracted, when enter through the interface of outer atmosphere layers. Then it can be used refraction principle to explain the sky and sun color.

Figure 1 gives the illumination of the sun light refraction by spherical atmosphere. The sun lights enter the spherical atmosphere, and refraction at the spherical interface. Then the sun lights enter spherical atmosphere at different angles, and were refracted to different color, and different direction lights, before scattering by the inner atmosphere. In Figure 1, the view point **A** was the morning time on the earth, this point received **R1** (red light line) and **B1** (blue light line) light. The **R1** light was from the sunrise, which shows the red sunrise. The **B1** light show the morning head above sky was blue. The view point **B** was the forenoon time on the earth, this point received **Y1** (yellow light line) and **B2** light , which show blue shy and yellow sun light. The view point **C** was the noon daytime. This point received **B2, B3, B4, B5, B6,** and **B7** blue light, which were refraction of sun light by interface of spherical atmosphere. Then the view point **C** see that sky was all blue, due to the refracted angles of blue lights, and then blue light focus on the view point **C**, which was yourself who are watching the sky on daytime on the earth. The view point **D** were the afternoon time, which point received **Y2** and **B7** light, and show the blue sky and yellow sun light look like the view point **B** forenoon time. The view point **E** was the evening time, which received **R2** and **B8** light. This point shows the red sunset and deep blue sky (insert photographs in Figure 1). This was a common day journey on the earth, and sun lights refracted by outer spherical atmosphere gave the color of red sunrise, blue sky, and red sunset.

The red color sun display on the morning and evening, when watching on the earth **(A, E** points view in Figure 1). The **B**, **D** points view the yellow color sun. And sun show white color on noon time at **C** view point. The common sense was that red sunrise or sunset sun show about bigger diameter than that of noon white color sun, which was dispersion of sun

light by atmosphere refraction. The sun color and sky color all connected with the light refraction of earth spherical atmosphere.

