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Scientific Research

Study Chromaticity of Solar Spectrum

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Abstract

The chromaticity of solar spectrum is studied with the help of a Solar Spectrum Monitor system that can detect individual color in the spectrum. Recent observations done by the detector on the Solar Radiation and the Erath Milieu Experiment suggest that the sun's visible spectral irradiance changes from May 2009 to September 2012. The data of Earth's coordinates and environment have been taken since April 2005 after the devastating Tsunami (December, 2004) of India. The bizarre data of *zenith angle*, *azimuth angle*, and *temperature* of the Earth's atmosphere show their changes of maxima and minima epoch to epoch. The data of solar spectrum monitor have been taking since 2009 and significant transformations of colored ratios $\Delta R_{B/W}$ and $\Delta R_{R/W}$ per hour are observed among the regions of each solstice between 2009 and 2012. The author advocates that the abrupt vagaries of the Earth's movements may cause devastating tsunamis, earthquake, volcanic eruption, cyclones and tornadoes in addition of anomalous changes of solar spectral irradiation, humidity, temperature and pressure; those effects may spoil ecological balance and extinct some living species from the soil of the earth.

Keywords

Astronomy, Atmosphere, Chromaticity, Disaster, Irradiation, Spectroscopy

1. Introduction

The most challenged questions among the nineteenth century scientists were what makes the sun shine and what are the sources of huge amount of energy necessary to support lives on Earth? In the middle of 20th century we come to know the exact answers of those questions when we discovered nuclear fission and fusion and the role of solar irradiation on our lives [1]. The Sun is a few billion years old and its ultimate fate is a *White Dwarf* like many other stars in the universe. Hence, are the solar luminosity, chromaticity and the trajectory of the Earth

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quiet perpetual? The objective of this study is to find out specific answers of these crucial questions and their impacts on our lives. As the debate wraths over global warming, nearly every scientist will sustain the fact that the Earth has gotten warmer in the last 4 - 3 decades. What continues to be debated, and rightfully so, is the reason for the warming trend. Since about 1950, the Earth's global surface temperature has risen by just more than 0.6 degrees Celsius or just over 1 degree Fahrenheit, and the decline of Arctic Sea Ice nearly 32% in 2007 measured in compare to 1979, from 1870 to 1992 the average sea level rise has been 1.7 mm. Before 1950 CO_2 level was almost steady (180 - 300 ppm), but level is drastically increased and in 2007 it is almost 400 ppm [2]. A lot of researches have been carried out in the astronomy and astrophysics. So far we are studying the chromaticity of solar spectrum and presenting results for the first time. Experimental observations of solar luminosity (L_S), angular momentum and atmospheric temperature of the Earth may help us to resolve some of the fundamental problems on global environments and that can be found elsewhere [3]. In the following sections experimental procedure, data taking, data analysis, results and discussions will be illustrated.

2. Origin of Solar Spectrum

(A) Source of Light

The light is a visible range of an electromagnetic (EM) wave that has been producing by *fusion reaction* in the core of Sun since its birth. Enrico Fermi discovered the fusion reaction and proton-proton (p-p) chain reaction is one the most dominant source of continuous irradiation of EM wave among the other sequences which is shown in **Figure 1**.

From this single reaction cycle we notice that positron (e^+) an antiparticle of electron (e^-), γ-rays and huge amount of energy (1.44 MeV) are generated. After a complete cycle two products of ${}^1_1H$ are attained and make the successive reaction again. It is the source of Green energy and that is better than fission reaction in terms of their mass-energy ratio.

(B) Characteristics of EM Waves

Positron is another source of EM wave that wave is generated over e^+e^- annihilation. When EM wave is penetrating a huge continuum (a few km) of photosphere different types of scatterings, e.g., Thomson scattering, Rayleigh scattering, Photoelectric effect, Compton scattering are taken place depending upon the various circumstances of the photosphere. Visible spectrum originated mostly from the atomic transitions of H (λ = 656 nm (red), λ = 486 nm (green)) and He atoms (λ = 588 nm (yellow), λ = 447 nm (violet)). The visible range of EM wave (200 nm - 900 nm) forms a solar spectrum which is depicted in **Figure 2**. It follows the Planck's radiation formula. Rayleigh scattering is the most dominant part in this continuum because of maximum numbers of neutral H is in the ground state. Hence significant information about the physical conditions of the Sun can be achieved by studying the chromaticity in different moments of the year.

