Half Quanta.

THE Wilson-Sommerfeld principle when applied to the case of a rotating molecule, supposed rigid, leads to the expression $mh/2\pi$ (m integral, h Planck's constant) for the angular momentum of the molecule, and on this basis, with the help of several other assumptions, it has been found possible to account very satisfactorily for the main features of the structure of band-series. The theory is found to apply not only to ordinary bands in the region of the visible spectrum but also to absorption bands of very different appearance, such as those due to the halogen acids which occur in the infra-red. In the latter case, however, a discrepancy exists which has given rise to a good deal of discussion. The observed bands consist of a number of lines distributed, to a first approximation, according to the formula

$$\nu = \nu_0 \pm m\omega,$$

where m takes successive positive integral values and ω is a constant. The line of wave-number ν_0 (*i.e.* $m=0$) is invariably absent.

The theoretical expression, on the other hand, is of the form

$$\nu = \nu_0 \pm (m - 1/2)\omega,$$

which, it will be noted, represents a similar set of lines displaced through a distance $\omega/2$. The reality of the discrepancy is therefore dependent upon the correct identification of ν_0 , and as this is not entirely beyond question some workers have preferred to take the value indicated by the theory, although by doing so fresh difficulties in the interpretation of the results arise. Einstein, however, pointed out (quoted by Reiche, *Zeitschr. f. Phys.*, 1920, p. 283) that theory and observation would agree if instead of the usual value $mh/2\pi$ for the angular momentum one assumed it to be given by $(m+1/2)h/2\pi$. The evidence from the infra-red absorption bands seems scarcely strong enough to warrant such a revolutionary change, but other data bearing on the question have recently become available. In the band spectrum of helium, for example, series exist which show this same peculiarity, and here its existence is indubitable, for the normal (*i.e.* theoretical) series are in this case also present, and a trustworthy value for ν_0 can be determined from them.

Following up Einstein's suggestion, I have found that the abnormal series may in all cases be very simply derived from the normal group by displacing the quantum number by one-half. As an illustration of the sort of agreement which is obtained I may cite the case of the $\lambda 5730$ band (see Curtis, *Roy. Soc. Proc.*, 101, 1922, p. 38), which consists of six series, only three of which satisfy completely the theoretical requirements. The "half-quantum series" calculated from these three are as follows:—

$$\begin{aligned} 17436.6 - 31.5m + 0.95m^2 \\ 17436.6 + 31.5m + 0.95m^2 \\ 17436.6 + 0.95m + 0.95m^2 \end{aligned}$$

The remaining three observed series are represented by the formulæ:—

$$\begin{aligned} 17437.3 - 30.0m + 0.87m^2 \\ 17436.8 + 29.5m + 1.09m^2 \\ 17437.3 + 1.15m + 0.87m^2 \end{aligned}$$

The correspondence is very close, having regard to the approximate character of the formulæ upon which the calculation is based. It is certainly good enough to justify the proceeding as an empirical method of expressing the relationship between the two groups and to encourage theoretical inquiry into its physical significance.

As the matter stands at present, the inference—

illusory though it may be—is that the molecules fall into two classes, according to whether their angular momenta are given by $mh/2\pi$ or by $(m+1/2)h/2\pi$. Transitions between the two classes do not occur (or, if they do, give rise to no radiation), since there are no lines corresponding to changes of one-half in the quantum number. That is to say, whether or no the half-quantum may be involved in the determination of the possible states of a molecule, it does not appear to play any direct part in the radiation process.

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Fossils in Burmese Amber.

AMBER mines have long been known in Upper Burma, or rather in the adjacent "unadministered tracts." In 1916 Mr. R. C. J. Swinhoe, of Mandalay, began to send me specimens of Burmese amber (Burmite) containing insects. As opportunity has offered, he has continued to obtain such material, all of which has been transmitted, after investigation, to the British Museum (Natural History). Up to the present time I have been able to describe 38 species of insects, three arachnids and one diplopod. Many other species, which I did not feel competent to deal with, or which could not be seen properly, exist in the amber, and will, I hope, eventually be described by others. On the whole, the fauna is very remarkable, containing a large preponderance of types which are usually considered primitive. The amber was said to come from Miocene clay, in which, however, it was presumably of secondary origin. Judging from the fossils, I suggested as early as 1917 that the amber might be actually very much older than Miocene, conceivably even Upper Cretaceous (*Amer. Journ. Sci.*, Nov. 1917, p. 360).

Recently, information has been received which tends to confirm the suspicion that the amber is much older than Miocene. Dr. F. A. Bather of the British Museum has kindly transmitted a letter from Dr. E. H. Pascoe, Director of the Geological Survey of India, dated July 20, 1921. Dr. Pascoe states that Dr. M. Stuart, in his recent journey down the Hukong Valley, saw something of the amber mines, and reported that the shafts were sunk in beds which appeared to be identical with the Tipam sandstone or the Irrawaddy series. Whether they passed through into underlying rocks could not be determined, but from the evidence obtained by Noetting and others it seemed probable that they frequently did. The Tipam sandstone is unconformable on the underlying beds, and frequently contains fragments of them in its lowest horizons. Such fragments may very well include lumps of amber derived from the underlying clays. Dr. Pascoe continues: "Among the debris of some pits sunk into these clays, which are the true home of the amber, Dr. Stuart found a fragment of chalky nummulitic limestone. The pits had been sunk into the clays, not to obtain amber, but flint from the chalky limestone lying in them. Dr. Stuart describes the clays as totally unlike any Disang beds that he had seen, and he is inclined to accept the view that they are Eocene in age. If it is possible to determine the species of the nummulate, I will let you know; but it is, of course, not certain that this nummulitic limestone occurs *in situ* within the clays."

On August 1, 1921, Dr. Pascoe wrote that Dr. Stuart thinks the nummulate is *Nummulites biarizensis* d'Arch., characteristic of the uppermost zone of the Lower Khirthar. The Khirthars correspond approximately, according to Mr. E. Vredenburg, to the Lutetian. The Lutetian represents the earlier part of the Middle Eocene, below the Bartonian.