# Studies of Christiansen effect on powdered glass using laser

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An experiment to demonstrate Christiansen effect is performed with irregular fragments of glass with He-Ne laser. Fifty colour photographs have been obtained using benzene, xylene and accetone as liquids under which the glass is immersed. Experiments have also been performed with spherical particles. This effect was demonstrated in 1884 by Christiansen who used powdered glass and put them inside a flat sided cell which is then filled with liquid and the refractive index of the latter was adjusted suitably by varying its composition. Beautiful chromatic effects are observed when the refractive index of the liquid is thus brought into coincidence with that of the powder for some chosen wavelength of the specutrum. This effect has been performed by laser light and photographs have been obtained on colour films for the first time. During the course of the experiments it has been observed that the cell becomes opaque for a restricted region of the cell in the vicinity where the surfaces of the two liquids meet. The cell becomes again selectively illuminated when the laser beam is incident at the boundary separating the two liquids. 

## I Introduction

When an optically isotropic solid like glass is powdered and put inside a flat sided cell which is then filled with a liquid and the refractive index of the latter is adjusted suitably by varying its composition or altering its temperature, beautiful chromatic effects are observed when the refractive index of the liquid brought into coincidence of that of the powder for some chosen wavelengths in the spectrum. The cell becomes transparent for a restricted region of the spectrum in the vicinity of that wavelength while the rest of the incident light passing through the cell is diffused out in various directions and appears as a halo surrounding the light source. This is known as the Christiansen effect observed by Christiansen in 1884. The effect has lot of practical uses. Lord Rayleigh made a passing suggestion to explain the observations of Christiansen. But it was Raman and co-workers[1-6] who gave adequate explanations to Christiansen effect through a series of papers published during early fifties. Raman and co-workers gave comprehensive explanation of the observed facts. The theory which Raman advances leans heavily on the concept of wavefront corrugation and in many respects similar to the earlier work by Ramachandran on clouds [7-9]. In the practical use of a so-called Christiansen filter, it is necessary, among other things by suitable methods to separate the light regularly transmitted by the filter from that diffused or scattered by it. If the particles are very large, the diffracted light would appear in directions very close to that of the regularly transmitted light, and its separation from the latter would be difficult. If on the other hand the particles are very small, the spectral width of the transmission would itself be greatly increased. Experiments to demonstrate the Christiansen effect are usually performed with irregular fragments of glass. With spherical particles one expects even more spectacular effects[2]. In one of the experiments Raman and Ramascshan[3] used two liquids acetone and carbondisulphide which have refractive indices respectively lower and higher than the glass for the whole range of visible spectrum. Hence, when a cell of one centimeter thickness containing the spherules is filled up with either one or the other liquid, the medium is incapable of regularly transmitting an incident light beam. When the spherules are surrounded by a liquid of lower index, the cell presents a brilliant sparkling appearance, due evidently to the emergence of light beams of considerable intensity from localized areas on its surface. The addition of a little carbondisulphide, though insufficient to render the cell transparent to any part of the spectrum, enhances the sparkling effect and make it more attractive by reason of play of colours similar to the "fire" of a dimond. On the other hand, when the liquid surrounding the spherules has a higher refractive index, these effects are not observed. The difference between the two cases, as well as the intermediate stages in which the cell is transparent to particular regions of spectrum can all be simultaneously observed by pouring enough carbondisulphide to fill the lower half of the cell and then adding acetone to fill the upper half. Raman and

Ramaseshan[3] also investigated the effect of distant monochromatic point source on a single spherule immersed in a liquid. It is worthwhile to note that when they investigated the effect, facilities for colour photography was not available. After Raman and co-workers not enough works have been carried out during last several decades on Christiansen effect. However works related to the application of this effect can be found in recent literatures[10-12]. These works are primarily related to the observation of the scattering media in Christiansen bands of ice crystals.

In the present work we are concerned with the observations of the Christiansen effect on irregular fragments of glass immersed in liquids of different densities and refractive indices using a 5 mW He-Ne laser source with wavelength at 6328Å

## 2 Experimental Setup

We have used the experimental set up similar to that used by Raman and coworkers[1-6] but the source of light in the present case is a 5 mW He-Ne laser of wavelength 6328 Å (red light). The glass fragments prepared are of different sizes. We have also used glass spherules of size 2 mm in diameter. In one set up the samples are immersed in sodium thiosulphate solution and a small drop of dilute sulphuric acid is added to produce minute particles of sulpher. The cell used is a test tube of diameter 2 cm and length 12 cm. The following table shows the nature of the samples and the type of liquids used in the present work.

| Sample | Liquids used |
|---|---|
| (a) Powdered glass | Acetone, Benzene |
| (b) Irregular fragment of glass size ~1 mm | Benzene, Xylene |
| (c) Irregular fragment of glass size ~2 mm | Benzene, Xylene, Acetone |
| (d) Glass spherules | Water Sodium thiosulphate solution |

The experiment has been carried out in a dark room. Light from the laser source is allowed to fall on the cell containing the glass samples immersed in the liquids. The test tube was illuminated non-uniformly. But depending on the angle of incidence the transmitted light indicates different degrees of illumination. It is interesting to note that there are regions of darkness and as well as brightness in the cell containing the samples. Photographs have been taken with the help of a camera using 35mm colour films. A large number of photographs have been taken for different illuminations. They are exhibited in Fig1. It must be emphasized that we have used only the monochromatic red light (6328Å) and the effect of this light on the phenomenon is clearly visible. There are several factors which we have to take into consideration for a proper explanation of the phenomenon. These include (a) refractive indices of the liquids, (b) size of the glass, (c) total internal reflection from the surface of the liquid or from the boundary separating the two liquids. In the case of the powdered glass in sodium thiosulphate solution gradual change of illumination can be easily seen when a drop of dilute sulphuric acid is added. This is presumbaly due to the formation of sulpher particles.