Major thrust of this exertion is to study the VIBGYOR region by the Solar Spectrum Monitor (SSM) detector system that is described in the following subsequent sections.

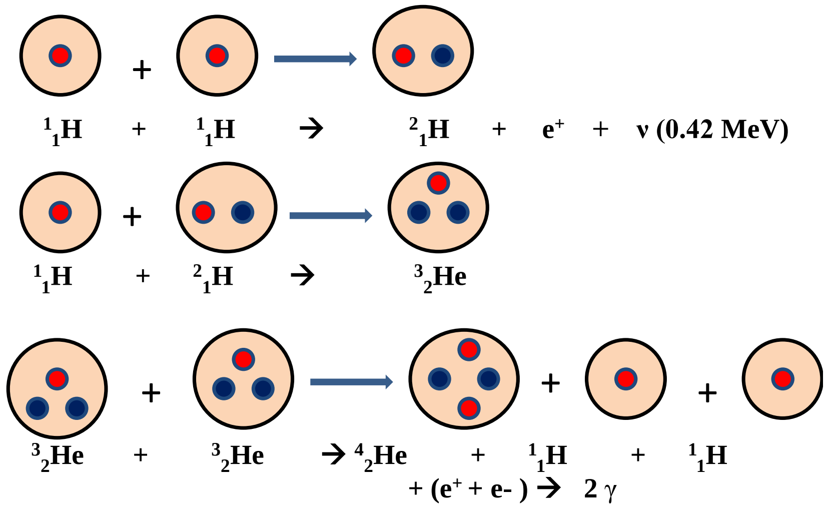

Figure 1. Proton-Proton chain reaction, a source of solar spectrum and energy.

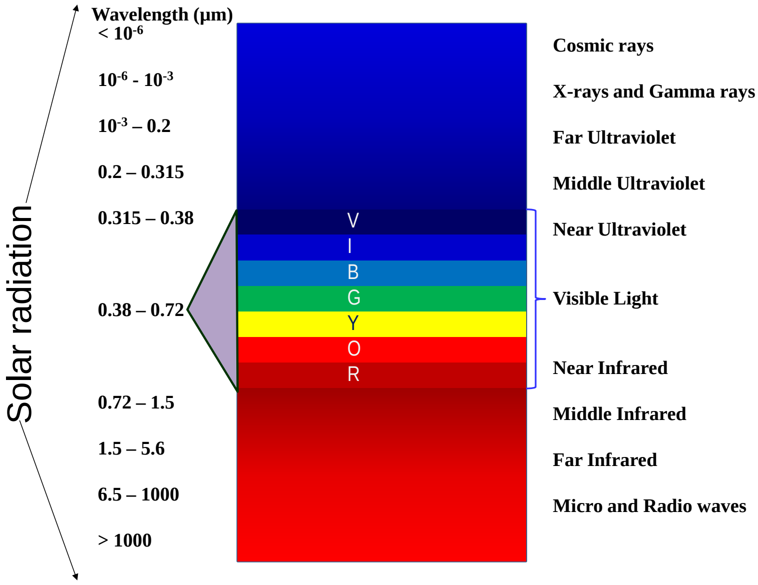

Figure 2. Characteristics of solar spectrum.

