Letters to the Editor

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Nuclear Structure

THE experimental evidence for the existence of the neutron has given added support to the view [1] that the nucleus may be composed of protons, neutrons, and α-particles. Heisenberg [2] has recently found it convenient to use a model with protons and neutrons only as the building-stones. In various papers, Aston [3] has determined the isotopic constitution of many of the chemical elements, but it has not been possible to say, from considerations of stability, just what isotopes may be expected to occur. The purpose of this note is to point out regularities for elements of low mass, and to suggest a possible building-up principle for such elements.

Starting with an α-particle, let us add alternately a neutron and a proton. The resulting nuclei are He 5, Li 6, Li 7, Be 8, Be 9, B 10, B 11, C 12, C 13, N 14, N 15, and O 16. With the exception of He 5, these, and only these, have been observed for this mass range. With O 16, this type of regularity ends, which might be interpreted as due to the formation of some sort of a closed shell. To a first approximation, let us suppose the mutual interaction of the added neutrons and protons to be small compared with their interaction with the α-particle. Then, when a neutron and a proton are added, the resulting field will still favour a neutron over a proton. If an analogy with the external electronic system subsists, then the α-particle may represent a closed *s*-shell, with two neutrons and two protons, while O 16 is obtained by adding on a closed *p*-shell, with six neutrons and six protons.

The continuation of this process is the addition of a *d*-shell, with ten neutrons and ten protons. The stability conditions appear to be different, two neutrons being more stable in the central field than a neutron and a proton. The order of addition is as follows : neutron, neutron, proton, proton, and repeat. This results in O 17, O 18, F 19, Ne 20, Ne 21, Ne 22, Na 23, Mg 24, Mg 25, Mg 26, Al 27, Si 28, Si 29, Si 30, P 31, S 32, S 33, S 34, Cl 35, and A 36. With A 36, this shell becomes closed. These nuclei, and only these, have been found for this mass range, just as in the previous case.

If n denotes the total number of neutrons and protons together, then, except for $n = 3$, 5, and possibly 8, there exists an isotope for every value of n below 36, according to the experimental evidence. We should expect this to be a general property, holding for values of n greater than 36, also. In the range $36 < n < 64$, several points are missing, namely $n = 38$, 42, 43, 46, 47, 49, and 57. The corresponding isotopes probably exist in small quantities, but until they are found, it is rather difficult to determine stability conditions for this mass range. However, simple considerations lead to a prediction of certain isotopes. Since the neutron number for $n = 37$, 39, and 40 is 20, it might be expected to be the same for $n = 38$, giving A 38. Similarly, one can predict V 49, Mn 53, and Co 57. In this range $36 < n < 64$, which may correspond to an *f*-shell being completed, all the isotopes, except Cr 53, have even neutron numbers. This is so striking that one wonders whether or not the isotope reported for $n = 53$ is really due to chromium.

The analogy with the external electronic structure seems to indicate that for large values of n, conditions may become quite complicated. The experimental evidence bears this out. More information seems to be needed, however, before stability questions in general can be settled. Whether or not the α-particle plays a fundamental part remains to be seen, but we can certainly disregard it for the lighter elements, and consider protons and neutrons as being the elementary constituents.

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Zurich, July 1.

[1] J. Chadwick, *Proc. Roy. Soc.*, A, 136, 705; 1932.
[2] W. Heisenberg, *Z. Phys.* (in print).
[3] F. W. Aston, *Proc. Roy. Soc.*, 1927–31.

Tidal Oscillations of Gravity

IN an earlier communication,[1] we reported the results of experiments to determine as exactly as possible the variations of gravity. We have now succeeded in increasing the accuracy and in eliminating the disturbances to such a degree that now the oscillations of gravity due to the attraction of the sun and the moon are directly perceptible in the photographic registrations. The arrangement of the apparatus is the same as stated in our previous letter.[2] The principal success was achieved by using the alloy *WT* 10 made by Krupp as material for the spiral spring. This material has an infinitesimal temperature coefficient of elasticity. By careful and repeated heating over a period of several months, it was also possible to reduce to a small factor the elastic after-effect. By this means the disturbances due to temperature are strongly suppressed, and also the uniform shift is very much diminished. The sensitiveness amounted

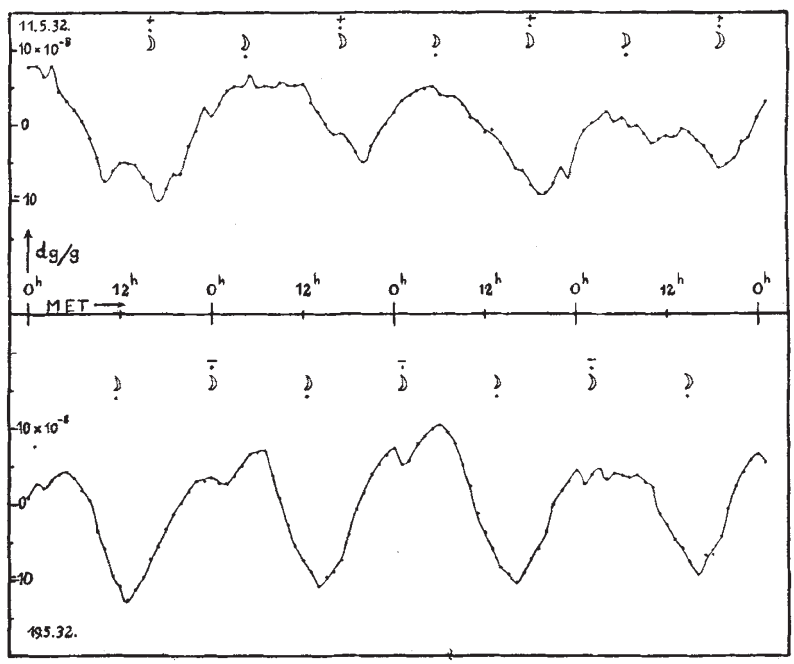

FIG. 1.