The Blue Flame produced by Common Salt on a Coal Fire.

THE blue flame produced by sprinkling salt on a glowing coal fire is a good example of common knowledge, which, not finding a niche and an explanation in text-books, becomes a recurrent topic of inquiry and discussion in scientific journals. It may perhaps be of interest if I add a historical note to what Prof. Merton has stated in *NATURE* of May 27, p. 683.

The blue flame in question appears to have been first treated from the spectroscopic standpoint by the late Dr. J. H. Gladstone in 1862 in a letter to the *Philosophical Magazine* (ser. iv., vol. 24, p. 417). Without being quite conclusive he seems to have regarded copper chloride as the source. The matter was raised again by an anonymous letter to *NATURE* in 1876 (vol. xiii. p. 287), and a discussion has recurred from time to time in these columns from that date until 1890. Full references to this are to be found in Kayser's "Handbuch der Spectroscopie," vol. v. p. 391. A communication to *NATURE* by T. N. Müller in 1876 (vol. xiii. p. 448) seems to have hit the mark. He recognised the flame as being like that of copper chloride, and, surmising that the source of the copper lay probably in the pyrites of the coal, found that the blue flame did not appear when salt was sprinkled on a glowing fire of charcoal. The matter was clinched by Salet in 1890 (*Comptes rend.* 110, p. 282), who identified the spectrum with that of copper chloride as carefully mapped by Lecoq de Boisbaudran, and he actually isolated metallic copper from the fuel ash.

The blue flame given by salt always seems to me distinguishable from that of carbon monoxide, and appears very bright by contrast with the yellow-red glow of the fire. It is somewhat surprising to see how far the yellow sodium flame is suppressed.

ARTHUR SMITHELLS.

The University, Leeds, May 28.

Optical Resolving Power and Definition.

IN *NATURE* of May 27, p. 678, Mr. A. Mallock suggests as a quantitative measure of "definition" in an optical instrument "the angular or linear size of the field of view compared with the smallest corresponding quantity which can be clearly distinguished," and proceeds to extend "definition" on an equivalent general basis to a number of other instruments.

Whether or not this proposal will serve a useful purpose in other directions need not be discussed here, but in the case of optical instruments the measure proposed will not commend itself to opticians, for it involves a radical change in the accepted meaning of "definition" in this connection. The suggestion in fact amounts to nothing more than the measurement of the angular field of view in terms of a unit which varies with the aperture of the lens and the wave-length of the light which is used, a proposal which surely carries its own condemnation in its enunciation. That the ratio in question is worthless as a measure of "definition" is obvious from the consideration that in many instruments, at say the centre of the field, the resolving power and the "definition"—that is the degree to which details of an object are clearly discernible in its image—may remain unaffected while the field of view is greatly changed by an alteration in the size of a suitably placed stop. Conversely in apparently similar instruments the "definition" may vary appreciably from one instrument to another while the field of view and the resolving power are alike in all cases.

The distinction between resolving power and definition is real but not easily defined in a few words. The former deals with the discernment of separate sources of such apparent minuteness that it cannot be claimed that the image indicates with any accuracy the shape of the source itself. The latter is concerned with the sharpness of the apparent image outline of larger objects. The former depends primarily on the dimensions of the first dark ring in the image of an apparently point source, and the conditions of observation require the range of wave-lengths of light forming the focussed image to be limited. The latter depends more upon the broad light distribution in the diffraction pattern than upon the alternations of light and darkness, and the range of wave-lengths is not an important factor. As the size of the rings is not greatly affected by small amounts of aberration, the resolving power is not a suitable measure of the correction of a lens system, but it is precisely upon the degree to which aberrations are removed that definition depends. Of two photographic lenses with the same resolving power, and the same field of view, one may give brilliant pictures because the definition is good and the other comparatively flat pictures because the definition is poor. To the user of simple instruments definition is of great importance, resolving power does not concern him.

This is not a suitable occasion on which to discuss the measurement of "definition" or the standards which are suitable for application to various types of instrument. The subject is one of great difficulty particularly in view of our ignorance of the extent to which it is possible to eliminate aberrations in systems of simple construction. Lest, however, readers of *NATURE* should be misled it cannot be too emphatically stated that in omitting from "definition" its most essential factor and substituting therefor an independent conception, Mr. Mallock's attempted generalisation is likely to prove only a cause of confusion to those who hope to measure the merits of optical instruments by its means.

T. SMITH.

The Difference between Series Spectra of Isotopes.

PROF. P. ZEEMAN mentioned to me recently some new measurements of the absorption spectrum of lithium which he undertook in order to prove the presence of both isotopes. It seems to me, that at the present time it is not certain what one should expect here theoretically. Bohr's formula for the change in the frequency ν due to the motion of the nucleus has been applied by him only to the cases in which a *single electron* moves around the nucleus; namely, to H and He^+ . Recently the formula has been also applied by various authors (see F. W. Aston, "Isotopes," p. 123—London 1922) to the calculation of the difference between series spectra of isotopes; this means to atoms in which *several electrons* move around the nucleus. So far as I know there are as yet no investigations on the equation which must for these cases replace Bohr's equation

$$\nu_2 : \nu_1 = \frac{M_2}{M_2 + m} : \frac{M_1}{M_1 + m} \quad \dots \quad (1)$$

(M_1 , M_2 , m are respectively the masses of the nuclei of the isotopes and of the electron; ν_1 , ν_2 are the frequencies of corresponding lines).