3. Theory

In order to determine the earth's *Zenith angle* (θ) and luminous currents by the SSM detector system that consists of colored plates ($Red \to R$, $Blue \to B$ and $White \to W$) coupled with photodiodes through optical fiber and a measurement table (see sec. IV), and θ can be determined by the following equation.

$$\theta = \tan^{-1}\left(\frac{S}{L}\right) \tag{1}$$

where, S and L respectively are the shadow length and length of the spike that is placed perpendicular on the table. Solar luminous current of a colorless plate (W) can be determined by the following equation:

$$I_{W,S} = S_{G,pd}\left(\frac{L_{W,S}}{4\pi R^2}\times\Omega_G\right)\times U_{\lambda,W} \tag{2}$$

where $I_{W,S}$ and $L_{W,S}$ respectively are current intensities due to W plate and solar luminosity, R is the distance between the Earth and the Sun. The luminous sensitivity of epoxy glass with photodiode is $S_{G,pd}$ which is assumed to be independent of the specific color band. Ω_G is the area of solid angle exposed by the solar spectrum, *i.e.*,

$$\Omega_G = \int_0^{\pi/2}\sin\theta\,\mathrm{d}\theta\int_{\pi/2}^{3\pi/2}\cos\varphi\,\mathrm{d}\varphi \tag{3}$$

and absorbed photons follow the Planck's distribution which is given by

$$U_{\lambda,w} = \frac{2\pi hc^2}{\lambda_w^5\left(\mathrm{e}^{hc/\lambda_w KT}-1\right)} \tag{4}$$

where h is Planck's constant, c is the speed of light, λ_w is the wave length. Similarly $I_{B,S}$ and $I_{R,S}$ can be determined respectively from the following equations:

$$I_{B,S} = S_{G,pd}\left(\frac{L_{B,S}}{4\pi R^2}\times\Omega_G\right)\times U_{\lambda,w} \tag{5}$$

$$I_{R,S} = S_{G,pd}\left(\frac{L_{R,S}}{4\pi R^2}\times\Omega_G\right)\times U_{\lambda,w} \tag{6}$$

The strategy of this measurement is to find out any change of luminosity of color plates that will envisage transformations in the reaction mechanisms inside the core of the Sun. When extraterrestrial photon enters into the earth's atmosphere its intensity can be reduced by the absorption of molecules at different atmospheric layers. It is impossible to measure accurate $L_{W,S}$, $L_{B,S}$ and $L_{R,S}$ with greater precision from the soil of the earth than in space. Therefore color luminous ratio with respect to whole spectrum of *W* plate will provide better information and understanding about the present status of the solar spectrum as well as the Sun. The ratio $R_{IB/IW}$ and $R_{IR/IW}$ can be derived using (2), (5) and (6) which are given below:

$$R_{IB/IW} = \frac{L_{B,S}}{L_{W,S}} = \frac{I_{B,S}}{I_{W,S}} \tag{7}$$

and

$$R_{IR/IW} = \frac{L_{R,S}}{L_{W,S}} = \frac{I_{R,S}}{I_{W,S}} \tag{8}$$

Experimentally we have accumulated huge data over the years and analyzed in order to achieve $R_{IB/W}$ and $R_{IR/W}$.

4. Experimental Procedures

(A) Detector Development

In **Figure 3** a simple and inexpensive SSM detector is depicted which consists of Silicon Pin Photodiodes (model: *BPW* 34), colored *B*, *R* and *W* epoxy glasses, optical fibers and a Micro-ammeter. Details of the SSM detector development and experimental procedure can be found elsewhere [3]. In order to study the chromaticity of the solar radiation spectrum data was taken throughout the year and year after year in every weekend and almost in every national holiday between 7:00 to 17:00. Colored luminous absorption currents produced by the solar irradiation exposed directly on to the plate surfaces were recorded by the micro-ammeter manually in each coordinates of the Earth about an hour interval.

(B) Measurement of Orbital and Rotational angles

The orbital and the rotational motions of the Earth respectively are about the Sun and its own axis. A round table scaled with a protractor in four quadrants by marking the East to West and North to South lines. An iron spike of length 20 cm is fixed at the center of the table for the determination of the θ and the φ angles respectively from the shadow length and from the protractor scale. The measurement table is calibrated with the help of a *Compass*.

