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Observations of Interference Patterns of Sun Light During Total Solar Eclipse

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Abstract: *Solar irradiance (light luminous intensity) observations during total solar eclipse at Neem ka Thana (India) on 24th, October 1995 are presented. Spatial and temporal dependent interference pattern of the Sun light comprising multiple constructive and destructive pulses at periodic intervals during the eclipse were recorded. The observations resulted during one-dimensional continuous scan of the solar disc by the diametrically opposite edges of the Moon. The periodicity of major interference pulses was observed to be 2 second. Furthermore the time-luminous intensity appeared to be mirror image in both plots. Further intensities of interference pulses occurring at second contact and at third contact during photosphere occultation were symmetrical. Interestingly the negative peaks of the said pulses were below the average luminous intensity during the totality. The said interference patterns are spatially spread over 10000 Km region of the Sun peripheral annular disc which corresponds to the outer region of convection zone.*

Index Keywords: Solar Eclipse, convection zone, convection current, interference pattern, shadow band, Sun spots, sun magnetic field, prominences, solar flares

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I. INTRODUCTION

For observations and investigations of the sun, total solar eclipses have always been ideal occasions for science fraternity, wherein many parameters like Corona, chromospheres, photosphere could be studied as the bright sun disc is covered by the moon disc. Solar radiance with sample at every minute has been studied by Krezhova et al [1] and found luminous intensity fluctuations, Power spectrum fluctuation in 2.8 GHz range reported by Alurkar et al [2]. Shelke and Ingole [3] reported light fluctuation during total solar eclipse on at Neem ka Thana where the power spectrum analysis of the light luminous intensity was presented.

Methods: Two light luminous intensity measuring electronic equipments (modulator) were designed by the author to record the shadow bands after first contact and before fourth contact. The equipment comprised a Light Dependent Resistance (LDR) as a sensor having sensitivity within visible light spectrum (500 nm to 665 nm) and a linear light luminous intensity to frequency modulator. First modulator (Ch.1) and second modulator (Ch.2) had different sensitivity and output of each modulator was connected to respective Hi-Fidelity audio double channel tape recorder having low noise Chromium tapes. These equipments were properly earthed and installed at the site along with Indian Physical Laboratory (IPL), Ahmadabad team. Knowing the constraints of the recording equipment, proper care was taken while recording the data. In the present article detailed observations recorded on Ch: 1 and Ch: 2 are presented. The totality of the eclipse at the said was to begin around 3 UT (8.30 am local time) for about 50 seconds. The recordings commenced at 2-45' UT and lasted for 30 minutes till 3-15' UT. The data recorded on each channel was demodulated using frequency to voltage converter. Voltage variation was visually checked on oscilloscope. Data from Cha: 1 was selected for 390 second. Relevant Data having significant fluctuations (X-X') was selected and printed on X-Y plotter (Figure-1). A data of 160 second duration evenly timed around totality from Ch.2 was selected and printed on X-Y plotter (Figure-1). For detailed study of Ch. 2 (Figure-1) all significant pulses were considered for analysis. Digital filter techniques were used to filter insignificant fluctuations and amplitudes were normalised. On either side of the mirror symmetry (O) all selected pulses before second contact were numbered 1, 2,…15 and after third contact were numbered 1', 2',…15' respectively in a sequence as shown in Figure-2. The average amplitude difference and average time difference between mirror copy pulses 1 and 1' to pulses 15 and 15' were computed as shown in Figure-3. The recorded time of the said pulses and the projected distances on the sun disc were computed as shown in Figure-4.

Analysis:

Origin of the interference pulses: During eclipse the lunar disc does one dimensional scan of the sun disc. The source of the energy of the luminous intensity plot is from the sun luminosity. The solar rays travel along the interstellar space, the moon, and through earth atmosphere. The interference of light is caused by the moon outer edge scanning continuous covering and uncovering the sun's disc during total solar eclipse hence the energy received has to be from the sun as there is no other source to be accounted for other than convection region and the chromospheres. However; the chromospheres is only 2000 Km thick as against 10000 km. estimated by the experiment. So it can be inferred that the only source remaining is depletion zone which would attribute to such fluctuations.