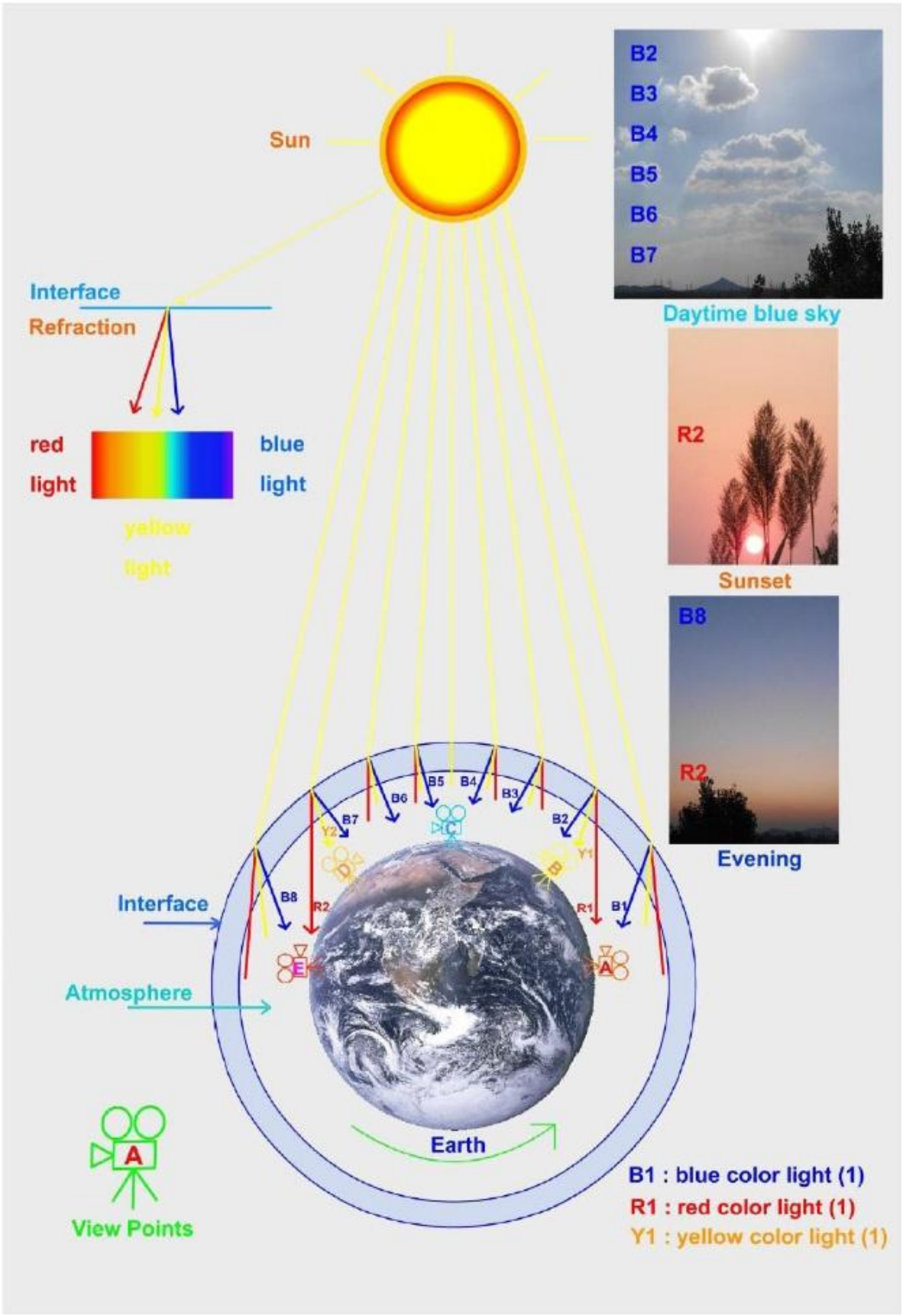

Fig 1: The illuminate of earth atmosphere refraction phenomena of sun lights to show red sunrise, blue shy, and red sunset.

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Table 1. Equation 1 give the attract force on different wavelength photons by earth mass at the areas of outer atmosphere.

λ(nm)	E_2 (Joule)	F (Newton)
200	9.93223×10^{-19}	8.11×10^{-35}
300	6.62149×10^{-19}	5.41×10^{-35}
400	4.96611×10^{-19}	4.06×10^{-35}
500	3.97289×10^{-19}	3.25×10^{-35}
600	3.31074×10^{-19}	2.70×10^{-35}
700	2.83778×10^{-19}	2.32×10^{-35}
800	2.48306×10^{-19}	2.03×10^{-35}

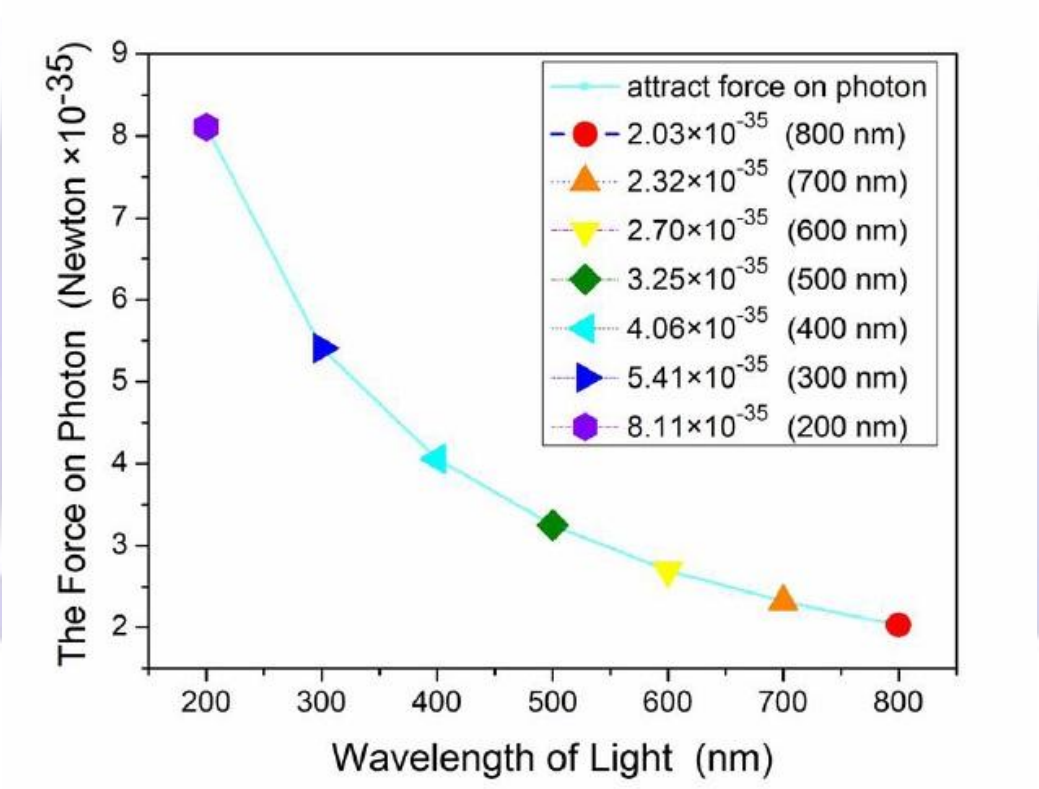

Fig 2: The attract force on photons of different wavelength light by earth mass at the areas of outer atmosphere (Data from Table1 by Equation 1)