In **Figure 4** θ, φ, *equator* (ABD), *prime meridian* (*NGJS*) etc. are illustrated. In each θ and φ, *T* was recorded by a *Mercury thermometer*. Experiments were performed in Kalyani, a city of West Bengal, India about 22˚39'N from the Equator, 88˚27'E from the Prime meridian and about 11 m above the Sea level. Equator is passing through the middle of India. Hence Southern parts of India are warmer (e.g. Tamil Nadu, Kerala) than Northern parts (e.g. Jammu & Kashmir and Himachal Pradesh which are full of Snow in winter).

Hence, we determine θ and φ respectively from the recorded shadow length and the position on the scale.

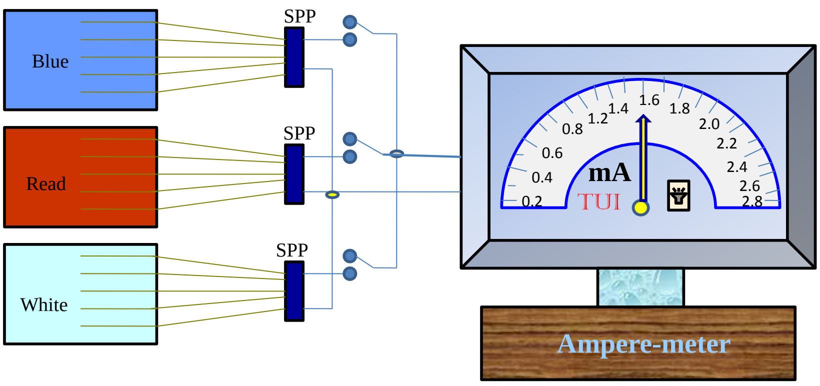

Figure 3. SSM detector is exposed directly by the solar spectrum.

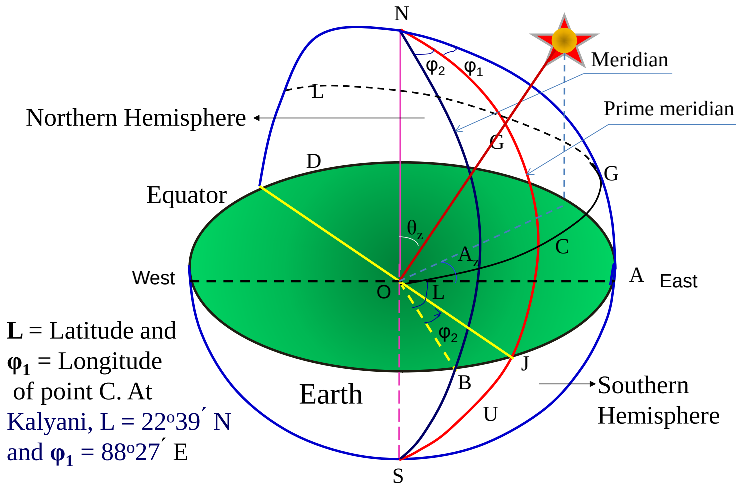

Figure 4. A Global view of the Earth with coordinates.

5. Results and Discussions

(A) Zenith angle (θ):

A typical spectrum of different measurements carried out between May 2009 and September 2012 is depicted in **Figures 5(a)-(f)**. The spectrum (d) shows the distribution of shadow length *S*, which can be used to determine *θ* distribution from (1). Global definition is exactly reflected in this measurement where we have noticed that *S* is minimum in summer, *i.e.*, *θ* is minimum due to the equator as the Sun is on the above of our heads (~12:00). In winter *S* goes to maximum as the earth's rotational axis tilted towards the north, hence *S* becomes longer *i.e.*, range of *θ* gets narrower than that of summer. The maximum and the minimum of each spectrum (d & e) respectively show the data of around December and June.

In **Figure 5(e)** the spectrum of *φ* is shown. During the summer (March-August) and winter (September-February) solstices *θ* and *φ* attain to minimum and maximum. The summary of *θ* at different times (7:00-17:00) in solstices are shown in **Figure 6** where maxima and minima of *θ* clearly infer the discrepancies among the years. Each peak between summer solstices and winter solstices indicate respectively the perihelion and equatorial motions. It concludes that equatorial motion is slower than the perihelion motion since diverse time periods are relating in these two regions. The summary of the measurement of *θ* among summer solstices and winter solstices are presented distinctly from where the drastic change of *θ* before and after the line of Tsunami is evidently described.

