Scattering of α-Particles by Light Atoms.

IN a letter to NATURE of Feb. 1, and in greater detail in the *Philosophical Magazine*, vol. 9, No. 56, February 1930, Prof. A. C. Banerji has discussed some wave mechanical calculations on the scattering of α-particles by light atoms. I should like to make some remarks on this problem, which I have treated in a paper to appear in the *Zeitschrift für Physik*.

The first remark refers to the choice of nuclear model. While Prof. Banerji has assumed a central field of force consisting of a repulsion proportional to the inverse cube of the distance to be added to the Coulomb field due to the nuclear charge, I have taken a model corresponding to that used by Gamow to explain the radioactive decay ; that is, for distances r larger than the 'radius' r_0 of the nucleus, the potential is supposed to be Coulombian and for $r < r_0$ a constant V_0. The scattering calculated by the mathematical method due to Born shows all the characteristic deviations from the normal Rutherford scattering, which have been traced experimentally by Bieler, Rutherford, and Chadwick.

We cannot expect that this very rough model should give quantitatively right results, but if we determine r_0 and V_0 so as to give the experimentally measured scattering for small angles, we obtain a first rough approximation to the potential in the nucleus. For aluminum we get for r_0 the value $2 \cdot 23 \times 10^{-13}$ cm., and for magnesium a somewhat smaller value, in agreement with the general increase of nuclear dimensions with atomic number. In contrast with this, Prof. Banerji, who also defines a 'radius' r_0, gets a larger value for magnesium than for aluminium. Besides, there is the difference that our r_0 does not depend on the velocity of the incident α-particle.

The above-mentioned scattering formulæ contains the velocity v of the α-particle and the scattering angle θ only in the connexion $v \sin \theta/2$; therefore if v and θ are varied so that $v \sin \theta/2$ is constant, the scattering will remain the same. This gives a very simple displacement rule, which allows us to calculate the scattering for every v and θ if the scattering is known for one value of v and all values of θ, or for one value of θ and all values of v.

It can be shown that this displacement rule, which seems to be in good agreement with experiments, holds for every nuclear potential of central symmetry if we confine ourselves to the first approximation of the Born method. That this is legitimate is not quite obvious, since the first approximation is not everywhere small compared with the zero approximation. For $r = 0$ the two approximations are, for example, of the same order of magnitude. Also Prof. Banerji confines himself to the first approximation of the Born method, and for his potential this approximation is even infinite in the origin.

The next problem is how to improve the very rough assumptions about the potential within the nucleus. For this purpose I have considered the following unclear model. Let r_0, r_1, r_2...r_n be a sequence of numbers so that $r_p > r_{p+1}$ ($p = 0$, 1, 2,...n). For $r > r_0$ the potential is again supposed to be Coulombian. Inside the shell $r_p > r > r_{p+1}$ it is supposed to have the constant value $V_p (p = 0, 1,...n)$. The Born method gives again a very simple expression for the scattering by this model. This expression contains the constants r_0, r_1...r_n and V_0, V_1....V_n. From the experimental scattering curves it will be easy to determine the constants V_p when the r_p's are arbitrarily given ; that is, we have a general method from the experimental data to determine the potential in the nucleus with any desired accuracy. The performance of this work demands, however, more accurate measurements than are yet at hand.

It should also be remarked that according to our formulæ the sensitivity of such determination of the nuclear potential will decrease for decreasing distances from the centre. Indeed, the influence of a change of the potential on the scattering result will vanish for distances very small compared with the de Broglie wave-length of the incident α-particle.

Added in Proof.—In the issue of *Die Naturwissenschaften* of Mar. 14, Mr. Th. Sexl has treated the problem of the scattering of α-particles from a point of view similar to that of Prof. Banerji. In addition, he has also considered the case of an attractive force, which varies with the inverse fourth and fifth power of the distance. The last case corresponds with the idea proposed by Debye and Hardmeier, that the anomalous scattering should be sought in the polarisation of the nucleus produced by the α-particle. As the agreement with the experimental results in none of the cases investigated by him is quite satisfactory, Mr. Sexl infers that a nuclear polarisation is insufficient to explain the results, and that some other effect must be looked for.

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        Feb. 21.

Electron Affinities of the Elements.

THE various attempts to find experimentally the electron affinities of the chemical elements have met so far with little success. Since such a determination would probably help in shedding light on chemical reactions and the formation of molecules, it is obviously important. Accordingly, a method is here outlined which enables one to say approximately which elements have a positive electron affinity, and also to predict the approximate position of whatever lines of the electron affinity spectrum occur.

By definition, the electron affinity of an atom is the ionisation potential of its negative ion, or the difference in energy between the normal state of the atom and the normal state of the ion. From the work of Bowen and Millikan and others on stripped atoms, many of the higher ionisation potentials are known. In the iso-electronic sequence Be^{++}, Li^+, He, H^-, the ionisation potentials of the first three are known, and so we may extrapolate to get that of the fourth. This would be our method of estimating the electron affinity of the hydrogen atom. In this case, one must make a long extrapolation (from $24 \cdot 47$ volts), and so the attainable accuracy is not extremely high. Assuming that the square root of the ionisation potential is linear in Z, the atomic number, which gives reasonable agreement with the experimental values, one finds the electron affinity of H to be $1 \cdot 4$ volts. Other methods of extrapolation may yield somewhat lower values. This is in agreement with theoretical work of Bethe (*Zeits. f. Phys.*, **57**, 815 ; 1929), who concluded that the electron affinity was greater than $0 \cdot 75$ volts.

If we examine the first row of the periodic table, then it seems almost necessarily to follow from any reasonable extrapolation that the electron affinity will show the following behaviour. For helium, it will be negative, indicating that He^- is not stable. For lithium, it will be greater, perhaps positive, to decrease again with beryllium, increasing to carbon, decreasing to nitrogen, and increasing to fluorine, where the value is about $3 \cdot 5$ volts. The second row shows a similar behaviour, the increases in both cases being linear.

The first excited states of H^-, 2^1S and 2^3S, lie close below the normal state of H, and the states 2^1P and 2^3P both lie above, tending to show that no discrete