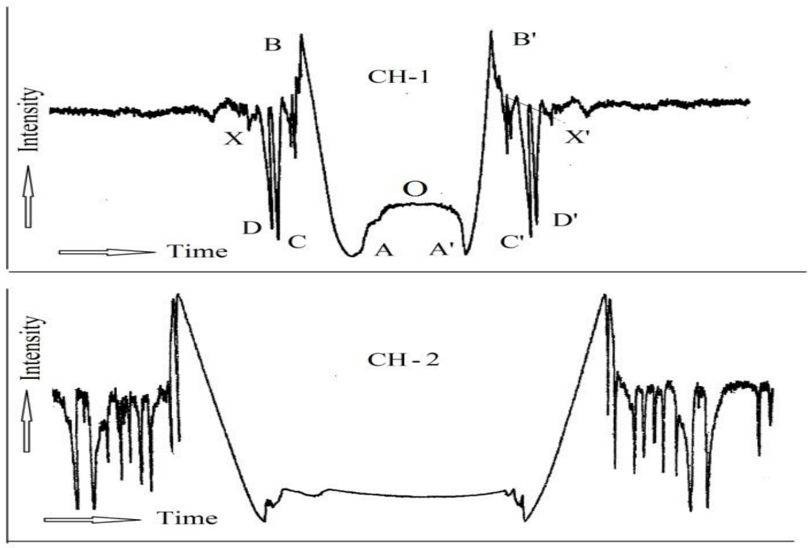

Figure-1

Plot shows X axis- Time, Y axis - the luminous intensity of light. Ch. 1 shows the actual Time v/s Luminous intensity plot recorded. O is temporal mirror line during totality on first channel. Prominent pulses before totality are marked A through D and marked A' through D' after totality between X and X' period. Ch. 2 shows another simultaneous relation between actual Time v/s Luminous intensity plot recorded between X and X' on second channel.

Due to the mirror symmetry (Figure-1 and Figure-2) the effect of the moon irradiance due to the earth reflection, earth atmosphere, and interstellar space is ruled out as it happens for a limited period before second contact and after third contact. Further the discrete mirror copy interference repeated pattern can be due to exposed sun photosphere as there cannot be discrete and temporal and spatial photo prominent activities so symmetrical across diametrically opposite photosphere surface.

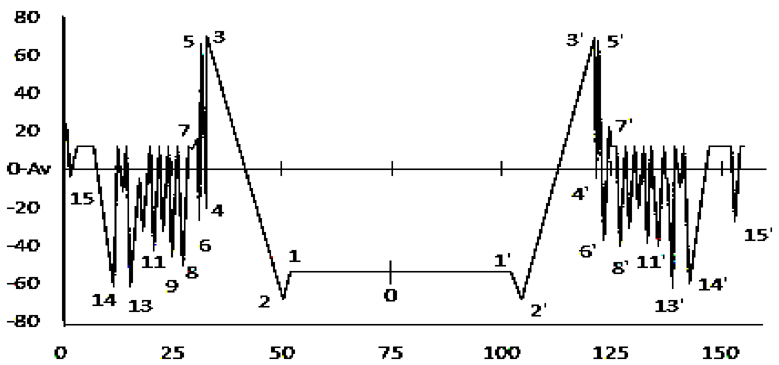

Figure-2

Plot shows digitized plot of Ch. 1. Time in Seconds v/s normalized amplitude of pulses. Pulses before totality are numbered 1 through 15 and after totality are numbered 1' through 15'. Natural number corresponds to mirror symmetry. O is temporal mirror line during totality. O-AV is average light luminous amplitude.

It can therefore be inferred from Figure-2 that there are likely to be discrete energy sources emitting visible light also on diametrically opposite sides of the disc of the sun other than fairly steady the photosphere. Pulse 1, 1’ are below the luminous intensity O during the totality show that the luminous intensity magnitude O is exclusively due to diffraction of the sun light and the moon’s disc. Pulses 3, 4, 5, 6, and 7 are due to interferences during second contact and are the most prominent fluctuations which attribute to the diamond ring. Other than photosphere, as per our data, there appears to be eight such sources corresponding to pulses from 8 through 15 and 8’ through 15’ diametrically opposite annular disc of the sun and the same can therefore be extended to the entire annular ring of the sun. So it can be logically inferred that such powerful light sources are just below the photosphere and form the top layer of light permeable convection zone. These zone are divided in to discrete layers while at the junction of each such layer a thermal transition takes place due to transfer of solar energy from the core and manifesting in emission of photons. Each such layer may be culminating in the formation of local loops thus stabilizing the heat transfer as compared to a single convection zone monolith layer. Further analysis shows that the constructive and destructive interference pulses swing equally over the average sun light at the respective contacts during second and third contact. It is observed from Figure-4 that the thickness of the photosphere at second contact observed to be divided in two parts of 310 and 100 Km amounting to 410 Km. Similarly pulses 3’, 4’, 5’, 6’, and 7’ are due to interferences during third contact which attribute to the second diamond ring. The thickness of the photosphere at third contact observed to be divided in two parts of 300 and 150 Km amounting to 450 Km which is in agreement with hitherto established photosphere thickness. Such two interferences may be attributed to the craters on the moon disc edges. From the observation of pulses 8 through 15 it can be inferred that there is a likelihood of multiple and discrete energy sources located at various distances with respect to the outer surface of the sun. Similar observation can be made about pulses 8’ through 15’ however; at the opposite side of the sun annular ring. Figure- 3 shows that the difference between of amplitude and timing of pulses from 1 through 15 and their counterpart are within 0- 1.75% and 0- 0.03% respectively which establishes that the discrete sources of energy are having similar magnitude and spatially equally distributed on the cross section of exposed sun disc. Such observation can be extended to Ch. 1 (Figure-3) further corroborating the results.