(B) Azimuth angle (*φ*):

Similarly *φ* is estimated and the summary of a typical measurement at ~9:00 is depicted in **Figure 7**. The significant discrepancies of *φ* among the years are deliberating slants of major axis of rotation in every year.

Especially before and after the Tsunami line the change of *φ* is remarkable and that brings a huge devastation. The dateline of Tsunami in March 2011 is depicted in the spectrum from where the difference of *φ* is estimated to be ~6˚.

(C) Temperature (T):

The recorded data of temperature is plotted in **Figure 5(f)**. The period of lower temperature measurement in winter solstice is shorter than that of higher temperature in summer solstice. The peak positions of each spectrum (d, e, f) are assumed to be symmetric and rotational and orbital axis are not changing. But we have found inconsistencies when we excavate the data profoundly. The overturned spectra of temperature indicate that ray of light from the Sun fall obliquely on to the surface of the Earth; hence temperatures dwindle in winter sharply. The summary of the measurement of *T* is depicted in **Figure 8** where difference of temperatures before and after the Tsunami is estimated. Results bring the same phenomena which we have concluded previously in the case of *θ* and *φ* respectively.

Environmental pollution is another factor that can change *T* enormously. Maximum *T* can be observed at noon and minimum respectively in the morning and in the afternoon. In the summer air pollution is minimum and *T* goes to maximum while in the winter *T* goes to minimum.

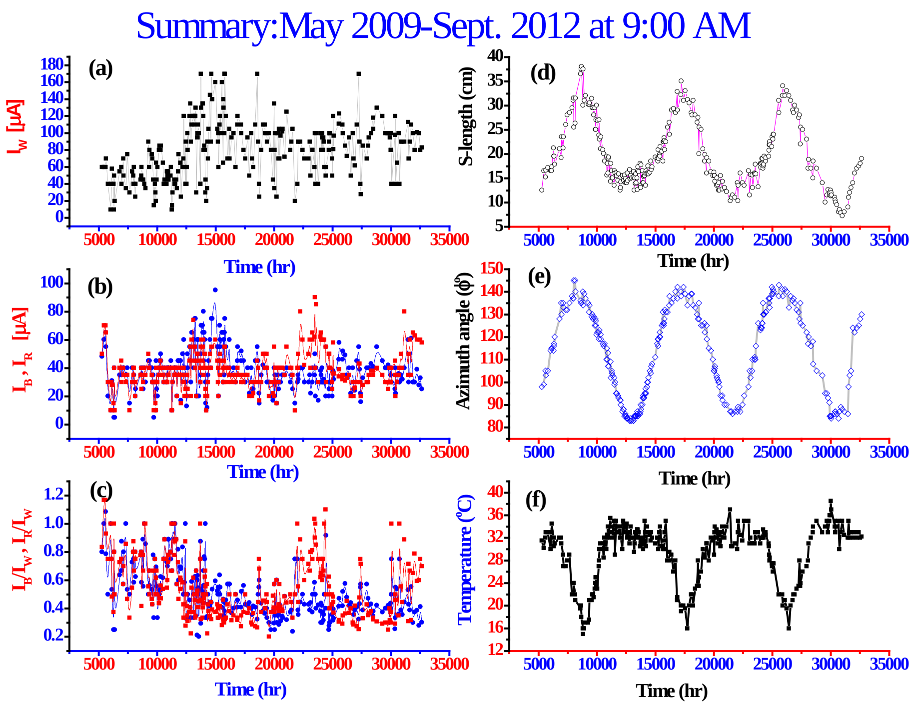

Figure 5. A typical summaries of astrophysical ((a)-(c)) and astronomical ((d)-(f)) data of the measurement.

