Leverhulme Research Fellowships

THE following Leverhulme research fellowships have recently been awarded, among others, for research in the subjects indicated: Dr. E. Ashley Cooper, lecturer in chemistry, University of Birmingham (activity of enzymes of bacteria); Prof. E. E. Evans-Pritchard, assistant professor of sociology, University of Cairo, Egypt (detailed ethnological and sociological study of the pagan Galla of Western Abyssinia); Dr. R. MacLagan Gorrie, Indian Forest Service (correlation of erosion damage and grazing in forest lands); Miss M. M. Green, late Government Education Department, Nigeria (anthropological and linguistic research among the Ibo tribe of Southern Nigeria—joint research with Mrs. S. H. Leith-Ross); D. Ll. Hammick, fellow and tutor, Oriel College, Oxford (interaction of nitro-compounds with aromatic bases and hydrocarbons); Dr. H. Stafford Hatfield (behaviour of crystalline substances in electric and magnetic fields); Dr. L. S. B. Leakey, part-time lecturer in the Kikuyu language, School of Oriental Studies, London (prehistory of East Africa); Mrs. S. H. Leith-Ross, late Secretary, Board of Education, Nigeria (home and social life of the women of the Ibo tribe of Southern Nigeria—joint research with Miss M. M. Green); N. E. Odell, geologist to the Louise A. Boyd Expedition to N.E. Greenland, 1933 (structure and metamorphism of the Franz Josef Fjord region of North-East Greenland); Dr. W. H. Taylor, assistant lecturer in physics, University of Manchester (application of X-ray analysis to the investigation of the structures of organic compounds). Grants in aid of researches have been made to the following, among others: Prof. K. A. C. Creswell, assistant professor of Muslim art and archæology, Egyptian University, Cairo, Egypt (researches on early Muslim art and architecture); Capt. C. R. P. Diver, Senior Clerk, House of Commons (South Haven Peninsula Survey, Studland Heath, Dorset. (1) Physiography and history. (2) Distribution of populations and ecology of several animal orders); J. Reid Moir (prehistoric archæology); Mrs. C. F. Tipper, University of Cambridge (plastic deformation of metals).

Museums Association

THE forty-fifth annual conference of the Museums Association will be held at Bristol on July 2–6, under the presidency of Dr. Cyril Fox. The general theme of the conference will be the modernisation of museums and art galleries. Dr. Cyril Fox will deliver his presidential address on July 3. A discussion on folk museums will be opened by Dr. R. E. M. Wheeler. Papers to be read include: "The Popularisation of Geology" by Dr. F. S. Wallis; "Maps in the Museum" by Dr. F. J. North; and "Science and the Public Museum" by Prof. A. E. Trueman. On July 6, the Gaumont-British Co. will give a demonstration of "The Film in the Museum". Further information can be obtained from the Secretary, Museums Association, Chaucer House, Malet Places, London, W.C.1.

International Congress for Applied Mechanics

THE fourth International Congress for Applied Mechanics will be held at Cambridge on July 3–9. The following general lectures will be given: Dr. V. Bush, "Recent Progress in Analyzing Machines"; Prof. A. Caquot, "Définition du domain élastique dans les corps isotropes—Courbes intrinsèques de résistance élastique apparante, et de résistance élastique vraie (endurance)"; Prof. J. P. Den Hartog, "The Vibration Problem in Engineering"; Prof. Th. v. Kármán, "Turbulence"; Prof. Ernst Schmidt, "Heat Transmission"; Prof. G. I. Taylor, "The Strength of Crystals of Pure Metals and of Rock Salt"; Prof. Herbert Wagner, "Über das Gleiten von Kärpern auf der Wasseroberfläche". An extensive series of sectional papers will also be read. Further information can be obtained from the Organising Secretary, Mr. A. H. Chapman, Engineering Laboratory, Cambridge.

Announcements

THE president and council of the Royal Society have recommended Viscount D'Abernon for election into the Society under the special statute which permits the election of "persons who in their opinion either have rendered conspicuous service to the cause of Science, or are such that their election would be of signal benefit to the Society".

THE meeting of the Faraday Society for the general discussion on "Colloidal Electrolytes", originally announced for September 25–27, has been deferred to September 27–29. The date has been changed partly to suit the convenience of those who are travelling to the U.S.S.R. for the Mendeléeff Centenary Celebrations.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A principal of Watford Technical and Art Institute—The Clerk to Hertfordshire County Council, 28, Castle Street, Hertford (July 4). Five probationary forest officers—The Secretary, Forestry Commission, 9, Savile Row, London, W.C.1 (July 4). An assistant lecturer in physics at University College, Nottingham—The Registrar (July 5). A junior scientific officer in the Admiralty scientific pool—The Secretary of the Admiralty (C.E. Branch), Whitehall, S.W.1 (July 7). Three geologists on the Geological Survey of Great Britain and Museum of Practical Geology—The Director, Geological Survey and Museum, 28 Jermyn Street, S.W.1 (July 9). A professor of surgery in the King Edward VII College of Medicine, Singapore—The Director of Recruitment (Colonial Service), 2, Richmond Terrace, Whitehall, London, S.W.1 (July 14). An archæological commissioner in Ceylon—Director of Recruitment (Colonial Service), Colonial Office, 2, Richmond Terrace, Whitehall, S.W.1 (July 31). A geologist in the Education Department of the Anglo-Egyptian Sudan—The Controller, Sudan Government London Office, Wellington House, Buckingham Gate, London, S.W.1.

