ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

A Relook on the Rayleigh scattering of Light from the Sunset Observations Viewing from Brahmaputra River

A.B.Bhattacharya[1], J. Pandit[1, 2], B. Raha[1], D. Halder[1], R. Bhattacharya[3], G. Biswas[3], R. Roy[3], A. Nag[4]

Department of Physics, University of Kalyani, Kalyani, West Bengal, India[1]

Department of Physics, JIS School of Polytechnic, Kalyani, West Bengal, India [2]

Department of Environmental Science, University of Kalyani, Kalyani, West Bengal, India [3]

Department of Physics, Modern Institute of Engineering &Technology, Bandel, Hooghly, West Bengal, India [4]

ABSTRACT: We collected photographs of Sunset at Brahmaputra River by three powerful digital cameras on January 26, 2014 to re-examine the scattering property of optics and also to investigate some fundamental theory in this field. The results provide some interesting basic concepts and suggest further problems in this direction.

KEYWORDS: Rayleigh scattering, Sunset, Digital cameras, Blue of the sky, Optics

I. INTRODUCTION

On January 26, 2014 we, a team of research workers of West Bengal, India working in the University of Kalyani and two Engineering colleges made a joint venture and successfully collected photographs of Sunset viewing from Brahmaputra River by constantly observing with three powerful high resolution digital cameras operated at different angles with a view to re-examine the scattering property [1] and to go into further insight into this very fundamental field of optics. The data we achieved from the received photographs suggested some interesting problems besides the verification of the existing scattering principle. The results achieved from the photographic documentations besides the Rayleigh scattering [2] principle are reported in this paper.

II. BACKGROUND

To Maxwell's equations the Mie solution, named after Gustav Mie, describes the scattering of electromagnetic radiation by a sphere. The solution takes the form of a systematic infinite problem. The so called Mie theory is ambiguous to some extent because it does not refer to an independent physical theory or law. However, presently, it is also used in broader contexts, for example when discussing solutions of Maxwell's equations for scattering [4] by stratified spheres or by infinite cylinders, or generally when dealing with scattering problems using the exact Maxwell's equations in cases where one can separate for the radial and angular dependence of solutions.

III. THEORATICAL APPROACH OF SCATTERING

Rayleigh scattering of sunlight in the atmosphere causes diffuse sky radiation, which is the reason for the blue color of the sky and the yellow tone of the Sun itself. Scattering by particles similar to or larger than the wavelength of light is typically treated by the Mie theory including the discrete dipole approximation and other computational techniques.
The size of a scattering particle is parameterized by the ratio x of its characteristic dimension r and wavelength λ following the equation.

$$x = \frac{2\pi r}{\lambda} \qquad (1)$$

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

Rayleigh scattering can be defined as scattering in the small size parameter regime $x \ll 1$. Scattering from larger spherical particles is explained by the Mie theory for an arbitrary size parameter x. For small x the Mie theory [2] reduces to the Rayleigh approximation. The amount of Rayleigh scattering that occurs for a beam of light depends upon the size of the particles and the wavelength of the light. Particularly, the intensity of the scattered light varies as the sixth power of the particle size, and varies inversely with the fourth power of the wavelength.
The intensity I of light scattered by a single small particle from a beam of unpolarized light of wavelength λ and intensity I_0 is given by,

$$I = I_o \frac{1+\mathrm{Cos}^2\,\theta}{2R^2}\left(\frac{2\pi}{\lambda}\right)^4\left(\frac{n^2-1}{n^2+2}\right)^2\left(\frac{d}{2}\right)^6 \qquad (2)$$

where R is the distance to the particle, θ is the scattering angle, n is the refractive index of the particle, and d is the diameter of the particle. The Rayleigh scattering cross-section [2] is given by

$$\sigma_s = \frac{2\pi^5}{3}\frac{d^6}{\lambda^4}\left(\frac{n^2-1}{n^2+2}\right)^2 \qquad (3)$$

IV. OBSERVATIONAL SITE

A map of Guwahati, Assam (Lat 26.19^{0}N, Long 91.73^{0}E) indicating the position of the river Brahmaputra is shown in Figure 1. The location of our observation where we installed the three cameras is also marked in the same Figure.

III. TYPE OF CAMERAS USED

We used three very good quality digital cameras of identical type having high resolution and many options of proper .recording. The particulars of the cameras used for taking the photographs are given in Table 1. The purpose of using the three cameras was to take photograph simultaneously for verifying all the fine points of each individual photograph and also to avoid the risk of missing any important observation due to unavoidable instrumental problem that can be suddenly appeared in course of recording the data.

