iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1317

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

The Nature of the Gaussian Pattern Observed at the Boundary Separating Two Liquids in Christiansen Cell

Rajib Mahanta[1]
[1]Department of Physics, Dibru College, Dibrugarh-786003

Abstract: In the present work we have studied the Gaussian pattern and its time evolution observed in the diffusion region separating two liquids in a Christiansen cell. It has been observed that there is a definite co-relation between the shape of the Gaussian pattern and the width of the diffusion region. When the diffusion band attains its maximum length, Gaussian pattern nearly vanishes. When laser beam is passed through this region of diffusion, a circular diffraction halo pattern has been observed. The time evolution of these Gaussian patterns will throw much needed light not only on the theory of the Christiansen effect but also to develop an optical technique to measure the rate of diffusion between two molecules.
Keywords: Christiansen effect, Gaussian pattern, Diffusion.

I. INTRODUCTION

The Christiansen effect is concerned with an optical technique to produce optical spectral filtering by transmission of incident light. This technique is based on refractive index matching property for a multiphase material, discovered by Christiansen [1]. When an optical isotropic solid like glass is powdered and is put inside a glass cell which is then filled with a liquid and its refractive index is adjusted suitably by varying its composition or altering its temperature, beautiful chromatic effects are observed. The cell becomes transparent for the particular wavelength while rest of the incident light passing through the cell is diffused out in various directions. This is known as the Christiansen effect after its inventor. It was Raman and co-workers [2-4] who gave adequate explanations to the phenomenon through a series of papers. The theory which Raman advances is concerned with the concept of wavefront corrugation and is similar to the work of Ramachandran on clouds [5], except that instead of air and water, one has two media of refractive indices n_1 and n_2. Experiments to demonstrate the Christiansen effect are usually performed with powdered glass but with spherical particles one expects even more spectacular effect. Clarke [6] showed theoretically that the diffraction profile is approximately Gaussian. This effect has found its applications in diverse field of science and technology [7-13]; mainly in IR study, glass technology, heat transfer and flow through porous media, atmospheric study, colloids and polymer study, optical sensor etc.

In a recent work we have described in detail about the role of diffusion on the chromatic patterns associated with the Christiansen effect where, we have indicated about time changing 'Diffraction halo' [14-15]. This dynamic 'Diffraction halo' appears when laser radiation is allowed to fall on the Christiansen cell containing two liquids miscible through diffusion. This paper is concerned with some salient features of Gaussian patterns observed in Christiansen experiment with continuous diffused light background.

II. EXPERIMENTAL

A Christiansen cell containing two liquids miscible through diffusion without glass spherules is placed against a continuous diffused light background and the chromatic patterns are observed. A high resolution video camera coupled with a computer has been used to photograph the chromatic patterns under different circumstances. An optical pattern resembling a Gaussian shape may be seen at the boundary separating the two liquids when is viewed against the diffused light back ground. Here we use acetone and CS_2, benzene and CS_2, water and acetone etc combinations. It may be noted that these types of optical Gaussian pattern and their time evolution have not been reported by earlier workers connecting with Christiansen experiment. The Gaussian patterns observed here do not depend on the shape of the sample cell. We have observed these patterns in square optical cell also. Twenty patterns have been photographed at different intervals of time to study their evolutions.

III.RESULTS AND DISCUSSION

It is instructive to record the optical patterns in the region of diffusion at different intervals of time, from the beginning and at successive stages to observe their developments till a stage of saturation is attained. Fig.1 shows the photographs of the optical patterns resembling a Gaussian shape. These patterns change in time with diffusion between two liquids. It is, however, essential to note that the Gaussian optical pattern appears in the field of view (Fig 1a) after about ten seconds. In fact it looks more like a region of discontinuity or region of absorption of radiation. The process of diffusion continues and the shape of Gaussian optical pattern changes accordingly. As may be inferred from Fig 1 (a,b,c …t) the Gaussian patterns broaden with the evolution of time and after ten hours the pattern nearly disappears for a cell of diameter 6mm.

