

# Journal notes

## ■ Pale Orange to Bluest Blue

When the International Commission on Illumination adopted its colour metric in 1931 the possibility of calculating a numerically exact specification of certain aspects of colour reacted strongly on the imaginations of workers in many fields. It seemed to the present author, for instance, that it would be interesting to subject to calculation the question "How blue is a mountain?" and a paper entitled "On the Colours of Distant Objects" originally appeared in the 1935 *Transactions of the Royal Society of Canada*. The subject was not quite so academic as the above remarks might indicate because it was also found that this work obviated the need for a separate theory of the visual range of coloured objects.

During the years since 1935 a great deal of research has been done on the theory of the visual range and on the general effect of the atmosphere on light. The paper reported here has much the same content as the previous paper but uses the results of these later investigations to render the theory of the colours of distant objects more concise. It is difficult to summarize the results very briefly but in general it turns out that the apparent colour of a distant dark object in very clean air approaches that of the bluest blue sky. Increasing amounts of impurity in the air bring the resulting colour near to white. The apparent colour of a brightly illuminated snow field, on the other hand, is a pale orange almost exactly complementary to the colour of the sky.

These calculations have a natural application in camouflage studies and are also of some interest in the inverse problem of what colour to paint an object so that it will be most easily seen at a distance. W.E.K.M.

The Colours of Distant Objects. By W. E. K. Middleton. *J. Opt. Soc. Am.*, 40: 374, June, 1950.

## ■ Luminescent Counting

Statistical variations in a counting system which consists of a source, a luminescent crystal, and a photomultiplier are analysed in this paper by the method of the generating function. It is assumed that the source is constant for a fixed period of time, although it emits particles at random. For definiteness, and to provide a maximum degree of statistical variation, it is assumed as well that the source is a gamma emitter and that only a fraction of the gamma rays fall on the luminescent crystal and are absorbed.

As is to be expected, the results show that the effectiveness of the system depends upon the ability of the crystal to receive energy from the source. They also show that a measure of the effectiveness of the remainder of the system is provided by the number of photoelectrons emitted by the photocathode for each pulse of energy absorbed in the crystal. This quantity, which depends upon

the luminescent efficiency of the crystal, the geometry of the multiplier-crystal arrangement, and the efficiency of the photocathode, should be at least 5 for faithful counting of the radiation pulses absorbed in the crystal. The number of photoelectrons must be much larger than 5 for good statistical accuracy if the current from the photomultiplier is measured. The results of Schiff and Evans for the statistical variations in the voltage of a condenser which is charged with the pulses from the multiplier are generalized to cover the case in which the size of pulses varies. F.S.

On the Statistics of Luminescent Counter Systems. By Frederick Seitz and D. W. Mueller. *Phys. Rev.*, 78: 605, June 1, 1950.

## ■ - - escence

The luminescence of a phosphor is emitted in a spectral band whose identity is clear even in the presence of a complex structure. The luminescence is due to an activator element at low concentration. In some phosphors a second, distinct band appears when the concentration of the activator is changed. A decrease in its content intensifies and ultimately isolates the shorter waveband and suppresses the longer waveband.

An increase in temperature has been found to have the same effect. In five common phosphors activated with manganese, there is a minimum concentration at which only the shorter waveband appears. Increase in temperature has no effect upon its spectral position. As the concentration is raised above the minimum, a second band appears and becomes progressively intensified. This band is reduced and eventually suppressed by a rise in temperature, with isolation once more of the shorter waveband. The position of the latter remains constant, whether isolated by reduction in activator content or by increase in temperature. Three other phosphors showed the temperature effect only.

The two-band emission is probably due to the occurrence of the activator element in two different luminescence centers, as single ions and as pairs of associated ions. Either a decrease in activator content or an increase in temperature would favor dissociation of the ion pairs into single ions. The shorter waveband would accordingly be ascribed to the centers with single ions.

Although this is the most reasonable explanation for the effect, it can be accepted only after definite proof for the existence of two centers. A criterion would be furnished by careful measurements of the spectral distribution of the phosphorescence as compared with the fluorescence. If one of the two bands should decay more rapidly, this would constitute definite proof that there are two luminescence centers. G.R.F.

Dependence of Emission Spectra of Phosphors upon Activator Concentration and Temperature. By Gorton R. Fonda. *J. Opt. Soc. Am.*, 40: 347, June, 1950.

## ■ Nuclear Emulsions

Developments in the past decade have made possible the use of emulsions sensitive to particles in accurate nu-

clear experimentation. There exist nuclear emulsions which can detect electrons, mesons (several types of which were discovered through their use), protons, and heavier nuclei.