TABLE 1

PARTICULARS OF THE CAMERAS USED

Camera maker	Nikon Corporation
Camera model	Nikon D90
F-stop	f/9 to f/5.6
Exposure time	1/320 sec to 1/125 sec
ISO speed	ISO-200
Focal length	105 mm
Max aperture	5

V. PHOTOGRAPHIC RECORDS

Figure 2 shows the photograph of Sunset as viewed from Brahmaputra River constantly by three powerful high resolution digital cameras operated at different angles with the purpose to re-examine the scattering property and to go into further insight into this very fundamental field of optics. Figure 2 revels photograph of Sunset as observed over Brahmaputra River by constantly monitoring three powerful high resolution digital cameras operated at different angles at the interval of around two minutes. It is interesting to note from the figure that there is a significant change of hour angle with reference to the horizon.

VI. RESULTS

Figure 3 shows a schematic diagram for a visibility of azimuth and altitudes for northern hemispheres. In Table II the variations of altitude and azimuth for the period of observation are pointed out.

IJIRSET

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

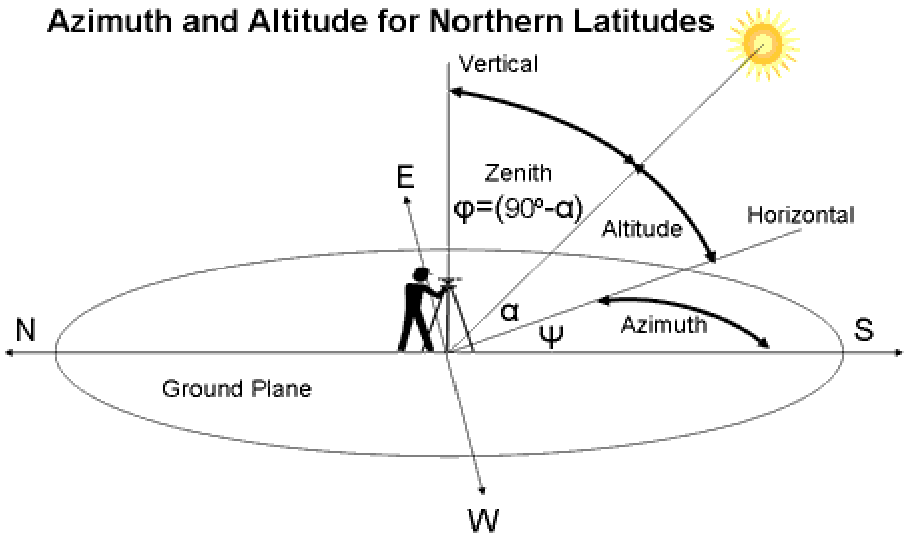

Fig. 3 Schematic diagram for a visibility of azimuths and altitudes for northern hemisphere

TABLE II
VARIATION OF HOUR ANGLE, ALTITUDE AND AZIMUTH FOR THE TIMES OF INTEREST
Declination of the observational site: 19.03^0

Time	Hour Angle	Altitude	Azimuth
16:26	53.36	21.35	234.54
16:28	53.86	20.98	234.86
16:30	54.36	20.62	235.17
16:32	54.86	20.25	235.49
16:34	55.36	19.88	235.8
16:36	55.86	19.5	236.11
16:38	56.36	19.13	236.42
16:40	56.86	18.75	236.72
16:42	57.36	18.38	237.02

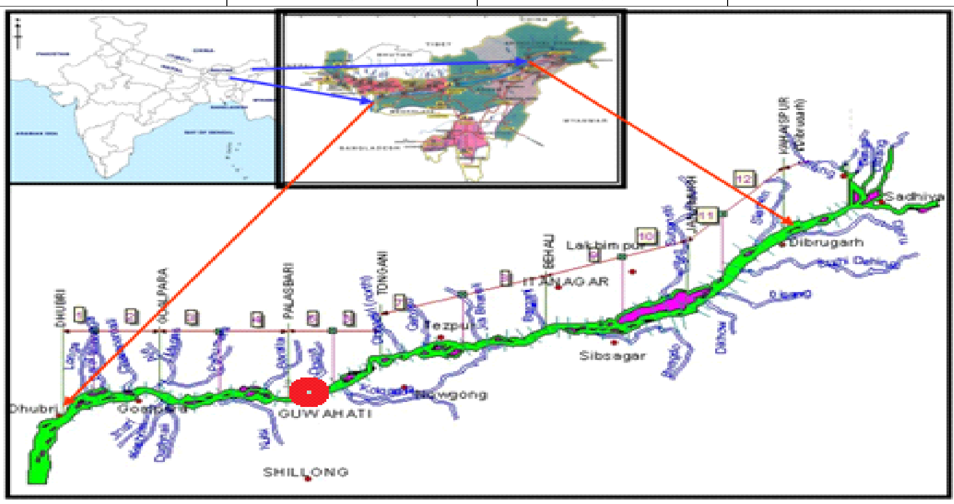

Fig.1 Map of Guwahati, Assam indicating the position of the river Brahamaputra with the red circle showing the site of observation