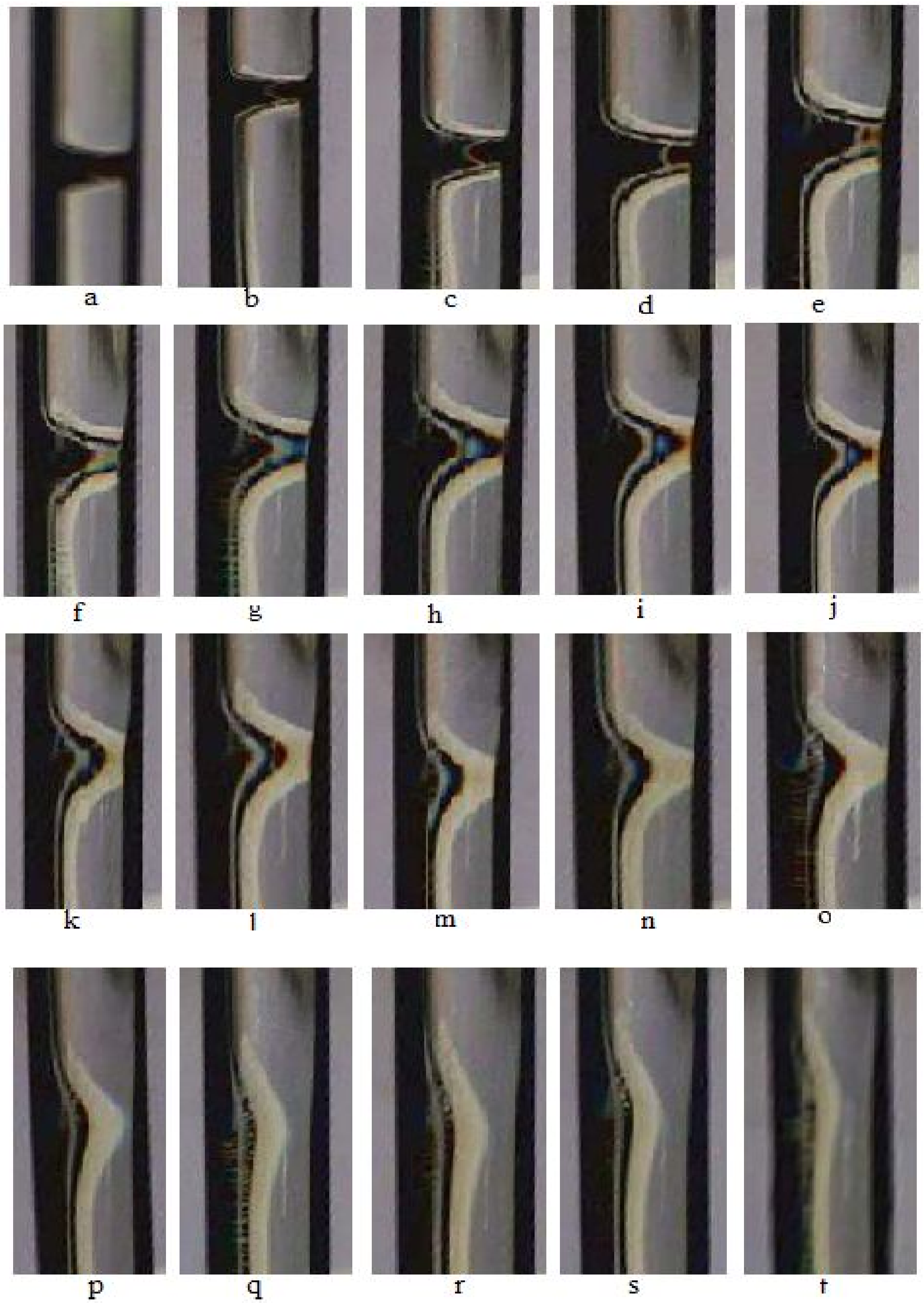


Fig.1**:** Time evolution of optical Gaussian pattern in Christiansen cell (liquid, CS_2 and acetone; cell length 40 cm and of diameter 0.6 cm).

It is worthwhile to note that to observe Gaussian optical pattern, diffusion between two liquid is necessary. In case where diffusion is not observed this effect is not demonstrate. For example, in the case of CS_2 and ethanol, there is no diffusion and hence no this Gaussian pattern. We have photographed the different Gaussian pattern for different pair of liquids. For the case of CS_2 and acetone the pattern nearly disappears after ten hours. It has been observed that there is a definite co-relation between the shape of the Gaussian optical pattern and the width of the diffusion band. From the photograph it is clear that when the diffusion band attains its maximum length, Gaussian pattern nearly vanishes. Another salient features as regards the Gaussian pattern is that pattern is always asymmetric and several lines of demarcation can be seen insides the Gaussian pattern itself. It may be also noted that the Gaussian pattern is slightly asymmetric towards lower side. This indicates that diffusion is more towards lower side due to gravitation. Table 1 shows the change of Gaussian pattern with passes of time for CS_2 and acetone combination. Fig. 2 shows how the Full width at Half Maxima (FWHM) evolves with time which is identical as we had observed with glass spherules [13].

