Crystal Structure of 1, 3, 5-Triphenylbenzene

IN a recent communication on the crystal structure of 1, 3, 5-triphenylbenzene, Dr. Kathleen Lonsdale[1] discusses the results of recent X-ray measurements on the crystal and concludes that the planes of the benzene rings of the molecules cannot coincide with the (001) plane of the crystal, as has been suggested by earlier investigators, but must be inclined to this plane.

This conclusion is fully supported by the results of our magnetic measurements on this crystal, and the magnetic data further enable us to calculate approximately the inclinations of the benzene rings to the (001) plane. The crystal is orthorhombic and its principal gram molecular susceptibilities along a, b and c axes are :

$$\chi_a = -141\,;\ \chi_b = -155\,;\ \chi_c = -309$$

respectively, in 10^{-6} C.G.S. E.M.U.

The c axis is thus an axis of approximate magnetic symmetry, the susceptibility along this axis being numerically greater than that along perpendicular directions by 161×10^{-6} per gram molecule. Had the planes of all the benzene rings in the unit cell been coincident with the (001) plane, the difference between the susceptibilities along the c axis and along perpendicular directions would have been much higher, namely, 216×10^{-6} per gram molecule. This shows that the benzene rings are inclined to the (001) plane, the angle of inclination θ being given by the relation $\cos^2\theta - \frac{1}{2}\sin^2\theta = \frac{161}{216}$; that is, $\theta = 24°$.

The optical constants of the crystal also support the above orientation of the benzene rings. The gram molecular refractivities (defined as usual by $R = \frac{n^2-1}{n^2+2}\cdot\frac{M}{\rho}$) of the crystal for vibrations along the a, b and c axes are[2] :

$$R_a = 115{\cdot}5\,;\ R_b = 115{\cdot}0\,;\ R_c = 77{\cdot}6$$

respectively, for the D lines. R_a and R_b are thus nearly equal and much greater than R_c, as we should expect. If we assume all the benzene rings to lie in the (001) plane, and *neglect the mutual influence of the optical dipoles induced in the different benzene rings*, we obtain for the birefringence of the crystal

$$R_a - R_c = R_b - R_c = 65.$$

The much smaller birefringence actually observed for the crystal, namely, $R_a - R_c = R_b - R_c = 38$, points to an inclination of the benzene rings to the (001) plane, at an angle θ determined, as in the magnetic case, by the equation

$$\cos^2\theta - \tfrac{1}{2}\sin^2\theta = \frac{38}{65}, \text{ or } \theta = 32°.$$

Since the mutual influence of the dipoles is by no means negligible as we have assumed in the calculation, this value of θ must be taken to represent only the *order of magnitude*, and is therefore not inconsistent with $\theta = 24°$ obtained from the magnetic data.

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[1] NATURE, 133, 67, Jan. 13, 1934.
[2] Groth, *Chem. Krist.*, 5, 342.

Production of Heat in Supraconductors by Alternating Currents

IT has frequently been suggested[1] that supraconductivity is a phenomenon not due to the normal electrons which cause ordinary electrical conductivity, but that one may have to take into account supraconducting electrons as opposed to the ordinary electrons. Such a hypothesis would seem to be in accord with the observed fact that there is no discontinuity in the heat-conductivity at the transition point[2]. In this case the following method would seem to enable one to determine the number of supraconducting electrons.

If the electrons taking part in the ordinary conduction above the transition point preserve their properties below it, their damping, characterised by the specific electrical conductivity σ, would presumably not vary appreciably. This cannot be observed with direct current, since the supraconducting electrons prevent one applying the electrical field. With an alternating current of sufficiently high frequency, however, this screening effect is not complete on account of the inertia of the electrons ; one might therefore expect an alternating current to produce motion of the normal conducting electrons with a consequent production of heat. By measuring this heat, it should therefore be possible to demonstrate the existence of these normal electrons and prove whether their general properties change at the transition point.

For ordinary electrons the relation between the current density $\mathbf{J}$ and the strength of electric field $\mathbf{E}$ is :

$$\mathbf{J} = \sigma\mathbf{E}$$

If we take into account the existence of the supraconducting electrons, we must because of their inertia replace this equation by :

$$\dot{\mathbf{J}} = \frac{1}{\Lambda}\mathbf{E} + \sigma\mathbf{E} \qquad (1)$$

where the inertia term

$$\Lambda = m/ne^2 \qquad (2)$$

depends, apart from universal constants, only upon the number n of electrons per cubic centimetre.

If we calculate the distribution of an alternating current in a supraconductor according to formula (1), we find that the current flows near the surface in a layer of finite thickness d. Considering in the first place not too high frequencies ν, such that $\sigma\Lambda\nu \ll 1$, and neglecting terms of second and higher powers in $\sigma\Lambda\nu$ (and the influence of the displacement current) we find :

$$d = \sqrt{\Lambda c^2/4\pi} \qquad (3)$$

In this approximation the thickness is therefore independent of the second term in (1), that is, the term taking account of the normal electrons, and is also independent of the frequency[3].

This term is important, however, for the production of heat. While with direct current only the magnetic field $\mathbf{H}$ occurs in the layer, with alternating current an electric field $\mathbf{E}$ appears which is given by Maxwell's equation $\text{curl}\,\mathbf{E} = -\frac{\mu}{c}\dot{\mathbf{H}}$. It is this which gives rise to the heat.

The amount of heat Q produced per unit volume