THEORETICAL PHYSICS IN THE U.S.S.R. DURING THE PAST TWENTY-FIVE YEARS

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THE advances of physics have been especially significant during the last quarter of a century; modern theoretical physics, in particular, is a child of this period. Our concern, in this article, is mostly quantum mechanics of recent times. The papers of 1932–38 mentioned in this article have been published in the *Physikalische Zeitschrift der Sowjetunion*, and the papers dating 1933–34 in the *Journal of Physics* (issued by the Academy of Sciences of the U.S.S.R.).

Relativity. Among the few papers on relativity theory a prominent place is due to the discovery made by the late Prof. Friedman of the non-static solution of Einstein's equations of gravitation (1922). This work has influenced the development of relativistic cosmology which has followed. We may also mention the recent memoir by Fock (1939) on the approximate solutions of the gravitational equations for bodies of finite extension, from which the equations for motion were automatically derived. Fock's calculations are much simpler than those of Einstein, Hoffman and Infeld for point masses.

General Quantum Mechanics. Mention is first of all due to Fock's approximate method, now widely used, which generalizes that of Hartree. To the same author we owe also an exhaustive treatment of quantum electrodynamics as well as a simple quantum derivation of Coulomb's law (together with Dirac and Podolsky). There is no need to dwell upon earlier studies by Fock in the relativistic generalization of Schrödinger's equations or on Frenkel's correction (Thomas-Frenkel's term) for the electron motion, as this is now discussed in text-books. It will be recalled that we owe to Frenkel the classical theory of a spinning particle (1926).

Of general interest is the idea of 'individual' error in measuring co-ordinates in the relativistic quantum mechanics. This idea, as contrasted with the common conjugate errors, was suggested by V. Ambarzumian and D. Ivanenko and developed especially by Schrödinger. 'Individual' errors for electromagnetic fields were discussed by Jordan and Fock and by L. Landau and Peierls.

Dirac's Theory. A thorough analysis of Dirac's equation has been undertaken by Ivanenko (introduction of hypercomplex numbers), by Fock (formulation by means of proper time) and others. Of particular importance is the theory of parallel displacement of Dirac's wave function (Fock and Ivanenko, 1929) by means of which Dirac's equation was immediately brought into a general relativistic form. This study was extended by Weyl, Schrödinger, Dirac and Pauli.

Meson Theory. Proca's equations were quantized by Ivanenko, Durandin and Ershov, who showed their inapplicability to electrons, but were recommended by Tuka, Heitler and Kemmer as the best device for the description of mesons. Purely classical mesodynamics, taking account of damping, in particular, were treated by Ivanenko and Sokolov concurrently with Bhabha. The difficulties here encountered, such as the unlimited growth of cross-sections upon scattering of meson nuclei (Sokolov), the impossibility of stable orbits for a meson revolving around a nucleus (I. Tamm), etc., are all

connected with the dipoleness of the meson as manifested both in electromagnetic and nuclear effects (Ivanenko and Sokolov). Hence the results of Smorodinsky and Landau (Compton effect on the meson) and those of Ivanenko, Sokolov and Rosman (population of a vacuum by meson pairs). We consider it as one of the most interesting results of the quantum theory of mesons that Sokolov (1941) has suggested a quantum account of damping which decreases the growth of cross-sections and thus eliminates a serious difficulty.

Atomic Nucleus. The modern model of the atomic nucleus composed of only heavy elementary particles suggested by Ivanenko (1943) raises the question as to new specific nuclear forces. The first model of nuclear forces realized by electrons and neutrinos was developed by Tamm and Ivanenko (1934). This is still a specimen for every model of forces (compare, for example, the prediction of non-central forces by Tamm, although as shown later on by Tuka the principal part is played here by meson forces).

The statistical theory of the nucleus was extended by Frenkel (nuclear temperature, electrocapillary vibrations, spectroscopy and fission) and by Landau (distribution of energy-levels). A detailed analysis of the chain reaction of the fission of uranium was carried out by Khariton and Seldovich. Migdal has analysed the tracks of the fission products.

Cosmic Rays. The complex equations of the shower theory of Heitler and Bhabha and of Oppenheimer and Carlson were first integrated in a concise form by Ivanenko and Sokolov (1938) with the aid of Mellin's transformations already mentioned in a previous publication by Landau. Further refinement was brought about by Tamm and Belenky, taking due account of the ionization losses.

Statistics and General Theory of Solids and Fluids. The general statistical theory of a continuum was given by Leontovich, Mandelstamm, Leontovich; and their associates (Shaposhnikov, Vladimirov, Galanin) have treated by classical means the study of various cases of sound absorption in fluids, strong and weak electrolytes, emulsions and suspensions. Much work was done on solids by Frenkel, who has just completed a monograph on fluids. Suffice it to mention his studies of excitation waves and some recent studies in plasticity (in collaboration with Kontorova, 1940), on the temperature dependence of surface tension (1940), and on the mechanical properties of amorphous bodies. We owe to Tamm an interesting consideration of the surface-levels of electrons in crystals. Landau has developed a very general fundamental theory of phase transitions 'of the second kind' connected with a jump in symmetry (1937). This study was extended by E. Lifshitz (1941).

Landau and his associates, Akhiezer and Pomeranchuk, treated sound absorption in solids by means of quantum mechanics. According to the recent hypothesis advanced by Landau, superfluid helium II is considered to be in a state of potential quantized motion which lies lower than the state of vortex motion.