In the case of one electron only, (1) follows immediately from the well-known transformation of the "problem of two bodies" from absolute to relative co-ordinates (see, e.g., Whittaker, "Analytical

Dynamics," § 46). For several electrons there is no similar simple transformation. The "radiating" electron compels the remaining electrons to execute motions of reaction, which also influence the nucleus.

Probably it will be possible to derive a sufficiently approximate formula for the case of the p - and d -motions of lithium. This must be very difficult, however, for the case of the 1.5 S-path. The fact that at all events equation (1) cannot be true in general for atoms with several electrons will be shown by the following example (though of course on account of the Principle of Correspondence not representing a process really occurring in nature): two electrons move around the nucleus in a centrally symmetrical configuration, at first in a two-quantum and then in a one-quantum circle. By symmetry the nucleus remains continually at rest. In this case therefore the liberated energy and, consequently, the radiated ν would, contrary to (1), be exactly independent of the mass of the nucleus. P. EHRENFEST.

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I SHOULD like to add a few remarks to the interesting letter of Prof. Ehrenfest about the contents of which he was so kind to inform me before publication. As pointed out in his letter, the effect of the mass of the nucleus on the spectrum of an atom, containing more than one electron, is a complex problem which depends on the electronic arrangement in the states of the atom, involved in the emission of the lines, in a way which has hitherto not received sufficient attention. Not only may the mass effect disappear completely in such cases, where several electrons move round the nucleus in equivalent orbits, but, as indicated by Prof. Ehrenfest, this effect may also in case of the motions which we actually meet in the emission of the series spectra be different from that calculated for an atom with one electron.

Although in the emission of these spectra we are concerned with motions whereby a single electron moves in an orbit different in type from the orbits of the other electrons, the problem differs essentially from the problem of two bodies in celestial mechanics. Thus according to the picture of atomic constitution, outlined by the writer in two letters to NATURE (March 24, 1921, October 13, 1921), we shall assume that the electron connected with the emission of the series spectra, although during the larger part of the revolution it remains outside the configuration of the electrons in inner groups, it will nevertheless in certain states penetrate into the interior of the atom during its revolution. The fact that the electron in the inner loop of its orbit is subject to large forces is of preponderant influence as regards the fixation of the energy in the corresponding stationary states of the atom. For such a motion the effect of the nuclear mass might differ essentially from that estimated from an examination of the mechanical properties of the motion in the outer loop only, and the question arises, whether the mass effect is sufficiently large to account for the discrepancies, observed by Merton, in the wave-lengths of certain lines in the spectra of lead isotopes, which although very small are yet much larger than those to be expected from the simple formula quoted in Prof. Ehrenfest's letter.

Although this question seems difficult to settle without a closer investigation, it would scarcely appear probable that the answer will be affirmative. On the other hand, it cannot be excluded that the discrepancies in question are due to a slight difference in the field of force surrounding the nucleus, arising from the difference in the internal nuclear structure

of the lead isotopes. This possibility has been discussed from various sides. At first sight we meet with the difficulty, that the dimensions of the nucleus (ca. 3×10^{-12} cm.), estimated from experiments on the scattering of α -particles, are exceedingly small in comparison with the dimensions of the orbits of the electron responsible for the emission of the series spectra, which are of the order 10^{-8} cm. or larger.

This difficulty may disappear, however, by considering the circumstance mentioned above, that in certain states the series electron during a short interval of its revolution penetrates deeply into the interior of the atom. In fact, we must assume, that this electron in the states corresponding to the S-terms of the series spectra penetrates to even smaller distances from the nucleus than the electrons in the innermost group of the atom, the dimensions of which are in lead smaller than 10^{-10} cm. To the possible importance of this point in connection with the spectra of isotopes my attention was kindly directed by Dr. Kramers in a discussion about Prof. Ehrenfest's letter. N. BOHR.

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The Destruction of Mosquito Larvæ in Salt or Brackish Water.

A NUMBER of experiments on the destruction of mosquito larvæ by the well-known system of "surface oiling," carried out at Hayling Island during the year 1921, supplied further evidence of the fact that this method is not one of universal application. The production of an unbroken film of a sufficiently lasting nature is sometimes an impossible task, notably in cases where the water surface is broken up by growths of reeds, etc., or is too freely exposed to the wind. In cases of this kind it is necessary to discard the oil film in favour of a "larvicide," that is to say, a substance which, by mixing with the infested water, will destroy the larvæ.

Unfortunately, however, practical information concerning larvicides is difficult to obtain. In the literature of the subject references are to be found to a number of suggested substances, but the vast majority of these stand self-condemned owing to the prohibitive cost that would be entailed by employing them in the prescribed "strengths" on any practical scale. A large number of these larvicides are, moreover, admittedly ineffective when added to brackish or salt water, and are consequently of little value in districts such as Hayling, where the salt-water mosquito, *Ochlerotatus detritus*, is the principal offender.

A number of tests have recently been carried out in the laboratory of the Hayling Mosquito Control, in the hope of discovering a larvicide which could be used successfully (and at a low cost) in salt, or partly salt, water. It was found that a liquid containing 15 per cent of soluble cresol, sold as a disinfectant under various names, gave very promising results in the laboratory. This liquid, at a dilution of 1 in 16,000, was found to kill the larvæ of *Ochlerotatus detritus* in one hour; at a dilution of 1 in 32,000, in one and a half hours; and at a dilution of 1 in 48,000, in three and a half hours. In the majority of these experiments the water containing the larvæ was of a salinity about half that of sea water.

In order to test this larvicide on a larger scale, a shallow stretch of brackish water adjoining the Hayling Golf Links was selected for experiment. This water was very heavily infested with the larvæ