Table I
Change of gaussian pattern with passes of time for cs_2 and acetone combination

Optical cell (Length 40 cm, diameter 0.6 cm)	
Figure 1	Time in minute
a	0.16
b	0.41
c	1
d	2
e	4
f	7
g	10
h	15
i	20
j	25
k	30
l	40
m	55
n	70
o	85
p	135
q	200
r	320
s	420
t	600

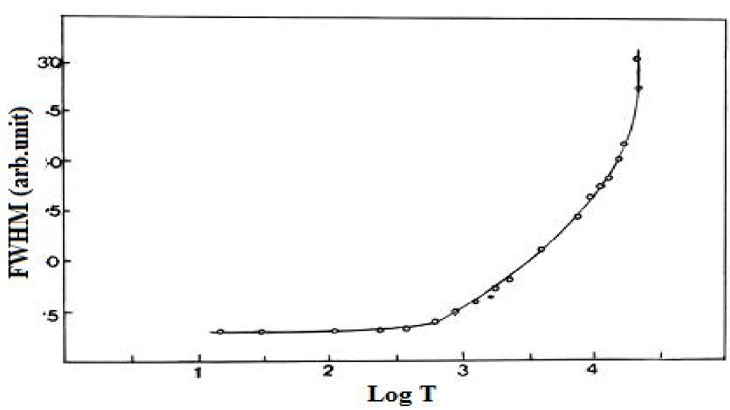


Fig 2. Changes of FWHM of the Gaussian patterns with time

Why the phenomenon described above manifests itself is not difficult to understand if we consider the process of diffusion, which is taking place between acetone and CS_2 to both sides of the boundary separating them. The density of the liquid at the boundary and in the region of diffusion is more than that lying above and is less than that lying below it. A refractive index gradient due to concentration gradient is taking place in this region, which is responsible for the Gaussian pattern.

IV. CONCLUSIONS

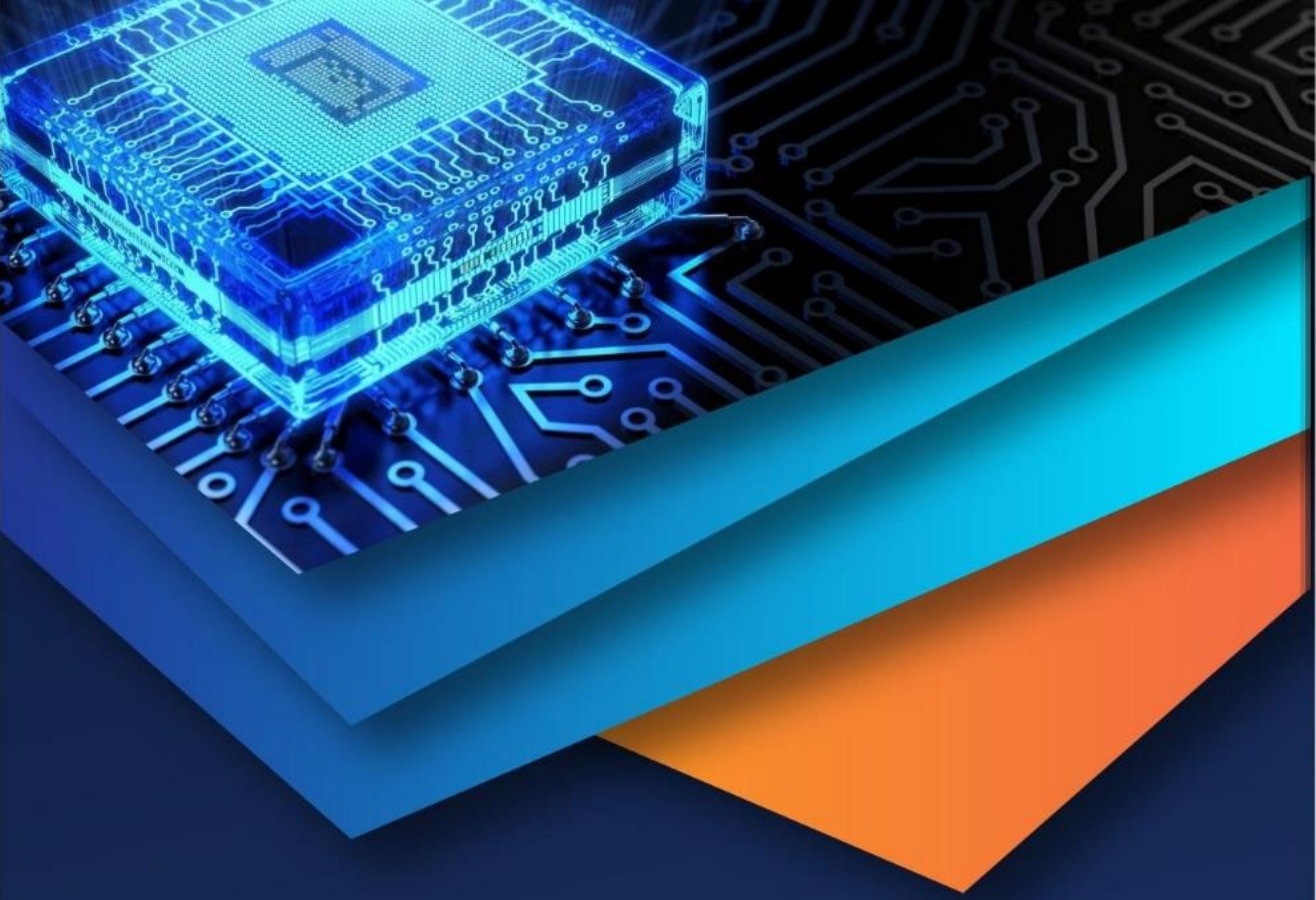
From what has been described above, it is apparent that the Gaussian pattern, plays a central role in Christiansen experiments where a combination of two liquids of nearly equal refractive index are used There may be a number of explanation to the above phenomenon . It is believed that a detailed investigation of these diffusion fringes will throw much needed light not only on the on the nature on the Gaussian pattern shape of the Christiansen effect but also on the rate of diffusion between two molecules.

