Letters to the Editor.

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The Excitation Potentials of Metallic Lithium.

A LARGE amount of work has been published on the excitation potentials of metals (the so-called excitation of soft X-rays). On account of the very great complexity, no precise correlation has been achieved between these experiments and the results of the theory of metal structure. But—especially in view of the scarcity of spectroscopic data on metals—it would seem that there should be, concealed in these results, information of fundamental importance for the theory of metals, if only we knew how to use them. The chief essential for any such use is to attain the utmost possible simplification, and thus, just as the theory of atoms was built up from results on hydrogen, one is led to the study of the excitation potentials of metallic lithium.

It happened that no experimental data on lithium metal exist. Experiments were therefore undertaken. The method used was similar to that of Richardson, with some refinements. The lithium metal was distilled on to a copper anode at a suitably high temperature to prevent so far as possible the condensation of impurities. The radiation from the lithium falls on a copper sphere and the photoelectric current which results is measured by an accurate balance method. Thus one can plot the intensity of the radiation from the lithium, as measured by the photoelectric current, against the voltage of the electrons producing it. A sudden increase in slope in this curve at a definite voltage indicates an excitation potential of metallic lithium.

The photoelectric current was found to start with a voltage of 6 volts. A further break was found at 9 volts. Then the curve runs quite smoothly, and finally almost linearly to 51·5 volts, where there is a very large break, in which the slope is immediately about doubled. A further smaller break occurs at 57·5 volts. Then again the curve runs quite smoothly and no breaks whatever are found so far as has been investigated (up to 400 volts).

Lithium metal consists of a lattice of nuclei each with two K-electrons; the outer electrons of the lithium atoms combine together to form the set of conduction states of the metal, which are known to have a voltage range of the order of 10 volts. It seems fairly safe to assume that the lower breaks obtained correspond to transitions among the conduction electron states.

There remains the K-radiation of the lithium metal, and one is forced to associate this with the breaks at 51·5 and 57·5 volts. By applying a voltage correction of the order of 2 volts, we may allow for the acceleration of the exciting electrons in passing through the surface field of the lattice and state that the minimum excitation potential for the K-radiation of lithium metal is about 53·5 volts.

On the analogy of ordinary hard X-rays, one might picture the excitation process as follows. An electron is ejected from a K-level either through the crystal surface or into one of the upper conduction levels, the deeper conduction levels being assumed to be filled up. The latter process requires the minimum energy. Then an electron may drop back into the empty K-level from any conduction level with the emission of radiation. Thus we might expect a K-spectrum extending over about 10 volts below the critical point; and since probably the emission process involving the least energy would be the most likely, we might suppose that the greatest intensity in the spectrum would be concentrated at the low energy end of the spectrum.

Some experiments on the velocity analysis of the photoelectrons, ejected from the copper by the radiation excited in the lithium by 300-volt electrons, did not confirm this picture. Though rendered slightly inconclusive by the considerable 'loss of velocity' effects which occur in the energy range of the lithium K-radiation, they indicated that the maximum intensity in the K-spectrum is concentrated near the excitation point, namely, at about 53 volts, and there appears to be some radiation up to 60 volts energy, though none beyond.

However this may be, an apparent difficulty certainly arises when we compare the value 53·5 volts of the critical potential with the value of the K-ionisation potential of the lithium atom which has been accurately calculated by Braunbek.[1] The value is 64·6 volts and thus there is a discrepancy of 11 volts to be accounted for. Any attempt to explain it as a perturbation of the K-level due to close packing is out of the question, as it would lead to the spontaneous explosion of the metal.

The low value obtained was therefore surprising and has led to great care being taken in the experiments to verify the result. The fact that the photoelectric current is always proportional to the primary current to the lithium shows that the observed excitation potential corresponds to a single process excitation.

To interpret the result, we must suppose that there are empty levels into which the K-electron can be transferred at the base of the conduction electron system, so that the K-electron does not have to be taken through the energy levels of the conduction electron system, but can stay in a level at the base of the conduction electron levels. In the unexcited state all such levels are certainly filled. But when a K-electron is removed, the state of affairs becomes radically changed owing to the altered screening of the nuclear charge. I am greatly indebted to Prof. Bohr for pointing out that this altered screening will in itself create new levels round an atom in the lithium lattice which will not be filled. The new levels will correspond to a smaller total energy than the normal conduction electron levels. Thus the K-electron can be excited into one of these new levels and a *resonance* radiation will be emitted just as would be the case with free atoms. This process, of course, does not preclude the excitation of K-radiation by ionisation.

We may add that experiments in progress with beryllium metal, though the results are not so simple as with lithium, lead to similar conclusions.

H. W. B. SKINNER.

H. H. Wills Physical Laboratory,
University, Bristol.

[1] *Zeit. f. Phys.*, **63**, p. 156.

Evidence for the Spin of the Photon from Light-Scattering.

IT is well known that in the encounters between molecules and photons, exchanges of energy occur which are rendered evident by the observed changes in frequency of the scattered light. Whenever in such an encounter a molecule gains or loses spin-energy, there is a corresponding change in its angular momentum, which can only be explained on the assumption that there is an equal and opposite change in the spin-moment of the photon. This involves definite consequences for the state of polarisation of the scattered