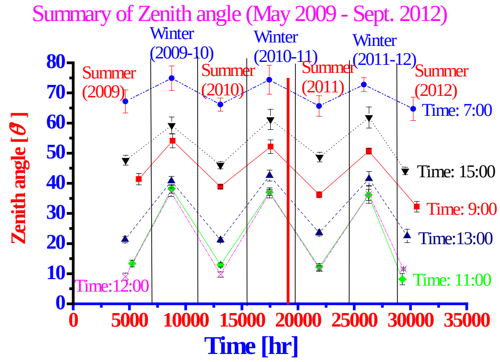

Figure 6. Spectra show the deviation of θ at different solstice regions which are indicated by the columns.

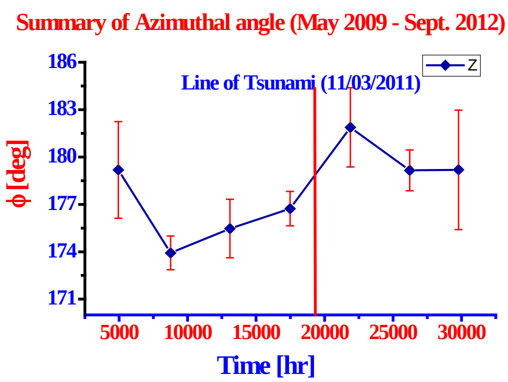

Figure 7. Spectrum shows the distinct variation of φ before and after the Tsunami.

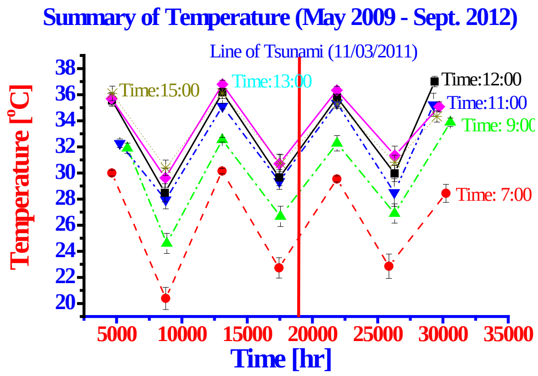

Figure 8. Variations of temperature are offered.

(D) Chromaticity:

In order to study the chromaticity of a solar spectrum the SSM detector system is used. The distributions of current produced by *W*, *B* and *R* plates are depicted in **Figures 5(a)-(c)**. In (a) currents of *W*, (b) currents of *B* & *R* (overlapped) and (c) ratios of I_R/I_W and I_B/I_W are presented. Those spectra don't have any peak as can be seen at right column. But the advents of maximum in summer and minimum in winter for a discrete period are visible due to the Earth's two periodic motions which are shown in the right column of **Figures 5 (d)-(f)**.

The intensity distribution of red light is dominated over the blue light and that is visible in the overlapping spectra. In the data analysis first of all we calculate average current after subtracting the background of each color plate considering the periods of summer and the winter solstices. Secondly we obtain ratios between I_B & I_W (**Figure 9**) and I_R & I_W to determine their differences and time period between same solstices among the years. Thirdly we divide these ratios by the difference of time interval (unit is assigned to be ppm) and plot them with respect to the mean period of the solstices.

One of the typical spectra of $\Delta R_{IB/IW}$ is shown in **Figure 10** that was analyzed from the data taken at ~9:00. Significant variations of colored ratios per hour between the similar solstices are observed. The rate of decrease of $\Delta R(I_B/I_W)$ from 2009 to 2010 in summer solstice is (7.46 ± 3.20) ppm and from 2010 to 2011 is (10.11 ± 0.32) ppm. We also determined the rate of decrease of $\Delta R(I_B/I_W)$ from 2009 to 2010 in winter solstice is (20.61 ± 2.21) ppm. Similar phenomena also can be observed in the rate of decrease of $\Delta R(I_R/I_W)$ which is tabulated in the 7th column of **Table 3**. The error bars of each point infer the statistical error. Bigger error bar represents smaller number of statistics over the six months period than the other points. Some times in summer (March-April-May), rainy seasons (June-July) and early autumn (August) the sky has various conditions: e.g., deep cloudy, cloudy, white nomadic clouds, blue sky, and bright blue sky just after the heavy shower. Hence variations of intensities observed more in the summer than that of winter solstices.