V. ACKNOWLEDGMENT

The author is thankful to UGC-NERO, Guwahati, India, for granting Minor Research Project. This work has been carried out under this Minor Research Project.

REFERENCES

[1] C. V. Raman, "The theory of the Christiansen experiment", Proc Indian Acad Sci, A, Vol. 29, pp 288-297, 1949.
[2] C. V. Raman and M R Bhat, "The Christiansen experiment", Curr Sci, Vol. 22 , pp.31-33, 1953
[3] C.V. Raman and M R Bhat, "The Christiansen experiment with birefringent powder", Proc Indian Acad Sci ,A **,** Vol. 41 , pp.61-66, 1955.
[4] C V Raman, K S Viswanathan, "A generalized theory of the Christiansen effect", Proc Indian Acad Sci ,A, Vol. 41 , pp.55-60, 1955.
[5] G. N. Ramachandran, "On transmission of light through a cloud of randomly distributed particles", Proc Indian Acad Sci, A, Vol. 17, pp.171-186, 1943.
[6] R.H. Clarke, "A theory of the Christiansen filters", Appl. Opt, Vol. **7,** pp 861-868, 1968.
[7] D.D Saperstein, "Perturbation of the IR absorption spectra of aromatic adsorbates in Microporous carbons by the Christiansen effect" J. Phys. Chem., Vol. 91, pp 6659-6665, 1987
[8] Hoffmann, H.J. and Steinhar, "Determination of glass in homogeneities from the spectral transmittance of Christiansen filters", Glass Sci. Techn., vol.71, 319-322, 1998.
[9] G. L. Fischer, W. Boyd and T. R. Moore., "Nonlinear-optical Christiansen filter as an optical power limiter", Optics Letter, Vol. 21, pp.1643-45, 1996
[10] M. Trohr, K. Roth and B. Jahne, "Measurement of 3D pore-scale flow in index match porous media", Experiments in Fluids, vol. 35, pp. 159-166,2003
[11] W. P. Arnott, Y. Dong and J. Hallett, "Extinction efficiency in the infrared (2–18 μm) of laboratory ice clouds: observations of scattering minima in the Christiansen bands of ice" Appl. Opt., 34, pp. 541-551, 1995
[12] K. Okoshi, N Sano, T.O., A. Tagaya., J. M., Y. Koike, M.F. and J. Watanaba, "The Christiansen effect of brightly colored colloidal dispersion with an amphiphilic polymer", J Colliod Interface Sci. , Vol.263 **,** pp.473-477, 2003.
[13] J P Lenney, Goddard, Morley, Snook and Fielden"An electro-osmotic flow system with integrated planar optical waveguide sensing", Sensors and actuators B, Vol. 39, pp. 212-217, 1997.
[14] R.Mahanta,C Siam,M. Konwar and G D Baruah, " The role of diffusion on the chromatic pattern associated with the Christiansen effect" Indian J. of Phys, Vol.79, pp1065-1068, 2005.
[15] R.Mahanta,C. Gogoi and G D Baruah, "Understanding rate of diffusion between two liquids in a Christiansen cell in terms of time evolution of diffraction halos", IJIRSET , Vol.6, pp 23081-86 December, 2017



doi crossref
10.22214/IJRASET

INDEX COPERNICUS
45.98

ISRA JIF
IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY