

comparison with theory. We wish to direct the attention of the experimentalists to this important problem.

MAX BORN  
HERBERT SYDNEY GREEN

Department of Mathematical Physics,  
University, Edinburgh.  
March 17.

- <sup>1</sup> Born, M., and Green, H. S., *Nature*, **159**, 251 (1947).  
<sup>2</sup> Landau, L., *J. Phys.*, **5**, 71 (1941).  
<sup>3</sup> v. Neumann, J., "Math. Grundl. d. Quantenmechanik" (Springer, Berlin, 1932), chapter 4.  
<sup>4</sup> Dirac, P. A. M., "The Principles of Quantum Mechanics" (Oxford Univ. Press, 1935), § 37.  
<sup>5</sup> Husimi, K., *Proc. Phys.-Math. Soc. Japan*, iii, **22**, 264 (1946).  
<sup>6</sup> Keesom, W. H., and Taconis, K. W., *Physica*, **5**, 270 (1939).  
<sup>7</sup> Reekie, J., *Proc. Camb. Phil. Soc.*, **36**, 236 (1940).

It occurred to me some time ago that the phenomenon of superfluidity might be qualitatively understood on the basis of the concept of de Broglie waves in analogy to the Ramsauer effect. At sufficiently low temperatures and consequently very small thermal velocities, the de Broglie wave-lengths of the atoms ought to become large compared with the atomic dimensions; thus the collision cross-sections of the atoms must become very small, and hence all those phenomena which are due to atomic collisions should become insignificant. Consequently, if a substance can exist in the 'liquid state' at all at such a low temperature, it will have a vanishingly small viscosity. I have pointed out this idea in discussions and lectures on the subject in the past, but did not think fit to publish it without a proper quantum-mechanical treatment. It is very satisfactory that this has now been done by Born and Green quite independently, and that the result of their theory essentially confirms the qualitative picture outlined above.

R. FÜRTH

Birkbeck College,  
University of London.

### Infra-Red and Raman Spectrum of Cyclo-octatetraene

As part of work on the structure and properties of cyclo-octatetraene, we have recently measured the infra-red spectrum between  $2\ \mu$  and  $20\ \mu$  of the liquid and vapour and the Raman spectrum of the liquid. The sample was prepared specially for this purpose, and purified by repeated re-crystallization. The infra-red spectra were measured with single- and double-beam recording spectrometers using prisms of rock salt, fluorite and potassium bromide. The Raman spectrum was excited with the mercury line  $5461\ \text{Å}$ , which lies to the long wave-length side of the onset of absorption, and photographed with a spectrograph having a large glass prism giving high resolution and medium dispersion.

The following Raman displacements were found ( $\text{cm}^{-1}$ ): 193(9), 294(4), 372(7), ? 488(0), 874(8), 950(5), 1205(5), 1440(2), 1655(10), 1740(1), 2950(5), 3003(10).

The infra-red bands found with the liquid were as follows ( $\text{cm}^{-1}$ ): 675(v.s.), 762(w.), 802(v.s.), 849(v.w.), 875(v.w.), 890(v.w.), 913(v.w.), 944(s.), 968(m.), 993(w.), 1033(w.), 1098(v.w.), 1140(v.w.), 1208(m.), 1228(m.), 1405(m.), 1580(m.), 1642(s.), 1734(m.), 1754(m.), 1789(w.), 1879(w.), 1922(w.), 2008(v.w.), 2340(v.w.), 2749(v.w.), 2789(v.w.), 2834(w.), 2970(m.), 3009(v.s.), 3281(v.w.).

With the vapour, at temperatures up to about  $80^\circ\text{C}$ ., some of the bands showed a well-defined contour. Thus the intense liquid bands at 802 and  $675\ \text{cm}^{-1}$  each split into a three-branch type at 793, 802,  $813\ \text{cm}^{-1}$  and 659, 670 and  $681\ \text{cm}^{-1}$ . The liquid bands at 944 and  $968\ \text{cm}^{-1}$  also showed contour which seems to be of the same type; but the branches overlap and the exact position of the sub-maxima observed may not be directly useful. Each of the bands at 1208,  $1228\ \text{cm}^{-1}$  found with the liquid appears to show contour, but overlapping again obscures it. Near  $3\ \mu$ , bands were found with the vapour at 2745(v.w.), 2834(w.), 2970(m.) and 3019(v.s.).

It is hoped to carry out a normal co-ordinate treatment of the results, and a complete discussion is therefore postponed; but the following comments may be made. First, while the Raman intervals obtained agree well with those recently reported by Lippincott and Lord, we have been unable to observe many of the weak displacements listed by these authors. It is peculiar that we failed to observe their fairly strong Raman interval of  $249\ \text{cm}^{-1}$ ; but as regards the remaining weak lines given by them it is possible that our exciting radiation was not intense enough to make them noticeable, in spite of repeated trials. On the other hand, it is possible that some of the weaker lines reported by them were due to residual impurities, but against this it is noteworthy that at least some of the intervals correspond to infra-red bands observed by us.

It is quite certain that a number of 'coincidences' between the Raman and infra-red spectra of the liquid occur. Unless the selection rules break down with the liquid, this would preclude the presence of a centre of symmetry. Other factors likely to indicate the exact selection rules which operate are less obvious. We have considered the results in terms of the structures  $D_{2d}$ ,  $D_{8h}$ ,  $D_{4h}$ ,  $D_4$  and  $D_{4d}$ , and while no clear decision seems possible, are inclined to think that they are in best agreement with the non-planar cradle type  $D_{2d}$  structure.

The solid polymer formed from cyclo-octatetraene on standing has also been examined in the infra-red. The presence of strong bands near  $10\ \mu$  and  $3\ \mu$  suggests that it contains hydroxyl groups.

M. ST. C. FLETT

Research Laboratories,  
Imperial Chemical Industries, Limited,  
Hexagon House,  
Manchester, 9.

W. T. CAVE  
E. E. VAGO  
H. W. THOMPSON

Physical Chemistry Department,  
University, Oxford.

### Infra-Red Spectrum of $C_nD_{2n+2}$ and the 'Long-Chain Frequency' in Paraffins

THE most characteristic feature in the infra-red spectrum of any long-chain paraffin ( $C_nH_{2n+2}$ ) is a strong band near  $14\ \mu$  ( $725\ \text{cm}^{-1}$ ). It was first noted by Coblenz<sup>1</sup>, but Lecomte<sup>2</sup> and many other workers have directed attention to it, while an extensive investigation of hydrocarbons at Oxford and Cambridge<sup>3</sup> during the War showed that any molecule containing the group  $-(CH_2)_n-CH_3$ , in which  $n$  is equal to or greater than 3, possesses this band. So far as we are aware, no satisfactory interpretation of