The change of colored ratios implies the decaying nature of intensities in the solar spectrum and abrupt flora of it can be noticed (see the ring) before and after the Tsunami. Similar data analysis is done for the I_R/I_W which is tabulated in **Table 1**. Results attribute the decline nature of I_R/I_W. In this case we can also estimate the rate of change of ratios between the same solstices which are arranged in **Table 2**. The differences between odd-th and even-th numbers respectively refer to the periods of summer and winter solstices. We have perceived the sudden change of *R* before and after the Tsunami line here too (4th row). The rates of changes of astronomical and astrophysical parameters estimated in this study are tabulated in **Table 3**. From these observations we confer that the unusual motions of the Earth not only bring vigorous destruction but also harm our environment equally.

Any change of intensities of L_S alters the humidity that may reflect in the monsoon of a tropical area. The abrupt variation of monsoon causes on our environment in diverse ways. For example excess rainfall in the South-East Asia brings huge floods that spreads epidemic in the post era. On the other hand seldom rainfalls bring drought in many parts of the North-West regions, results scarcity of food and drinking water. Moreover the oxygen production by *Photosynthesis* depends on the colors and its intensities as well. The entire creature must be suffered from the insufficient oxygen production in nature in various ways especially in the respiratory systems. Hence these studies create exclusive spaces for multidisciplinary researches in an outstanding domain.

What a big threat it is in our lives!? Many interesting challenged questions result from this measurement and some of those are discussed sequentially. More advanced detector system is required in order to find out the

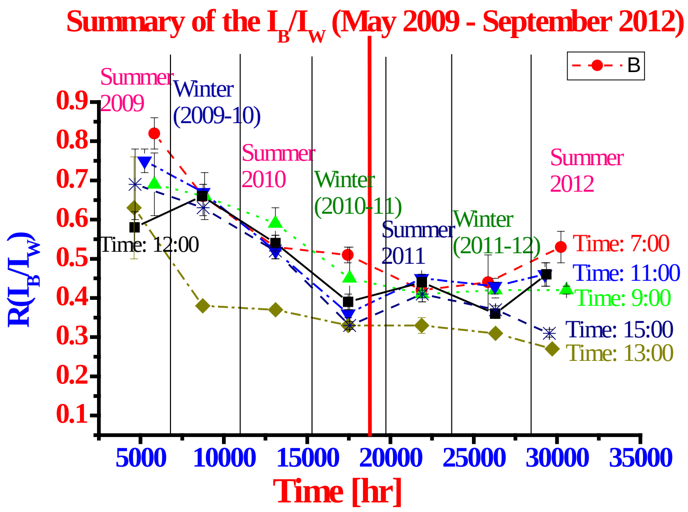

Figure 9. Variations of I_B/I_W over the years [hr] at different moments of days are shown.

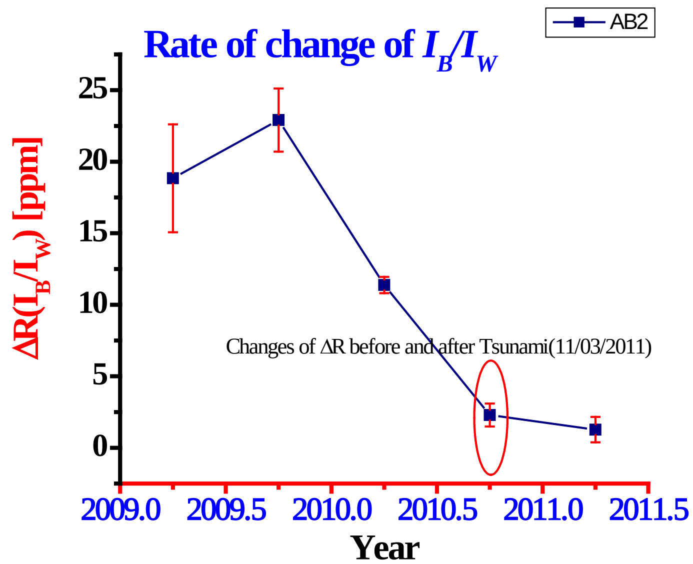

Figure 10. Spectra show the rate of changes of current ratios. Error bars indicates statistical error.