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

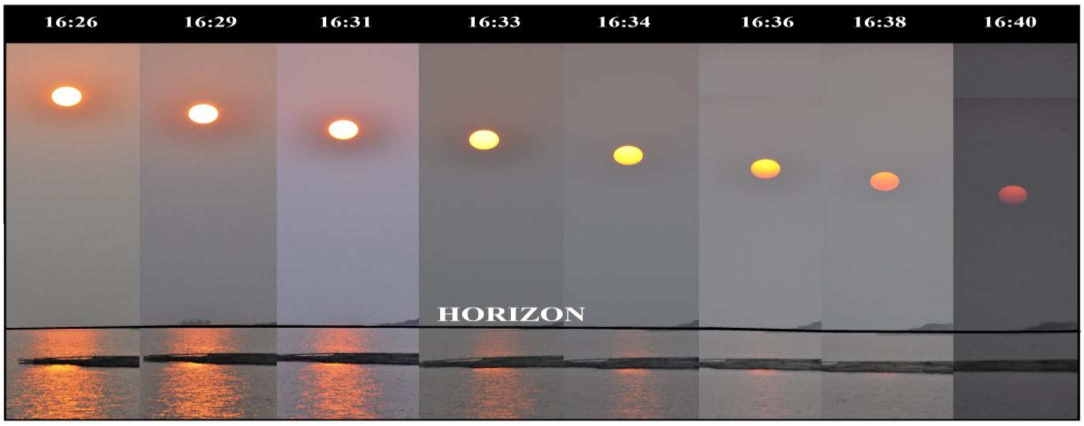

Fig.2 Photograph of Sunset as viewed from Brahmaputra River

VII. DISCUSSION

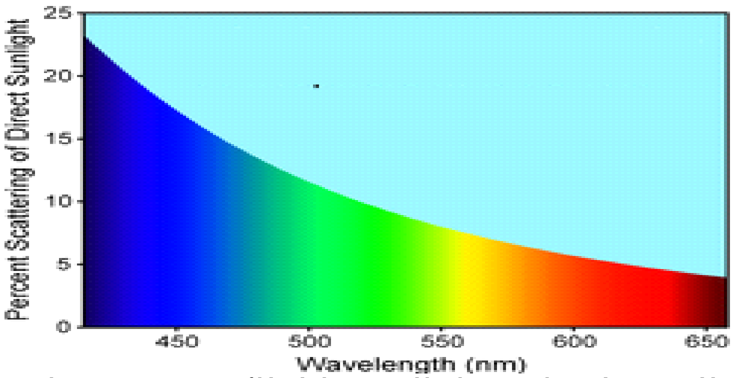

Fig.4 The greater proportion of blue light scattered by the atmosphere relative to red light

Rayleigh scattering occurs from individual molecules where the scattering is due to the molecular polarizability, which describes the amount of the electrical charges on the molecule for the purpose of moving in an electric field. The amount of Rayleigh scattering from a single particle can usually be expressed as a cross section. As for example, the major constituent of the atmosphere, nitrogen, has a Rayleigh cross section of 5.1×10^{-31} m^2 at a wavelength of 532 nm (green light) which means that at atmospheric pressure, about a fraction 10^{-5} of light will be scattered for every meter of travel. In Figure 4 the greater proportion of blue light scattered by the atmosphere relative to red light has been shown, which clearly indicates that the Rayleigh scattering provides the atmosphere with its blue colour.

The strong wavelength dependence of the scattering ($\sim\lambda^{-4}$) suggests that shorter (blue) wavelengths are scattered more strongly than longer (red) wavelengths. The present findings in the indirect blue light coming from all regions of the sky supports strongly the principle of the scattering phenomena but at the same time revealing some interesting characteristics changes with reference to horizon and hence will be able to provide further information when careful observation of the characteristic variations will be taken into consideration. Rayleigh scattering is, in fact, a good approximation of the manner in which light scattering occurs within various media for which scattering particles have a small size parameter. A portion of the beam of light coming from the sun scatters off molecules of gas and other small particles in the atmosphere. Rayleigh scattering basically occurs through sunlight's interaction with randomly located air molecules.

Sun, like any star, has its own spectrum and falls away in the violet. In addition the oxygen in the Earth's atmosphere absorbs wavelengths at the edge of the ultra-violet region of the spectrum. The resulting color, which appears like a pale blue, actually is a mixture of all the scattered colors, mainly blue and green. On the other hand, glancing toward the sun, the colors that were not scattered away, the longer wavelengths such as red and yellow light, are directly

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

visible giving the sun itself a slightly yellowish hue. However, when observed from space, the sky is black and the sun is white.

REFERENCES

[1] C.F. Bohren and D. Huffman, "Absorption and scattering of light by small particles", John Wiley, New York 1983.
[2] S. Chakraborti, "Verification of the Rayleigh scattering cross section". American Journal of Physics 75 (9), 824−826, 2007.
[3] P. Lilienfeld, "A Blue Sky History", Optics and Photonics News, 15(6), 32–39. 2004.
[4] Stover and C. John, "Optical Scattering: Measurement and Analysis", SPIE Optical Engineering Press, 1995.