Considered the refraction connected with the earth mass and Relativity Theory, that mass produce attract force and act on the photons of sun light. This force can act on the photons and change the light directions, then give sun light refraction phenomena at outer atmosphere. The Equation 1 [10] was the "energy attract force equation" deduced from the Newton the principle of gravitation [11] and the mass-energy equation (***E=mc²***) of Einstein, which can be used to explain the sun light refraction at outer spherical atmosphere.

$$F = G\frac{M_1(E_2 / c^2)}{r^2} \qquad (1)$$

In Equation 1: M_1 was the mass of earth (5.977×10^{24} Kg) added with atmosphere mass (about 6×10^{10} Kg). E_2 was the energy of photon. r was the radius of earth (6371393 m) added with thickness of atmosphere (about 1×10^{6} m). The c was light speed (299792458 m/s). The G (gravitation constant) [12] is about $(6.67428\pm0.00067)\times10^{-11}$ $m^3kg^{-1}s^{-2}$. F was the force of earth act on photon at about outer atmosphere.

Table 1 and Figure 2 illuminated the earth mass attract force act on the different wavelength sun photons at outer atmosphere. The 200 or 300 nm was about blue color light wavelengths, which were attracted by earth mass as about 8. 11~5.41×10^{-35} Newton force. The 700 or 800 nm was about red color light wavelengths, which were attracted by earth mass as about 2.32~2.03×10^{-35} Newton force. The earth attract force act on 200 nm photons was about four folds than that act on 800 nm photons. The short wavelength light, such as blue light, with have higher attracted force by earth mass. While long wavelength light, such as red light, have lower attracted force by earth mass. The attract force by earth mass changed the light directions to give refractions at outer atmosphere, which was in the areas of earth mass attract force. The short wavelength light changed direction angle was larger than that of long wavelength light, due to the attract force on blue light was more large than that on red light. Then the blue light change larger transmitted angle than red light, which different photon energy have different attracted force by earth mass, then the sun light gave chromatic dispersion phenomena at outer earth spherical atmosphere. Then the sky show blue color and sun show red color.

So considered the Figure 1 and Equation 1, the blue light were under higher attracted force by earth mass and change large angles transmitted direction, and focused on the watcher on earth, which display the blue sky. The sunrise or sunset show the red light were under lower attracted force by earth mass, and change small angles transmitted direction, and the red light reach the watcher on earth, which show the red sun at morning or evening.

Einstein Relativity Theory pointed out that the light offset when photons through the gravity fields of planet or star. The Equation 1 of “mass-energy attract force equation” explain earth mass gravity act force on the photon at outer atmosphere, and the sun light offset and refraction in earth atmosphere, then give blue color sky and red sun. So the “energy attract force equation” [10] can better understand the Einstein Relativity Theory.

Refraction of earth atmosphere can be used in atmosphere optical applications. The optical telescope application should revise the observed angles values by the correction of atmosphere refraction. The satellites communication also should considered atmosphere refraction effects on the radio wave emit/receive systems. The satellites over the ground will be clearer and more precise by analysis the atmosphere refraction. The navigation and location satellites also should consider the atmosphere refraction effects to the more precise location. And the astronomy observation, such as radio astronomy telescope, should also consider the atmosphere refraction for the more precise astronomy observation and data analysis.

CONCLUSION

In conclusion, the red sunrise, blue sky, and red sunset were due to the refraction of sun lights by outer spherical atmosphere, which to give different angles, different color, and different directions light, at different day time. The blue sky was the refracted blue light focus on watcher on daytime. The red sunrise and red sunset was the refracted red sun light to watcher on morning or evening. So the sun lights refraction by outer spherical atmosphere display the beautiful red sunrise, blue sky, and red sunset. The “energy attract force equation” of Equation 1 can be used to explain these earth spherical atmosphere refraction phenomena. That sun light refraction principle, and with “energy attracts force equation”, will help to better understand the Relativity Theory. This result can benefit for the telescope application, satellites communication, astronomy observation, and other atmosphere optical applications. Tomorrow, the red sunrise, blue sky, and red sunset will still be on.

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