

Optical and Acoustic Detection of Ball Lightning

THE recent controversy about ball lightning¹⁻⁴ stimulates me to report an observation of such an event, which occurred in September 1963.

This event occurred at approximately 11 a.m. in the entrance hall of the Plöckenhaus, a restaurant below the Plöckenpass in the Carnic Alps (Austria). Students from a field trip of the Geology Department of the Universität Heidelberg were staying inside this restaurant because of a thunderstorm with heavy rain. Some of the students were sitting in the guest room and some were standing in the entrance hall. The outside doors of the house were open. The door between the guest room and the entrance hall was, as I remember, closed. The floor of the entrance hall consists of heavy limestone plates. Also in the entrance hall was a St Bernard dog, lying on the floor.

Suddenly, through the open outside doors, a whitish yellow ball appeared just above the floor. It was slightly larger than a tennis ball, and its speed was about that of a walking person. The light ball moved about 2 m in the direction of the dog and finally exploded with a loud bang, like a gun shot. The dog jumped away as it saw the moving light ball. All the people in the entrance hall (about five) saw the ball and heard the bang. People from the guest room came out to ask what happened, because they had heard the bang. I do not remember feeling any radiation heat from the bang, nor smelling anything after the explosion. We, the bystanders, explained this event as a "Kugelblitz" (ball lightning).

The optical observation by several people, the reaction of the dog, and the acoustic perception of the people in the adjacent room are hard to explain by the optical illusion hypothesis for ball lightning.

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¹ Argyle, E., *Nature*, **230**, 179 (1971).

² Jennison, R. C., *Nature*, **230**, 576 (1971).

³ Charman, W. N., *Nature*, **230**, 576 (1971).

⁴ Davies, P. C. W., *Nature*, **230**, 576 (1971).

On Fireballs

THE recent discussions on fireballs prompt me to put on record that a few years ago I saw one when staying at a villa near Malcesine on the east shore of Lake Garda in Italy.

A bad thunderstorm had been raging and, because I still harbour a childish phobia about looking at lightning, I had not been looking out of the window. But as the storm slackened and was passing away, I did look out and saw a brilliant ball of white fire "sitting" still on one of the pylons carrying power lines along the east side of Garda, only a few hundred yards from our villa. It sat on one of the horizontal cable bearing cross-beams, and its diameter was less than the vertical distance between the cross-beams. There could be no question of my, or my friends, seeing an after-image of lightning, particularly as I never look at lightning myself.

We looked at the fireball for some time, but as it did nothing but sit still, we lost interest; when we looked out later, it had disappeared.

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BIOLOGICAL SCIENCES

Crystal Structure of the Visual Chromophores, 11-*cis* and all-*trans* Retinal

THE visual chromophores, 11-*cis* and all-*trans* retinal (Fig. 1), are present in both rod and cone cells of vertebrate retinas and in the corresponding organs of insects and crustacea¹. The isomerization of the 11-*cis* isomer to the *trans* form may be the only step in the visual process which is initiated by light; several succeeding changes in the visual pigment are known to occur in the dark^{2,3}. In spite of their importance in vision, the conformation of the chromophores have not been determined. Their three dimensional configurations in the crystalline state are presented in this communication.

Theoretical chemists have attempted to explain the stability and predict the structure of 11-*cis* retinal. Recent calculations predict a very slight difference in energy for the two isomers⁴⁻⁶, which is consistent with thermodynamic measurements⁷. However, the structural models proposed differ from the conformation found in the crystal*. In these calculations, bond distances and angles characteristic of *trans*-carotenoids were assumed, and various conformational possibilities were explored by varying torsional angles about bonds. The discussion below indicates that several small but significant distortions in bond angles may be critical in the folding process.

The collection of X-ray diffraction data requires a relatively stable crystal. Fortunately, crystals of the *cis* isomer are more stable than its solutions, which easily isomerize at room temperature. Preliminary attempts to collect data indicated that a special environment was needed. The four-circle goniostat of an automatic diffractometer was enclosed in a light-tight container maintained at 16-17° C and continuously purged with dry nitrogen. In this manner, it was possible to collect 2,345 integrated intensities from one freshly synthesized crystal over about 4.5 days. The data were corrected to compensate for a 20-25% downward drift in monitored intensities. A total of 2,995 independent reflexions was also collected from the *trans* isomer.

(The 11-*cis* isomer formed twinned crystals in space group P2₁/c with $a=7.540$, $b=10.666$, $c=22.102\text{Å}$, $\beta=95.19^\circ$, and four molecules/cell. The *trans* isomer crystallized in P2₁/n, with $a=14.961$, $b=8.279$, $c=15.316\text{Å}$, $\beta=104.87^\circ$, and four molecules/cell. Both isomers were crystallized from petroleum ether (Baker Analyzed Reagent, boiling point 36-37.5° C). Crystallization was initiated at 5° C and completed at -20° C. The *cis* isomer was synthesized when needed from commercially available *trans* retinal, using the methods of refs. 8 and 9.) The unit cell parameters found for the *trans* isomer agreed with those reported by Kuwabara *et al.*¹⁰.

Approximate positions for the carbon and oxygen atoms of the two isomers were established by the symbolic addition procedure¹¹. Refinement of the atomic positions and their apparent anisotropic thermal parameters was accomplished with standard least squares refinement programmes. For both isomers, the hydrogen atoms of the chain and most of the methyl hydrogens were located in difference maps. Based on cell data the agreement factors, that is the crystallographic R-factors, are at present 12.6% (11-*cis*) and 9.9% (*trans*). Further refinement and full hydrogen determinations seem feasible, and the final results, along with more crystallographic detail, will be published later.

The suggested three dimensional structures of the two retinals are presented in Fig. 1. The all-*trans* retinal chain is planar,

* Since our manuscript was prepared an article has appeared¹⁶ which does theoretically propose a ground-state configuration for 11-*cis* retinal, closely resembling that reported here. The torsional angles of the chain are predicted by Honig and Karplus, and these parameters effectively define the shape of the molecule. Their torsional angles are all within 11° of our experimental values.