between r , Nne^2 , m , and h ; and if we introduce this relation in Dr. Lindemann's expressions for ν , all the different expressions become identical.

By a consideration of dimensions only, we cannot calculate the numerical factors which determine the exact values for the frequencies of the spectrum of an element; in order to do this, we must introduce more detailed assumptions as to the constitution of the atom and the mechanism of emission of radiation. A discussion of the special assumptions used in my calculations will be found in a paper on the influence of electric and magnetic fields on spectral lines, which will appear shortly in the *Philosophical Magazine*.

N. BOHR.

The University, Copenhagen, January 5.

DR. F. A. LINDEMANN (*NATURE*, January 1) disagrees with the theoretical interpretation of my recent work on X-ray spectra (*Phil. Mag.*, December, 1913). He objects to my statement that the results so far obtained strongly support the views of Bohr, and considers that they yield no information about the structure of the atom beyond confirming the views of Rutherford and van den Broek. My work was undertaken for the express purpose of testing Broek's hypothesis, which Bohr has incorporated as a fundamental part of his theory of atomic structure, and the result of the test certainly confirms the hypothesis. In my opinion, however, further definite conclusions can be drawn from the results, and these conclusions strongly support other features of Bohr's theory. Moreover, I cannot accept the alternatives which Dr. Lindemann offers to my formula representing the values of the principal frequencies observed.

Dr. Lindemann's arguments are based on the principle of dimensions. This method of treatment is of historical interest, as we owe to it the introduction of Planck's quantum h into the discussion of atomic structure. So long as the only factors, common to all atoms, on which this structure was known to depend, were e , m , the charge and mass of an electron and Ne the charge of the nucleus, it was impossible to obtain a quantity of the dimensions of a frequency. In an electromagnetic system the introduction of c , the velocity of light, might get over this difficulty, but it has proved more profitable to treat the problem as electrostatic and make definite calculation possible by using h .

We will call the assumption that h is a fundamental factor in the atom the h hypothesis. It then follows from the principle of dimensions that the frequency of an atom, $\nu = f \frac{e^4 m}{h^3}$, where f is a numerical constant which depends on N , and also on the arrangement of the electrons in the atom.

The reason why Dr. Lindemann arrives by the same argument at an indefinite result is that he takes r , the distance of the electron from the nucleus, or else rN to be an independent factor in the calculation. No independent natural unit of length, which would apply to an electrostatic problem, is known, and the separate introduction of r or rN appears to me to be unwarranted. Bohr has pointed out that the fundamental frequency ν_n of ordinary series spectra is obtained by putting $f = 2\pi^2$ in the formula given above, while my work shows that the frequency of the principal line in the X-ray spectrum of elements from Ca, $N=20$ to Zn, $N=30$ corresponds with

$$f = 2\pi^2 \cdot \frac{3}{4} (N-1)^2.$$

The simplicity of the expression f in these two cases is itself an argument in favour of the h hypothesis. It is, however, more strongly supported by the fact that the frequencies in the X-ray spectrum are pro-

portional to $(N-1)^2$. Two alternative explanations can be given for the occurrence of $(N-1)$ and not N . It is just possible that two of the elements which precede calcium have the same atomic number. A mistake would then have been made each time in reckoning N , and ν would really be $\propto N^2$. It is much more likely that the repulsion of the other electrons cannot be neglected compared with the attraction of the nucleus, and then N must be replaced by $(N - \sigma_n)$. In either case we conclude that as we pass from atom to atom $\nu \propto (Fr)^2$, where F is the resultant electrostatic force on the vibrating electron. In other words, a quantity of dimensions $T(ML^3T^{-2})^2$ remains constant, and since the mass is always the mass of an electron $M^7L^2T^{-1}$ remains constant. By putting $p=1$ a quantity is obtained of the same dimensions as h . For these reasons I conclude that the experiments support the h hypothesis, which has been put forward in three distinct forms, first by Nicholson, then by Bohr, and recently by J. J. Thomson.

