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The Quantum Theory.

THE jurisprudence of scientific law is a matter for the consideration of the philosopher, but the simple scientific worker can often form a fair idea of the condition of a science by examining what is the constitution of the legislature which is making its laws. In some sciences the government is parliamentary; in others, it is more like the rule of a supreme court of justice. In biology, for example, consider the subject of organic evolution. Here government has been nearly always parliamentary, and among the leading authorities there has usually been a very wide divergence of opinion. Sometimes the conservatives have been in power, sometimes the radicals, and it is sad to record that, as in other spheres of activity, it has often been the chief object of either party to "dish the Whigs" or to keep the Tories out, rather than to attempt to perfect the system of law. With this type of legislature progress is certainly made, but is only made by a succession of rather violent reactions; the Natural Selection Act is passed in spite of the bitter opposition of the conservatives, and for many years is regarded as a panacea for all ills, but, in spite of Mendel's Law (carried without a division), the present seems to be a time of reaction, and the conservatives are having another innings because of certain evilly-disposed creatures which persist in making variations without any eye to their own interests.

In the inorganic sciences, on the other hand, law has more usually been made by processes that may be likened to the rulings of a court of justice, so that they command immediate and universal acceptance—this may be only the naive estimate of a layman as to judicial infallibility. Newton propounds the law of gravitation, and there is no appeal; Kelvin and Clausius put forward the second law of thermodynamics, and they are quoted in all subsequent cases. But at times questions have arisen on which the bench has been divided, and then recourse must be had to the other type of legislation. Such a case has been radiation. If we may misapply our metaphor still further, all through the eighteenth century "members might vote as they pleased" as to the nature of light; but in the nineteenth century Fresnel's ruling took the matter out of the hands of parliament. At the beginning of the twentieth century, Planck's study of the question revealed a flaw in the decision, and again

the matter came before parliament under the new name of the Quantum Theory.

In 1914, Mr. Jeans wrote the first edition of the report now before us.[1] At that time the matter was very definitely under the control of the parliamentary type of government. There were the die-hards, especially strong in Great Britain, who would not abandon the logical perfection of the classical theory of Maxwell in spite of its proved inadequacy and of the sterility from which it had long suffered. There were the moderate men who were reduced to a state of almost complete agnosticism, and there were the Bolsheviks, ready to multiply any ν by h and face the consequences, however absurd—may we suggest quantising the eight-hour day so as to determine the amount of work to be done by the proletariat? In this parliament, Mr. Jeans occupied a rather special position, for he had been one of the leading conservatives, but had recently been converted to liberalism, and the report was particularly addressed to the die-hard party. In the lapse of the last ten years there has been no clear-cut discovery which would remove the quantum theory from parliamentary control, but the steady evolution of the theory of spectra has led to a shifting of opinion towards the left; the die-hard is now an agnostic, and the moderate man is himself ready to undertake the respectable process of quantisation. In consequence of this trend, the new edition of the report is no longer a polemic, but an outline of what is now a generally accepted—if incomplete—body of doctrine.

The quantum theory is based on two classes of argument—the positive and the negative. On the positive side, it has already succeeded in classifying in main outline the whole system of line spectra, and this would alone have justified it; but it should never be forgotten that the really conclusive proof lies on the negative side. Without breaking absolutely with the classical theory, it is impossible to explain either the radiation formula or the vanishing of specific heats at low temperatures. This side of the subject depends on highly abstruse considerations of the partition of energy, and so is shirked in many writings; we may count it as a great merit of the present work, that it has retained and amplified the detailed discussion of radiation given in the first edition.

By far the greatest change in the report is, of course, in the spectrum theory. The first edition was written shortly after Bohr's original discovery, and so could only contain the combination principle and the barest outline of the simple hydrogen spectrum. Now we have Sommerfeld's quantisation, the relativity correction, the motion of the nucleus, and a short reference to the Zeeman and Stark effects. The treatment of the more complicated spectra is very slight; they are regarded mainly as depending on analogy with hydrogen, and no account is given of any of the exceedingly shaky mechanical models which have been invented. There is also a sketch of the developments in purely classical dynamics which have been found to apply in such a curious way to the theory, including the beautiful principle of adiabatic invariance. The account of Bohr's correspondence principle is rather brief; it contains the formal statement, but scarcely shows the wide field which it has influenced. In some ways this is a good thing, for the principle is quite clear-cut and precise, but there has been a tendency of late to use it to describe any analogy, however vague, between the classical and the quantum systems of mechanics. The last chapter contains a discussion, of necessity very indefinite, of the possibilities of reconciliation between the old and the new mechanics.

We may note a few omissions. There is no mention of the theory of the specific heats of gases, though this theory is now really as sound as that of solids, and is a good deal simpler. Taken in conjunction with infra-red band spectra (which also are not mentioned) it constitutes one of the strongest confirmations of the whole theory. There is also no mention of the wonderful experiment of Stern and Gerlach, which shows directly that atoms orientate themselves in space according to the dictates of the quantum theory. Nor is the anomalous Zeeman effect discussed—but this is perhaps right; for though this effect has been analysed by the help of quantum principles, yet it, and with it the gyromagnetic effects, would appear not to belong to that theory, but to indicate some other quite different type of departure from classical mechanics. As this question is still rather unsettled, and is treated fully in other works, we need not very much regret its absence. The whole report furnishes an admirable summary of those parts of the quantum theory which are now really well established. It is probable that the physical outlook on the whole system will be revolutionised, but it will be very surprising if the subject-matter of the report cannot be taken over, mathematics and all, in the new interpretation.

[1] The Physical Society of London. Report on Radiation and the Quantum Theory. By J. H. Jeans. Second edition. Pp. iv+86. (London: Fleetway Press, Ltd., 1924.) 7s. 6d. net.