P. Gombás: Statistische Behandlung des Atoms Handbuch der Physik, Vol. 36, pp. 109—231, 1956.

The statistical theory of the atom and wave mechanics are disciplines closely related by birth and development. Both theories enable us to solve the manybody problems of atomic physics, and even the fields of their application are identical. They differ, however, inasmuch as the statistical theory cannot be set up without taking wave mechanics into account, but it is at the same time an illustrative model-like approximation to the latter. The great advantage of the statistical model lies in its simplicity. Calculations performed with it require much less time than the corresponding wave-mechanical calculations. The statistical model is the only key to many a problem since the possibility of performing wave-mechanical calculations is but one of principle. In practice, owing to their puzzling intricacy, no such calculations can be carried out.

Gombás' article covers the problems of theory and practical application both (except for nuclear applications, a field to which Gombás and others have made important contributions in other papers). The article under review is divided into six chapters, the first five being devoted to the general problems of the theory and the sixth to applications. This last chapter is almost as large as the first five together.

Chapter 1 is concerned with the general theoretical foundations. The theory is based upon the statistical theory of a free electron gas: the Fermi—Dirac statistics and especially its particular case for very low temperatures. The various energies of a free electron gas are simple functions of the electron density. Thus the energy of the ensembles of electrons around the nucleus can be expressed in simple terms (kinetic, electrostatic, exchange and correlation energy).

Chapter 2 describes the beginnings of the development of the statistical method, starting from the first basic works of Thomas (1926) and Fermi (1927). The Thomas—Fermi model takes into account the kinetic and the electrostatic energy only. Thus, for the determination of electron density a very simple differential equation is obtained, which yields universal solution for any atom. In spite of its simplicity the Thomas—Fermi model is a fairly good approximation to experiment and can be used to describe most of the properties of the atom except for certain specific wave-mechanical properties.

Chapter 3 shows the further development of the Thomas—Fermi model: the gradual improvement of this too simple model by taking into account further effects. The exchange interaction is an effect accounted for by Dirac's model while Gombás' generalized model takes into consideration the correlation energy too. Gombás has shown that the consequent application of the Weizsäcker correction to the kinetic energy requires a further modification of this correction. Chapter 3 includes also the corrections for very high temperature, the relativistic correction, etc. The consideration of all these effects has improved the statistical model to such an extent that it can be regarded as a very good approximation to the more exact but a great deal more complicated model of wave-mechanics.

Chapter 4 is devoted to the introduction of the perturbation calculation of wave mechanics into the statistical theory. The consequent statistical perturbation theory was originated by Gombás.

Chapter 5 deals with the extension of the statistical theory of the atom in various directions. Special emphasis must be laid here upon the statistical formulation of the Pauli principle, one of Gombás' most important achievements, according to which the Pauli principle can be regarded as stating that the electrons cannot occupy a filled state of lower energy owing to the repulsion of the electrons of lower energy exerted on them. Gombás succeeded in determining the repulsive potential in a simple form. Chapter 5 also treats of the relation between the statistical model and wave mechanics and includes Gombás' recent idea that from the formal point of view the basic equation of the statistical atom model can be regarded as a Schrödinger equation. This fact shows the close connection between the two theories. Finally, the dynamic (non-static) model is described.

Chapter 6 is devoted to the other wide range of problems: that of applications. It shows how wide the range of applications of the carefully constructed theory is. In connection with the application to atoms chapter 6 acquaints us with the interpretation of the periodic system on the basis of the statistical model as well as with the calculation of ionization energies, mean excitation energies, atomic spectra, atomic and ionic radii, diamagnetic susceptibilities, polarizabilities, the data of Compton lines and atom form factors. A comparison of calculated and empirical data shows the very good agreement between theory and experiment. The range of applications for molecules is not so well developed, as here, in contrast to atoms or solids, there is no spherical symmetry and thus the calculations become very intricate. However, good results were obtained in this field too, e. g. nuclear distances and binding energies were determined for several diatomic molecules. The possibilities of applying the statistical theory to crystals are also manyfold and cannot be enumerated here. It is worth while, however, mentioning Gombás' theory of metals, a very important application of the statistical theory of the atom. Many of the results obtained by Gombás in connection with the general development of the theory can be applied to the theory of metals. This fact clearly shows the unity of theory and practice. The range of applications treated of in this chapter is closed by calculations for material under high pressure.

In his article on the statistical theory of the atom in the new Encyclopaedia of Physics Gombás shows very fine didactic sense in developing a gradually improving theory. At each stage of development figures are given to show the extent to which the newly introduced expressions approximate the electron density distribution calculated by Hartree's wave mechanical method.

Gombás and his collaborators played an overwhelming part in working out the statistical model of the atom. We are proud of Gombás' significant contribution on behalf of Hungarian science to this great international Encyclopaedia of Physics.

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