## 3 Discussion

The experimental set up and the manner in which they are observed need to be described adequately before a suitable explanation is presented. It is understood that the present observations are a part of the Christiansen effect, but with difference. We have observed that a broad band is observed at the boundary

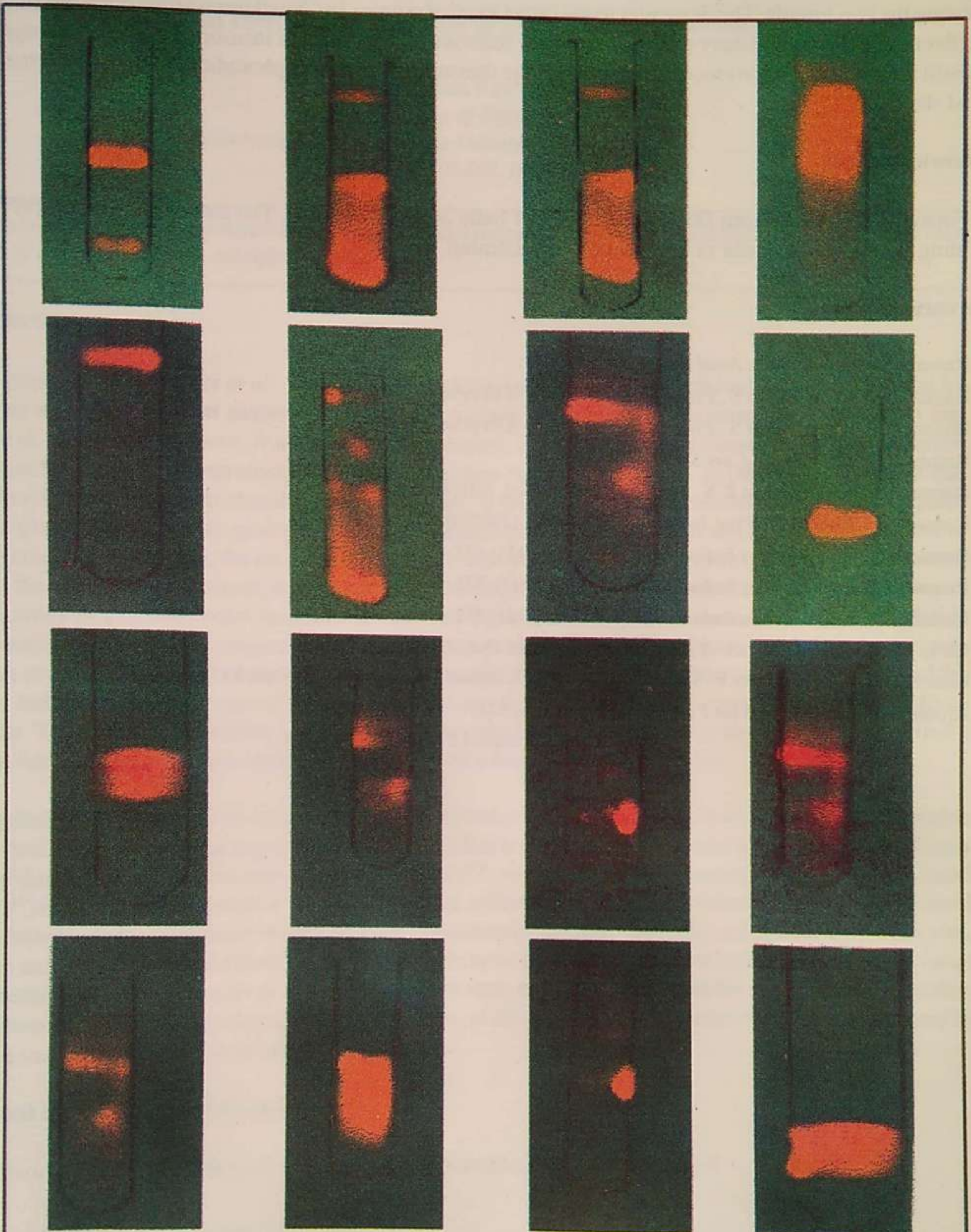

Fig 1 Photographs of Christiansen effect using He-Ne Laser at 6328 Å
with powdered glass immersed in different liquids.

separating the two liquids. This is similar to the broad band of colours in Christianscn effect observed in white light. Because of the preliminary nature of the study there are uncertainties in measurements. Future improvement will include the measurement of intensity of the transmitted light with photodiodes and measurement of optical depths.

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