Table 1. Summary of I_R/I_W.

Solstices	Average Time (hr)	Average I_R/I_W
Summer-2009	5137.33	0.68 ± 0.01
Winter-2009-10	8758.17	0.59 ± 0.02
Summer-2010	13096.92	0.56 ± 0.02
Winter-2010-11	17487.17	0.44 ± 0.03
Summer-2011	21885.08	0.58 ± 0.02
Winter-2011-12	26219.33	0.49 ± 0.02
Summer-2012	29779.67	0.33 ± 0.07

Table 2. Summary of rate of change of (I_R/I_W).

Differences of Solstices	ΔT [hr]	$\Delta I_R/I_W)$	Rate $\Delta_{IR/IW}$
1^{st} - 3^{rd}	7959.59	0.12 ± 0.06	15.1×10^{-6}
2^{nd} - 4^{th}	8729.00	0.15 ± 0.01	17.2×10^{-6}
3^{rd} - 5^{th}	8788.16	0.02 ± 0.01	2.27×10^{-6}
4^{th} - 6^{th}	8732.16	0.05 ± 0.01	5.72×10^{-6}
5^{th} - 7^{th}	7894.59	0.25 ± 0.05	31.7×10^{-6}

Table 3. Summary of rate of change of astronomical & astrophysical parameters.

Differences of Solstices	$\Delta R_\alpha \left[\times 10^{-5}\right]$	$\Delta R_\varnothing \left[\times 10^{-5}\right]$	$\Delta R_T \left[\times 10^{-5}\right]$	$\Delta R_{pd} \left[\times 10^{-4}\right]$	$\Delta R_{IB/IW} \left[\times 10^{-6}\right]$	$\Delta R_{IR/IW} \left[\times 10^{-6}\right]$
Summer 1^{st} - 3^{rd}	10.80 ± 2.88	45.5 ± 14.80	9.96 ± 1.79	4.23 ± 1.06	18.84 ± 3.77	15.11 ± 7.56
3^{rd} - 5^{th}	6.14 ± 1.48	72.9 ± 7.51	4.32 ± 1.82	3.60 ± 0.04	11.38 ± 0.57	2.27 ± 0.57
5^{th} - 7^{th}	31.20 ± 3.74	26.9 ± 16.1	1.26 ± 0.29	5.56 ± 0.06	1.27 ± 0.89	31.70 ± 6.33
Winter 2^{nd} - 4^{th}	22.91 ± 2.78	33.60 ± 2.34	16.61 ± 2.29	4.73 ± 0.03	22.91 ± 2.29	17.23 ± 1.17
4^{th} - 6^{th}	9.27 ± 2.63	27.71 ± 2.29	4.58 ± 8.02	0.70 ± 0.23	2.29 ± 0.80	5.72 ± 1.14

discrepancies among the astrophysical parameters in the solar spectrum. Our future work is to develop an advanced detector system for the search of celestial Positronium, the reason of global warming and related ecological problems.

6. Conclusion

We have developed a SSM detector system and measured the rate of change of color luminosities in terms of currents produced by color plates and determine the trajectories of the Earth's movement. This study may open a new domain of researches: 1) the Sun consists of many cells of different atoms and longevities. Hence sporadic rate of fusion reaction is possible to observe, 2) the huge magnetic field, ejection of solar flare, sun's spots, electron-positron plasma etc. are the sources of versatile luminosities in the solar spectrum, 3) Luminosities of individual color bands are changeable, which are observed in this study, 4) the alteration of chromatic intensities play crucial roles in ecological imbalance, especially the creation of oxygen in *Photosynthesis*, falling of solar energy, and those studies are going on, and 5) the change of intensity of color bands and color in the solar spectrum may excavate rare syndromes by congenital process or by revitalization, those can extinct many species of lives from the soil of Earth.

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