Again, the Einstein-Bohr equation

$$h\nu = W_1 - W_2$$

can be written

$$h\nu = hf_1 - hf_2,$$

or more simply

$$\nu = f_1 - f_2,$$

which expresses clearly the beat or heterodyne character of the observable frequency ν derived from two unobserved or unobservable frequencies f_1, f_2 characteristic of the atom, due to the necessity of standing waves or ' repeat patterns ' of the electronic waves in their passage around the nucleus.

So, too, the Einstein transformation equation

$$T = (t - vx/c^2)/\sqrt{1 - v^2/c^2}$$

may refer to a particle moving with velocity v relatively to an observer. Now this equation, as de Broglie pointed out, involves another velocity u, which may be denoted by c^2/v and is greater than the velocity of light.

It may be thought of as a phase velocity, of which v may be shown to be the group velocity. In the case of a mass m, moving with velocity v, if we state

$$h\nu = mc^2$$
$$c^2 = uv$$
$$u = \lambda\nu$$

and multiply the left sides together, and the right sides, and equate, we have after cancelling

$$\lambda = h/mv.$$

This is the precise relation which Davisson and Germer, and G. P. Thomson, have shown to hold for an electron. Thus the frequencies of waves seem to be achieving a remarkably fundamental rôle, comparable with that of energy. Waves of what ? The key to the central tower of physics has yet to be found. No less obscure is the connexion between the two different types of electric charge and their attendant waves. The linkage between energy and time, which resembles that between p and q in Dirac's equations, also suggests a close relationship between energy and frequency.   A. S. Eve.

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A Cosmological Conjecture.

According to quantum mechanics, a harmonic oscillator of frequency ν has a lowest energy state the energy of which is $\frac{1}{2}h\nu$. When the electromagnetic field is treated, after Rayleigh and Jeans, and Debye, as an assemblage of independent harmonic oscillators, one of which is associated with each of the normal modes of vibration of the ether, this leads to the result that there is present in all space an infinite positive energy density. It is infinite because there is supposed to be no upper limit to the frequencies of possible normal modes.

According to Dirac's theory of the proton (*Proc. Roy. Soc.*, A, January 1930) there is an infinite negative energy density associated with an infinite number per unit volume of relativistic electrons in negative energy states. Moreover, since the electrons are handled as a wave phenomenon, for great negative energies the number of states in unit energy range presumably is the same function of the energy as the number of normal modes for the ether is of the frequency.

It is, therefore, a natural conjecture to suppose that these two infinite energy densities just cancel each other. If they do, it indicates a certain artificiality in our present theories and points to the possibility that radiation and the electromagnetic field may be assimilated into a unified theory which regards them, like the protons, as another aspect of the negative energy electrons. In such a theory, these two infinite energy densities would be balanced off at the outset and so would never appear.

We refrain from calling our conjecture a theory in deference to the views of Prof. H. E. Armstrong recently expressed in these columns.

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Unimolecular Films.

The changes of state occurring in unimolecular films were the subject of a recent investigation (Lyons and Rideal, *Proc. Roy. Soc.*, **124**, A, 322 ; 1929). It was concluded, following Müller (*Proc. Roy. Soc.*, **114**, A, 542 ; 1927), that the molecules in the film were generally tilted. The suggestion was made that in the solid films of long chain substances the tilt of the molecules and therefore their areas were determined by the interlocking of zigzag chains. Since these views have recently been criticised (Adam, *Proc. Roy. Soc.*, **126**, A, 526 ; 1930), owing partly to a misunderstanding, a recapitulation of them and the evidence in their favour seems desirable.

The hypothesis of interlocking chains applies to *solid* films. These may be considered as consisting of unimolecular ' crystalline ' sheets. The hypothesis requires that long chain substances with small asymmetric polar head groups should give such films (where the chains have lost their flexibility) with one of two limiting areas ; namely, 20·6 sq. A. and 26·2 sq. A. per molecule. Clearly, substances with bulky substituents in the chain and those containing the large disc-like aromatic nucleus cannot be used to test this suggestion.

The smaller area is given by a very large number of compounds, but the larger area, as is to be anticipated, is only obtained in a few instances, and its validity has been questioned on both the experimental and theoretical sides.

The results of Adam and ourselves on the amines and their hydrochlorides show that the films of these materials are more complex than was suspected previously. A more detailed investigation is now being made, the results of which will be published on completion of the work. However, it may be stated that the solid films of heptadecylamine have been obtained both with areas of 20·6 sq. A. per molecule and 26·2 sq. A. depending on the conditions. The amine hydrochlorides (with which most of Adam's work was carried out) have yielded as yet only areas of 20·5 sq. A. per molecule in agreement with his values. The variations in area seem to be due to a fundamental property of the system and may possibly be due to a dimorphism as for the ureas (v. inf.). The X-ray data on amine hydrochlorides (Bragg, Solvay Congress Rep., 1925, 36) show corresponding anomalies which were also attributed to polymorphism.

The criticism on the theoretical side was chiefly concerned with the properties of the ureas.

The long chain ureas give an area of 26·2 sq. A. per molecule below a certain temperature, above which they give 20·5 sq. A. It was suggested that the sharpness of the transition, which occurs over a very narrow temperature range, is inconsistent with the hypothesis of interlocking chains. We consider that this sharpness is to be expected, for probably the change is due to a true transition between two distinct crystalline states. This is an example of