and be attainable by, changes in some of these without departure from the general program.

This paper surveys the geometric materials available for physical interpretation, the extent to which physical theory has so far been absorbed into that interpretation or superposed upon it. At several points it appears that there is some flexibility of choice possible in certain of these auxiliary postulates, in particular as concerned with the relation of optical and mechanical phenomena within material bodies, the phenomena of rotation, and the meaning of an electromagnetic field.

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Atomic Constants and Dimensional Invariants.

By A. C. Lunn.

It has been recognized for some time that the number of universal physical quantities revealed by experiment, but not yet utilized for the practical reduction of the system of arbitrary units, is more than sufficient to complete that reduction so as to give for every kind of measurement a natural unit. Since in most cases the measurements are not yet accurate enough for putting this reduction into effect it is convenient to retain consideration of those quantities as having dimensions corresponding to the scheme of units antecedent to such reduction. The redundancy means then that the excess quantities should be expressible in terms of the others, and several relations of this kind have been proposed. Equivalently, there must exist a number of dimensional invariants corresponding to this excess. On the one hand the recomputation of a suitable list of such invariants gives an impartial scheme for introducing improved values from measurement, and on the other a test of the scope of theory in a certain sense is found in the number of invariants whose values as deduced accord with experiment.

As illustration this paper lists seven quantities which can be considered as dimensioned in the familiar three-unit scheme and hence must have a fundamental system of four invariants, to which may be added the mass ratios of hydrogen and helium atoms to electron. The theories of Planck, Bohr, and Lewis and Adams in effect assign numerical values to three of these, and in this paper are shown certain tentative values for others enough to complete the list, so accurate in terms of present data as to suggest the possibility of deduction from theory, and such as to give in particular simple formulas for the action constant and constant of gravitation.

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Measurements of the Amount of Scattered Homogeneous X-rays of Wave-length 0.712 Å. per Gram of Carbon.

By C. W. Hewlett.

A narrow beam of x-rays from a molybdenum Coolidge tube excited at 30 k.v. was first passed through a zirconium filter and then allowed to fall on the scattering material. The radiation transmitted by the filter under this condition was nearly homogeneous, being almost entirely the α_1 radiation of the K series of molybdenum.

The scattering material was contained in a cylindrical capsule 0.47 cm. in diameter and was mounted on the axis of an x-ray spectrometer in such a way that it could be continuously rotated during the scattering measurements. The scattered radiation was received by an ionization chamber which was mounted to rotate about the spectrometer axis and about 36 cm. from the scattering material. The ionization current was measured by a quadrant electrometer. The width of the primary beam of x-rays was slightly greater than that of the capsule of scattering material, and its height was 2.40 cm.

The scattering of powdered artificial graphite, liquid mesitylene and diamond chips was measured between 2° and 158° from the incident beam. The amount of scattering material for graphite and mesitylene was about 0.35 gm., and for diamond about 0.79 gm.

The intensity of the incident beam and that of the scattered radiation was measured in the same units. The total absorption coefficient, and the total amount of radiation taken from the primary beam by the scattering material, was measured for graphite and mesitylene. The total scattered radiation was then calculated as a fraction of the total radiation taken from the primary beam, making an estimated allowance for the scattering in the 0.50 unit solid angle inaccessible to the ionization chamber, and for the absorption of the scattered radiation within the scattering material. It was assumed that the true mass absorption coefficient of diamond was the same as that determined for graphite and mesitylene and the mass scattering coefficients of all three were calculated with the following results:

Substance.	Density	True Mass Abs. Coeff.	Mass Scattering Coefficient.
Mesitylene	.863	.351	.184
Graphite	1.48	.351	.198
Diamond	3.51	.351	.234

The above results are probably not in error by as much as 10 per cent.

Thomson's theory of scattering gives for carbon a mass scattering coefficient of .200. This is based on the assumptions (*a*) that the electrons are small compared to the wave-length of the primary beam, and (*b*) that they scatter independently. This latter condition is very probably not satisfied in the scattering by carbon of wave-length 0.712 Å. The increase in the scattering coefficient with increasing density shown in the accompanying table is very probably due to the fact that as the atoms get closer together the electrons under the influence of the primary radiation vibrate more nearly in phase and consequently emit more scattered radiation.

The distribution of the scattering for graphite and diamond shows the maxima characteristic of the crystal structures of these materials. The actual amount of scattered radiation in the lines is however only a small per cent. of the total scattered radiation, a large part of it lying in between the maxima. Theory predicts a large intensity of scattering at very small angles from the primary beam, but these experiments show that the scattering approaches zero at these small angles. Determinations of the absorption coefficient in aluminum of the scattered radiation at fourteen angles about equally distributed in the region of investigation failed to show any difference in quality of the scattered and primary radiation.

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The Spectrum of Secondary X-rays.

By Arthur H. Compton.

An examination of the secondary rays excited in different materials when x-rays rendered nearly homogeneous by filtering were employed, showed that the secondary radiation was of a softer type than the primary rays which struck the radiator.[1] More recent experiments have shown that this phenomenon is not confined to heterogeneous x-rays, but occurs also when the rays incident upon the radiator have been reflected from a crystal.[2] The most obvious interpretation of these results was that in addition to scattered radiation there appeared in the secondary rays a type of fluorescent radiation, whose wave-length was nearly independent of the substance used as radiator, depending only upon the wave-length of the incident rays and the angle at which the secondary rays were examined.

In order to obtain more definite information with regard to the characteristics of the secondary x-radiation, a study has been made of the spectrum of the secondary rays excited in various substances by the x-rays from a Coolidge tube having a molybdenum target. A small piece of radiating material, such as celluloid or aluminium, placed in front of the first slit of the spectrometer, was illuminated by incident x-rays at approximately 90° with the secondary beam under investigation. The spectrum was studied by means of a calcite crystal grating, using both the ionization and photographic methods.

The spectra obtained show lines identical in wave-length with the primary K lines from molybdenum, thus proving that a part of the secondary radiation is truly scattered and unchanged in wave-length. In addition to these lines, a general radiation is observed which is more prominent in the secondary than in the primary beam. When the x-rays incident upon the radiator were unfiltered, the general secondary radiation had a broad intensity maximum at a wave-length slightly under 1 Å. U. On introducing a zirconium filter between the x-ray tube and the radiator, thus giving a primary beam consisting principally of the $K\alpha$ line from molybdenum together with some fluorescent K rays from zirconium, a much sharper maximum in the secondary fluorescent

[1] Phys. Rev., 18, 96 (1921).

[2] Nature, Nov. 17, 1921.