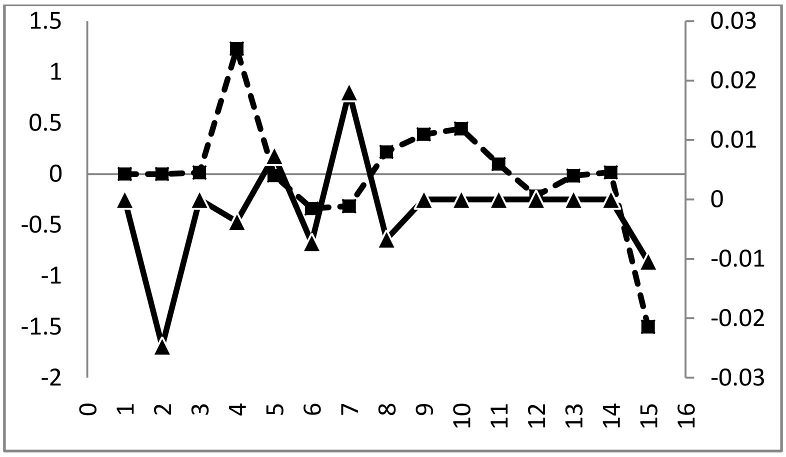

Figure-3

Plot shows pulse number v/s average % amplitude difference by dotted line on primary axis and average % temporal difference on secondary axis.

It can therefore be inferred that the outer annular ring of the sun’s surface comprises 8 such energy sources and the distance between two successive sources attributes to the thickness in the formation of annular layers as shown in Figure-4. From the mirror symmetry it can be inferred that the thickness of each layer is identical to its opposite counterpart having approximately of 1000, 600, 600, 700, 850, 900, 1100, and 3200 Km respectively as measured from the outer surface towards the centre of the sun respectively. Further the layer (1100 Km thick) between 13 and 14 pulses appears to be the most active in energy emission as observed from the strongest and prominent interferences (Figure-1). The total thickness of these layers appears to be approximately 10000 Km. Since after pulse 15, 15’ there is no major interference recorded (Figure-1 Ch. 1) hence it can be inferred that either there are no further discrete convection layers or the media below is opaque.

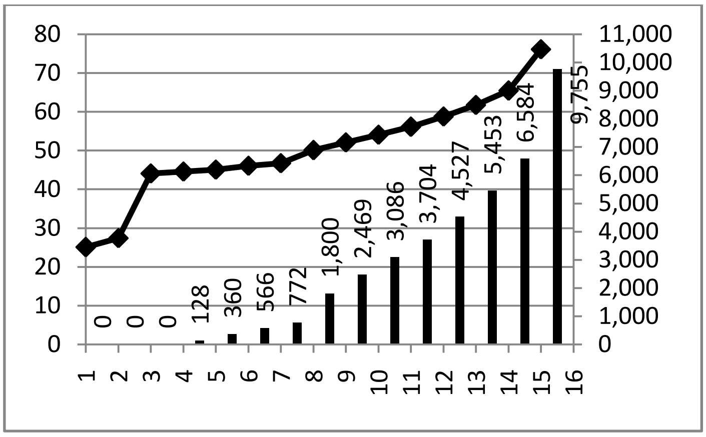

Figure-4

Plot shows the relation of marked pulses v/s respective timing in seconds on primary axis and distance from photosphere in convection zone in Km on secondary axis

II. DISCUSSION

1. The source of energy of the interferences observed is the sun light when the lunar disc does one dimensional scan of the sun disc across its diameter. Multiple interferences show that there are such multiple energy sources. The symmetry of the interference pulses shows that they are identical and located at symmetrical distance on the sun annular ring. These sources start immediately after the photosphere. Each of the sources is located at the junction of layers having definite and uniform thickness. The total thickness of all the layers is about 10000 Km below photosphere being part of the outer layer of convection zone. These layers do not look like opaque. They constitute about 5% of convection zone (200000 Km Thick).