Quantum Theory of Metals and Semi-Conductors. In this connexion we may mention, first of all, the pioneer work, at Joffe's Physico-Technical Institute, of Frenkel on electronic and 'hole' conductivity, on rectification, etc. It will be noted that Frenkel was the first to suggest the ingenious idea of the degenerate gas in stars. Some valuable work on semi-conductors has been done by Blokhinzev and Davydov.

An interesting result of Landau's work is the proof of diamagnetism of the quantum electron gas. It was shown by Landau that in a transient state superconductors are composed of alternating common and superconducting regions.

As to the quantum theory of metals, Tamm and Blokhinzev have ascertained the role of image forces in the escape of electrons, and Tamm has discussed in detail the photo-effect from metals.

Many properties of ferromagnetic bodies have been accounted for by I. Akulov's anisotropy law. The quantum theory of ferromagnetic alloys, magnetostriction, etc., was developed by Vonsovsky (1940). The role of anharmonic effects in conductivity was discussed by A. Smirnov. A noteworthy place is occupied by Granovsky's and Vlasova's work on plasma.

Optics. Numerous detailed computations of spectra were carried out in the Leningrad Optical Institute by means of Fock's approximate methods. Much work was done on molecular spectra by Eliashevich and Stepanov. The modern theory of phosphorescence as a series of bimolecular reactions was developed by Blokhinzev (1937). Mandelstam and Leontovich extended the classical, and Tamm the quantum, theory of the Raman effect in solids. Leontovich studied the Rayleigh scattering in anisotropic fluids.

Among the ideas of Mandelstam's school mention may be made of an ingenious explanation by Tamm and Frank of the new kind of radiation, discovered by Cherenkov in Vavilov's laboratory, as due to electrons moving at a velocity exceeding the phase velocity of light in the given medium.

It is not possible to discuss, within the confines of the present article, various problems of classical electrodynamics and their technical application as pursued by Mandelstam and Papalexi with their associates Rytov, Filipov and others. Mention may, however, be made of the theory of non-linear vibrations, which has had some interesting practical implications (compare the monograph by Andrianov and Khaikin).

The above is a concise outline of the development of theoretical physics in the U.S.S.R. We may point with satisfaction to the existence of several scientific schools, and of a great number of young men of science who have already done valuable research. Work on theoretical physics carried out in the U.S.S.R. during the past twenty to twenty-five years has played a noteworthy part in modern developments of the subject.

TERMINOLOGY IN THE GEOLOGICAL SCIENCES

By DR. R. H. RASTALL

FOR many years past and especially of late in publications and conferences dealing with war-time problems and post-war planning, much stress has been laid on the unfortunate fact that in Great Britain the governing classes and the general public are not geologically minded. This is not the place to discuss in detail the disastrous neglect of economic and applied geology and mineralogy in some of the universities of Great Britain, but it is proposed rather to point out some ways in which the study and

appreciation of geology by ordinary non-specialist educated people is rendered unnecessarily difficult.

One of the most glaring of these obstacles is by no means confined to geology, but is common to all biological sciences, namely, the volume and complication of the nomenclature now current. To the ordinary person, these sciences present themselves mainly as masses of outlandish and arbitrary names, which seem to have no sense or reason about them. Now there can be no doubt that of late years this has got much worse in geological studies, owing to the superabundance of minute detail now prevailing both in stratigraphy and palaeontology. Fortunately, in petrology there has recently been a definite reaction against the multiplication of unnecessary names, although even this has not received all the support that might be wished.

By far the greater part of the trouble arises from the activities of the palaeontologists. It is now a common saying and only too true that a field worker cannot name his own fossils: they all have to be sent to a specialist—a most unfortunate state of affairs, and a very unfair handicap on the field-worker. It remains to consider what are the real causes of this situation. First of all, there is one inevitable reason: the extension of knowledge, against which nothing can be said. But the real crux is the way in which that extension of knowledge is employed. Now, unfortunately, the whole tendency has been and is to make things infinitely more complicated, instead of any attempt at simplification. It is commonly understood that modern palaeontology is supposed to be founded on evolutionary lines, but it really seems that the present tendency to hair-splitting distinctions and infinite multiplication of new names is exactly contrary to the true principle of evolution. All the emphasis is on differences instead of resemblances: dividing instead of grouping. Many such distinctions correspond to extremely minute differences. Hence natural relationships are concealed, not emphasized. This is not the spirit of Darwin and Wallace.

In palaeontology this tendency finds expression in the institution of new genera. In the case of new and hitherto undescribed fossils this is, of course, necessary, but the reference is here to the infinite sub-division of old and well-established genera. It is scarcely too much to say that almost no fossils known in the times of William Smith, Lyell, Buckland, Sedgwick and Murchison still retain the same names, and it might almost be said of the era of Lapworth and Geikie. Such well-known names as *Terebratula*, *Rhynchonella*, *Ostrea* and *Pecten* have practically disappeared from the literature. The graptolites have probably suffered less than any other group in this way, probably because the authorities on this group happen to have been outdoor geologists. One such alteration in this group may perhaps be mentioned: the abandonment of the earlier name of *Nemagraptus*, which led too obviously to undergraduate attempts at humour (but I see no graptus).

The last sentence but one really touches the root of the matter. All these modern developments are mainly due to museum specialists; people with the Civil Service mind, who spend all their time indoors, surrounded by mountains of monographs instead of mountains of rocks, and appear to delight in making everything as complicated as possible. This is not evolutionary progress, but obscurantism, and if natural science in any form is ever to become a