SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

RECENT DEVELOPMENTS IN NUCLEAR PHYSICS

THE post-war development of accelerators for atomic particles has enabled a new high-energy branch of nuclear physics to be developed, the main objective of which is the study of the forces between nucleons and their relation to mesons and the meson fields. This forms the subject of the presidential address to Section A (Mathematics and Physics) by Sir John Cockcroft.

In Britain we have brought into operation within the past year, for the study of this field of physics, a billion-volt proton synchrotron, a 400-million volt cyclotron and a 330-million volt electron synchrotron, while the Harwell cyclotron has produced protons and neutrons of energies up to 180 million volts. In the United States, in addition to machines of these types, proton synchrotrons of 2 and 6 billion volts are now operating.

Experiments on the scattering of protons by protons and protons by neutrons have demonstrated the exchange nature of the nuclear forces. The scattering of protons in succession from carbon and hydrogen targets have shown that protons after scattering have about 80 per cent of their spin axes pointing in one direction, that is, they become polarized. This results in four times as many being scattered to the left as compared to the right from the second target. This demonstrates another characteristic of nuclear forces—the very strong interaction between the spin of the nucleon and its orbital motion—which produces a non-central force.

The high-energy collision of nucleons produce π-mesons at nuclear energies greater than 200 million volts. At energies of a billion volts pairs of heavier mesons have been created. One of them is the excited proton first discovered by Rochester and Butler, originally called the V^0 meson. The other is a θ° meson, which decays into two π-mesons.

These and other mesons are very closely connected with nuclear forces. In nucleon collisions of medium energy, momentum is transferred through the intermediary of the 'meson cloud' associated with a nucleon. When the collisions are energetic enough, the π-mesons materialize, live for a hundred-millionth of a second and decay. In still closer encounters the heavy meson must play a similar part in nuclear forces, giving rise to shorter-range components of the force.

Mesons are now produced in such large numbers by the accelerators that they can be used for experiments on the properties of the meson. Thus the π-meson has been shown to have zero spin—like an alpha-particle or light quantum. It can form a compound nucleus with a nucleon of a very high degree of excitation. It can also form mesic atoms in which the meson plays a similar part to an electron in the atom, and mesic X-rays are produced in orbital transitions.

The address concludes with a reference to the dangers and peaceful potentialities of these powerful nuclear forces.

NEW IDEAS IN CHEMISTRY

SIR JOHN LENNARD-JONES, president of Section B (Chemistry), remarks in his presidential address to that Section that when the British Association last met in Oxford in 1926 physicists pictured electrons in atoms as rotating in orbits around a central nucleus like a solar system. Though this view had great success in clarifying the behaviour of atoms under the influence of light, and in providing a theoretical basis for the periodic table of elements, it had little influence on chemistry, for it did not prove possible to extend the mode of description to molecules. It was the wave theory of matter which opened the way. This provided a novel way of describing the states of electrons in atoms and molecules and a new technique for calculating their stationary states.

In the new theory two ideas were found to have an important place. The first one was that electrons are indistinguishable from one another, so that an interchange of any two does not produce an observable change. The second one was that electrons in atoms and molecules obey strictly the rule that no two take the same role at the same time. Electrons are said to have the 'property of exclusion'. No theoretical proof has been given of this—it is injected into current theories as a working rule and is justified only by its success in predicting the properties of matter.

These two ideas, together with the wave description of electrons, have proved of great importance in explaining the properties of molecules; in fact, it may be said that a unification of atomic physics and chemistry has thus been brought about. The property of exclusion appears to be more powerful than the forces of repulsion or attraction such as exist between electrical charges of like or unlike kind. These latter are of short range and cease to be effective beyond lengths of atomic dimensions; but the 'awareness' which one electron seems to have of another of the same kind of spin seems to extend throughout a molecule, however large it may be. Electrons can thus influence each other over distances many times greater than the sizes of the atoms which a molecule may contain.

The property of exclusion implies that electrons of the same spin avoid each other as though there were a powerful force of repulsion between them. This plays a vital part in fixing the shapes of molecules and, in particular, in producing the directed valencies of carbon. The occurrence of 'lone pairs' of electrons and the asymmetric distribution of charge in molecules can be traced back to the same property. Thus this seems to be the primary cause of electron-rich regions and the agent impelling chemical reactions to go.

One of the most interesting and profitable applications of the new ideas has been to the structure of conjugated molecules. Many of their characteristic properties, such as alternating polarity and the shifts of electrons under the influence of substituents, can now be understood in principle in terms of the same concepts used for saturated molecules.