Since nuclear emulsions reveal the passage of the particle by means of the developed grains, they give a picture similar to that obtained with a cloud chamber. There are, however, important differences: the emulsion is continuously sensitive, requires no moving parts, and its high density, furthermore, makes for much greater sensitivity per unit volume. In consequence, it is ideally suited to situations in which time resolution is not required. Its high specific sensitivity makes the collection of track data rapid, thus simplifying the experimentalist's problem of keeping conditions constant during exposure. The emulsion technique has the obvious drawback associated with arduous microscopic analysis of the plates.

One application has been to measure neutron spectra by observing the tracks of proton recoils originating in the emulsion. Some investigations have been made of the high energy limit of the emulsions used in this manner. The investigation reported here attempts to determine the low energy limit on neutron spectra which can be studied quantitatively by means of this technique. The essential result is that Ilford type C2 emulsion can be used reliably down to 500 kilovolts and with reasonable precision down to 300 kilovolts if suitable corrections are applied. A reason for this limitation can be found in the small number of grains, less than five, rendered developable by lower energy recoil protons, and the probability that an intermediate grain can be missing and so make difficult the identification of a track.

It might be hoped that the low energy limit can be decreased somewhat by further reducing the developable grain size.

F.R.

Nuclear Emulsions and the Measurement of Low Energy Neutron Spectra. By N. Nereson and F. Reines. *Rev. Sci. Inst.*, 21: 534, June, 1950.

## ■ Geomagnetic Cosmic Ray Effects

For many years data have been collected on the intensity of cosmic rays at numerous places on the earth, both at sea level and at high altitudes. Experimentally the following four effects have been found and identified with the influence of the magnetic field of the earth; the latitude effect, the longitude effect, the east-west effect, and the azimuthal effect.

The latitude effect presented strong evidence that a majority of the energy in the primary cosmic rays is in charged particles with individual energies up to 17 billion electron volts (Bev); the longitude effect fitted in with the known eccentricity of the equivalent dipole field of the earth; the east-west effect gave evidence that positively charged particles predominated over negatives in the energy range 10 to 30 Bev; the azimuthal effect at intermediate latitudes gave further evidence on the ratio of negative to positive particles in the primary radiation.

Data taken recently in a B-29 airplane, flying at a constant pressure altitude of 30,000 feet from 64° geo-

magnetic north to the geomagnetic equator, combined with data taken on the azimuthal effect at various zenith angles at 36,000 feet above the equator, have now made it possible, with the help of calculations of Lemaitre, Vallarta, and others, to establish experimentally the dependence of the minimum momentum a charged particle must have to reach the earth at a given latitude in the east-west plane. This has been done for the vertical, at 45° east, and at 45° west. Such information is important particularly at intermediate latitudes where the detailed calculations have not in general been carried through.

The above correlations are possible only if the number of primary negative particles is negligible compared with the positives and is taken as strong evidence that negatively charged particles in the energy range here dealt with are entirely absent or produce negligible effects in the atmosphere.

H.V.N.

Correlation of Geomagnetic Cosmic-Ray Effects. By H. V. Neher. *Phys. Rev.*, 78: 674, June 15, 1950.

## ■ Polystyrene, Warm and Cool

This investigation represents an attempt to understand why noncrystalline rubber-like polymers suddenly lose their flexibility and become brittle when cooled to a particular temperature, and conversely why an amorphous plastic such as polystyrene when heated to a particular temperature suddenly becomes either flexible and rubbery or fluid.

Specific volumes and liquid viscosities were measured versus temperature for polystyrene of different chain lengths. The so-called second order transition was identified as the temperature  $T_g$  at which the thermal expansion coefficient changes abruptly. The viscosity-temperature coefficient furnished a measure of the internal mobility of the liquid polymer. The embrittlement of amorphous polymers below  $T_g$  is analogous to the formation of low molecular weight glasses. The mobility of segments of the polymer chains necessary for volume equilibration and elastic or viscous deformation decreases continuously with decreasing temperature as the configurational arrangement of nearest neighbor segments becomes more compact. This mobility becomes so small at  $T_g$  that the local liquid structure is kinetically frozen in. Decreasing the polymer chain length lowers  $T_g$  in proportion to the concentration of chain ends thus introduced; this is due to a disruption of the liquid structure by the chain ends.

The chief results emphasize the importance of the local configurational structure of the liquid polymer in determining its properties. No quantitative description of this structure is possible at present.

P.J.F.

Second-Order Transition Temperatures and Related Properties of Polystyrene. I. Influence of Molecular Weight. By Thomas G. Fox, Jr. and P. J. Flory. *J. Appl. Phys.*, 21: 581, June, 1950.

## ■ The Polystyrene Molecule

This paper is the report of an intensive study of the molecular properties of a typical high polymer, polysty-