I have not succeeded in obtaining agreement between my results and the vibrations considered by Nicholson. Bohr's theory, on the other hand, explains why there is a general spectroscopic constant, ν_0 , given by $f = 2\pi^2$, and at the same time demands that the principal X-ray frequency should be given by $f = 2\pi^2 \cdot \frac{3}{4} (N-1)^2$. This agrees with the experimental result if the vibrating system is a ring of four electrons, all vibrating together; since $\sigma_4 = 0.96$. Two things, however, suggest that either Bohr's theory or my interpretation of it requires modification. In the first place, it fails to account for the second weaker line found in each spectrum. In the second place it is difficult to see how a ring of four electrons can store up enough energy to vibrate as a whole. Perhaps the examination of the spectra of other groups of elements will suggest a solution of these difficulties.

H. MOSELEY.

Oxford, January 5.

"Atmospherics" in Wireless Telegraphy.

WITH reference to Prof. Perry's letter on "atmospherics" in *NATURE* of January 8, a description of some experiments made by us in the summer of 1912, and continued last summer, may be of interest. A receiving station was erected near Rothbury, in Northumberland, with an antenna consisting of two horizontal wires stretched about 3 ft. from the ground. The receiving apparatus consisted of a galena-tellurium detector and telephone circuit coupled to two inductances connected to the antenna wires and having a variable condenser in circuit between them. The length of the antenna was varied during the experiments, but for most of the time was about 500 yards each way, the direction of the wires being approximately north-west and south-east. No earth connection was used.

The antenna was laid on a slight slope, the receiving hut being situated in a field, but in each direction the antenna wires passed through extensive woods, the whole district in the vicinity being thickly wooded. During the observations of 1912 the ground was nearly always very wet owing to the excessive rainfall.

According to the views put forward by Prof. Perry, it would naturally be expected that atmospherics would be either absent or greatly diminished in intensity with an antenna such as we used. So far from this being the case they were both numerous and loud, so much so that we adopted this form of antenna as being suitable for investigating the direction from which atmospherics emanate. For this purpose we used crossed horizontal wires connected to a form of radio-goniometer, the well-known directive effect of

horizontal antennæ being thus utilised. The observations were not sufficiently numerous to justify definite conclusions being drawn, but so far as they went they tended to support Mr. Marconi's results as to the southerly origin of these disturbances.

The aërials of many stations are, of course, to some extent directive, and this may account for the comparative immunity of one station from atmospheric disturbances while another in its vicinity is more disturbed by them, although both might be affected equally by local thunderstorms.

WILFRED HALL.

H. MORRIS-AIREY.

9 Priors Terrace, Tynemouth,
Northumberland, January 12.

A Recently Discovered Stone Circle, near Matlock, Derbyshire.

ON the summit of "Bilberry Knoll," in the district of Matlock, latitude $53^{\circ} 7' 1\frac{1}{2}''$, and longitude $1^{\circ} 32' 15''$ W., there are remains of what I believe to have been an important station in prehistoric times, dedicated to the sun-worship cult.

The highest point of the hill is crowned by a mound, obviously artificial, built up of large boulders and earth, and, although much disturbed, many of the stones occupy positions in which they were originally placed. Some of them appear to form part of the circumference of a circle with thirty-six bays, or divisions, of 144 ft. diameter. Near the centre there are two chambers, one in horse-shoe form, and the axis through these chambers is in line with the "Nine Ladies," a well-known circle, on Stanton Moor.

The range of hills (of which Bilberry Knoll forms the highest point, 928 ft. above O.D.) occupies a very strong natural position, and the summit was apparently further protected by ramparts, remains of which may be seen about 200 yards south of the circle mound.

The circle commands an extensive view in every direction, and there are in sight more than thirty positions which bear distinctive names.

To discover the significance of some of these positions I have taken observations of the sunset on those days usually regarded as sacred in the "Druidical," or sun-worship cult, more particularly of the May Eve and June Solstice festivals. But sunsets down to the horizon are rare, and I had no data by which to determine the true date of *May Eve*. I ultimately decided on May 11 as being consonant with May Eve (old style), and this year, on that date, the *full disc* of the sun rested upon a distant horizon (altitude $10'$), exactly over the intersection of intervening hills, on an alignment N. $58^{\circ} 00'$ W.