Letters to the Editor

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Exchange Forces between Neutrons and Protons, and Fermi's Theory

FERMI[1] has recently developed a successful theory of β-radioactivity, based on the assumption that transmutations of a neutron into a proton and vice versa are possible and are accompanied by the birth or disappearance of an electron and a neutrino.

This theory implies the possibility of deducing the exchange forces between neutrons and protons, introduced more or less phenomenologically by Heisenberg. (This idea occurred also quite independently to my friend, D. Iwanenko, with whom I have since had the opportunity of discussing the question.) Consider two heavy particles a and b, a being in a neutron and b in a proton state. If a becomes a proton and b a neutron the energy remains unchanged. Now these two degenerate states of the system may be linked up by a two-step process: the emission of an electron and a neutrino by the neutron a which becomes a proton, and the ensuing re-absorption of these light particles by the proton b which becomes a neutron. The energy of the system will be in general not conserved in the intermediate state (compare the theory of dispersion). The emission and re-absorption of a positron and neutrino may also take place[2]. In this way the two degenerate states of the system considered are split into two energy states, differing by the sign of the exchange energy.

Since the rôle of the light particles (ψ-field) providing an interaction between heavy particles corresponds exactly to the rôle of the photons (electromagnetic field), providing an interaction between electrons, we may adapt for our purposes the methods used in quantum electrodynamics to deduce the expression for Coulomb forces.

Putting $\psi = \psi_0 + g\psi_1 + g^2\psi_2 + \ldots\ldots$, where g is the Fermi constant ($\sim 4 \times 10^{-50}$ erg. cm.^{3}), and using the theory of perturbations and retaining only that part of ψ which corresponds to the absence of light particles in the initial and final states, we obtain

$$\left(H_0 - i\hbar\frac{\partial}{\partial t}\right)\psi_2 \sim \left(K \mp \frac{1}{16\pi^3\hbar c r^5} I(r)\right)\psi_0,$$

where K is an infinite constant, r is the distance between a and b and $I(r)$ is a decreasing function of r, which is equal to 1 when $r \ll \hbar/mc$ (m is the mass of the electron). Neglecting K, one would obtain the same result if one introduced directly in the wave equation of the heavy particles an exchange energy $A(r)$:

$$A(r) = \pm \frac{g^2}{16\pi^3\hbar c r^5} I(r),$$

the sign of $A(r)$ depending on the symmetry of ψ in respect to a and b. Introducing the values of $\hbar$, c and g, we obtain

$$|A(r)| \ll 10^{-35} r^{-5} \text{ erg.}$$

Thus $A(r)$ is far too small to account for the known interaction of neutrons and protons at distances of the order of $r \sim 10^{-13}$ cm.

If the difference of masses of the neutron and of the proton is larger than the sum of the masses of an electron and a neutrino, the emission of light particles by a heavy particle may take place without violation of the conservation of energy. But again the corresponding value of the exchange energy may be shown to be far too small

$$|A(r)| < g_1'\left(\frac{mc}{\hbar}\right)^3 \sim 10^{-18} \text{ erg.}$$

Our negative result indicates that either the Fermi theory needs substantial modification (no simple one seems to alter the results materially), or that the origin of the forces between neutrons and protons does not lie, as would appear from the original suggestion of Heisenberg, in their transmutations, considered in detail by Fermi.

IG. TAMM.

Physical Research Institute,
State University,
Moscow.

[1] Fermi, *Z. Phys.*, **88**, 161; 1934.
[2] Wick, *Rend. R. Nat. Acad. Lincei*, **19**, 319; 1934.

Interaction of Neutrons and Protons

As electrons and positrons are expelled in some reactions from nuclei, we can try to treat these *light* particles like the photons emitted by atoms. Then the interaction of *heavy* particles (protons, neutrons) can be considered as taking place *via* light particles described by the equations of a ψ-field in the same manner as electromagnetic, for example, Coulomb, interaction takes place through an electromagnetic field, or photons.

The *first* order effects are the expulsion (or absorption) of an electron, which case was treated recently by Fermi, or of a positron. We may remark that the application of Fermi's formalism to positron disintegration of light nuclei (which we get by changing the sign of the charge number and taking for the latter the appropriate value) gives results which fit, though not very accurately, the observed relation between the half-period and the maximum energy of the disintegration particle[1]. Though there seems to be a quantitative disagreement between Fermi's theory (applied to positrons) and positron disintegration, on the other hand the calculated values for K and Rb support Fermi's assumption of the existence of quadripole transitions of heavy particles, giving too big values for the half periods in comparison with the usual dipole disintegrations. The exceptional position of K and Rb is in some way rather *anschaulich*. We may remark that the Sargent-Fermi rule, in contrast to the Geiger-Nuttall law, shows a less pronounced dependence on the charge number, so that for qualitative considerations even the wave functions of free particles can be used.

The *second* order effects give specially the probability of production of pairs, which is in the case of the ψ-field less effective than in the electromagnetic case, as the charge, e, is much bigger than Fermi's coefficient, g (the 'charge' for the ψ-field). The most important second order effect is the subsequent production and annihilation of an electron and positron, in the field of proton and neutron,