2. As per Figure-4 the last pulse appears at about 10000 Km over the Sun region, which is close to 5 % of convection zone just below the photosphere. The thickness of convection zone is about 200000 Km. It is known that the convection zone transfers the energy of the sun from deep below to the surface by strong thermodynamic activity through convection presumably by single loop formation between radiactive zone to photosphere. It comprises mainly plasma and free electron which are electric conductors. It has been said that this layer is comparatively opaque and no radiation can pass through. The convective motions themselves are visible at the surface as granules. From the available literature the convection zone is postulated to be monolith attributing to heat transfer activities. The convection zone comprises plasma. The plasma comprises nuclei of carbon, nitrogen, oxygen, calcium, iron etc and free electrons. The pressure and density of plasma decreases from core to the surface. It is known that convection is not unidirectional heat transfer phenomenon. It takes place due to circulation of mass from high temperature to low temperature and vice the versa. Not much light is thrown as to how a single layer of convection zone engages in convection activity. It implies that that there might be many circulation sub-zones or layers comprising loops continuously forming multiple convection layers which might contribute in enhancing thermodynamic action and temperature stabilization. Though it has been postulated that the convection zone is opaque but from our observation it implies that it may not be so opaque at least in the top annular peripheral zone up to 10000 Km as we could detect eight such distinct interferences related to such convection layers. From our observations it can be inferred that top annular peripheral ring of the sun comprises multiple distinct layers. Further the layer 13 and 14 at a depth of about 5500 and 6500 Km (1000 Km. Thick) respectively appear to be the strongest. All layers might have been formed due to difference in density of the plasma ions, pressure difference and the temperature difference associated between them. Each such transition layer might have its own convection means heat transfer activity. At such junctions or transition region where energy transfer takes place, may become a source of energy emission. In this manner the annular peripheral rings associated with each convection layer may develop multiple local convection current loops due to thermodynamic action. The convection current comprising charged plasma in a form of convection loops is associated with magnetic field as per electromagnetic phenomenon and hydro dynamic (MHD) principle thus forming electromagnetic dipoles. Such dipoles have a tendency, due to magnetic forces, to align themselves to form closed plasma toroids encapsulating means enclosing magnetic field lines within. Whenever thermodynamic activity increases it thereby increases the convection by plasma tube thus increasing the toroid magnetic flux, further culminating in the increase in the diameter of the toroid due to electromagnetic forces and vice the versa. In this manner part of the thermal energy is converted in to magnetic field resulting in to thermodynamic and electromagnetic interaction. Whenever, due to decrease in pressure or local disturbances, the said toroid breaks, the enclosed magnetic field opens up in the form of magnetic flux

energy and gets suddenly released. The breaking and assimilation of multiple toroids may result in continuous magnetic activity on the sun. The orientation of such electromagnetic toroid will be decided by the temperature difference associated with thermodynamic activity and Carioles force. Breaking and assimilation of such toroids may be continuous phenomenon within the convection zone and at times in the process the thermal activities toroids may get larger and larger till the various forces are balanced. However; when such toroids come close to the surface of the sun, inner magnetic force may overcome the force exerted by outer layer of the sun and the plasma tube may burst open. Such toroids may look like granules. Moment the plasma tube breaks the magnetic flux associated with trapped energy gets released and the magnetic flux travels at a speed of light in the interstellar space along with the broken plasma tube in the form of prominences, solar flares giving rise to coronal mass ejections (CME). The remaining buried the plasma tube collapses due to loss of magnetic field thus hindering the heat transfer thereby reducing the temperature of the prominence tubes as observed in dark spots associated with opposite magnetic poles.

III. CONCLUSIONS

During the solar eclipse light fluctuation in the form of pulses attributed to constructive and destructive interference of light emitted by the sun disc occurs from approximately 10000 Km to diametrically opposite 10000 Km of the annular peripheral surface of the sun. Such fluctuations have been observed to be ditto mirror copy. The distances of these pulses and layer thicknesses from the photosphere have been calculated and appeared to be within the top annular peripheral layer of convection zone. During diamond ring effect the solar light luminous intensity considerably increases and decreases about average luminous intensity. The light during totality comprises the sun luminous light diffracted by occulted moon disc and twilight. Formation of plasma toroid tubes and its association with heat transfer, thermodynamic and electromagnetic interaction, CME, cooler sun spots associated with opposite magnetic poles discussed.

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