At the June solstice the results were more decisive, the sunset being almost exactly over the "Nine Ladies." This well-known circle lies a little more than five miles away, N. $46^{\circ} 30'$ W., and the height of horizon is about $13'$. And N. $46^{\circ} 00'$ E., with a similar altitude, stands "Blakelow Hill"; this hill would thus indicate the rising sun, and, conjointly with the "Nine Ladies," provides irrefutable evidence of purpose. For, whereas "Blakelow Hill" is a distinctive natural feature, the "Nine Ladies" occupies a *chosen* site, slightly below the highest ground, on a broad plateau. And, whilst it is in sight, and indicates the sunset from "Bilberry Knoll," it is not in sight from a circle only $1\frac{1}{2}$ miles away on Harthill Moor, nor from "Arbor Low," which is within $5\frac{1}{2}$ miles, though a difference of very few yards in position, on higher ground, would have placed it in sight of all three. It was therefore clearly established as an adjunct to "Bilberry Knoll."

Comparing these results with data which I have

since obtained from Sir Norman Lockyer's valuable work on "Stonehenge," I find the alignment for sunset on May 6 to be about N. $61^{\circ} 00'$ W., but the date actually observed appears to be subject to local variation, the Roman calendar being May 9 (the date of a fair day at Matlock). Making allowance for this, and for variation in obliquity of the ecliptic, it seems probable that this hill intersection would indicate the sunset on the eve of the May year festival.

The alignment for the June solstice I make N. $47^{\circ} 15'$ W., which is so near as practically to confirm my conclusions.

Investigations on the various sites would, I believe, prove that the better-known Derbyshire circles, "Arbor Low," the "Bull Ring" at Dove Holes, and "Wet Withins" on Eyam Moor, were also established with alignments to distinctive features that would indicate the rising and setting sun on these dates.

JOHN SIMPSON.

Spring Mount, Bank Road, Matlock,
January 5.

Trepanning among Ancient Peoples.

A NOTE in NATURE of October 30, 1913, p. 273, referring to the late Dr. Lucas Championnière's paper on prehistoric trepanning, which was read at the last annual public meeting of the Five Academies in Paris, contains this observation:—

"It is remarkable that the operation was not practised among highly civilised races like Greeks, Egyptians, Arabs, Hindus, and Chinese. . . ."

But the subjoined quotations would seem to militate with the soundness of this expression so far as it concerns the ancient peoples of Greece and India:—

"In surgery his (Hippocrates's) writings are important and interesting, but they do not bear the same character of caution as the treatises on medicine; for instance, in the essay 'On the Injuries of the Head,' he advocates the operation of 'trephining' more strongly and in wider classes of cases than would be warranted by the experience of later times" ("Encyclopædia Britannica," 1910, vol. xiii., p. 518).

"The next most elaborate chapter (of the Hippocratic collection) is that on wounds and injuries of the head. . . . Trephining was the measure most commonly resorted to, even where there was no compression" (*ibid.*, vol. xxvi., p. 125).

"Jivaka (afterwards termed the King of the Physicians) had learnt the whole art of healing with the exception of the operation of skull-opening. Now a man who was afflicted by a cerebral malady came to Atreya (Jivaka's master) and asked him to treat him. Atreya replied that the man must dig a pit that day and provide it with dung. . . . When Atreya came, he placed the man in the pit, opened his skull, and was about to seize the reptile with his pincers (when Jivaka advised him how to take it away). . . . When all this had been done the man was cured" (E. A. von Schiefner, "Tibetan Tales," trans. Ralston, 1906, p. 98). The same book, p. 100, relates how Jivaka cured a man whose head itched greatly by drawing out of his skull a centipede through the same operation. In the "Lives of Jivaka and Amrapālī (his mother)," translated into Chinese in the second century A.D., he is said to have used a golden knife in skull-opening.

"Les Saniassis sont enterrés jusqu'au col; un Religieux du même ordre casse des cocos sur la tête du mort jusqu'à ce qu'elle soit brisée; ensuite on la couvre de terre. On ignore aujourd'hui le motif de cette pratique singulière, à moins que ce ne soit pas pour faciliter à leur âme le moyen de sortir par une ouverture plus honnête que la bouche, les oreilles et