HIGH-ENERGY ACCELERATORS, COSMIC RAYS AND ELECTRICAL PROCESSES IN GASES

DUBLIN MEETING OF THE PHYSICAL SOCIETY

THE spring meeting of the Physical Society was held in the Physics Department, University College, Dublin, during March 30–April 1, with the president of the Society, Prof. R. Whiddington, in the chair. This was the first—though, it is to be hoped, not the last—time that the Society has met in Dublin, and the attendance of about one hundred and twenty included about fifty visitors from Great Britain and the Continent. The president of University College and the provost of Trinity College, Dublin, each gave an informal reception which provided opportunities for discussion and social contacts. Three sessions were devoted to topics connected with high-energy accelerators and cosmic rays, and one to excitation and collision processes in gases.

Accelerators

T. G. Pickavance (Harwell) reviewed the problem of accelerating particles, particularly protons, to energies greater than 1 GeV. The synchrocyclotron offers no serious technical difficulties, but the size and cost of the magnet limit its use to energies less than 1 GeV. Neutron and proton intensities of $10^{6}/cm.^{2}/sec.$ at some hundreds of MeV. and strong π-meson beams of energy about 200 MeV. are readily obtainable. Above 1 GeV. the synchrotron holds the field for protons, though the necessity of varying the frequency in step with the magnetic field to keep the orbit radius constant makes stability more difficult to attain. The regular operation of the Brookhaven cosmotron at 2·2 GeV. shows the reliability of the device. In present machines the field decreases with radius, so that $dH/dr = -nH/r$, where for stability n lies between 0 and 1. In the strong-focusing or alternating-gradient machine, it is proposed to build a magnet consisting of a large number of sections with $|n| \gg 1$ and positive and negative values in alternate sections. Strong vertical and horizontal focusing forces act in alternate sections. The frequency of oscillations due to scattering and energy-spread at injection is greatly increased and the amplitude is correspondingly reduced. At first it appeared that a vacuum chamber section 2 in. × 2 in. could be used with a magnet radius of 300 ft., but further studies have shown that small errors due to magnet section misalignment and irregularities in the field can in certain circumstances lead to resonant oscillations the amplitude of which builds up catastrophically. At present it appears that it may be possible to use a gap $3\frac{1}{2}$ in. × 4 in. and accelerate protons to 20–30 GeV. at a cost of 20×10^{6} dollars. Machines for this energy region are being designed at Berkeley and the laboratory for the European Council for Nuclear Research.

The Birmingham proton synchrotron, which is now producing protons of energy near 1 GeV., was described by J. L. Symonds and C. A. Ramm. Symonds described the magnet circuit and gave details of the method used to achieve the correct relation between magnetic field and frequency over the cycle. The rate of rise of the field with time depends only on the generator voltage, nominally 1,100 V., which varies from cycle to cycle. The difference between the actual voltage and a standard voltage of 1,100 is used to correct, from moment to moment, the speed of the rotating condenser which varies the frequency of the radio-frequency oscillator in step with the increasing magnetic field. Ramm described the injection system and gave details of a very ingenious device for plotting trajectories in the synchrotron field.

J. R. Richardson, describing the Berkeley accelerators, announced that the bevatron has produced protons of energy 5 GeV. It is proposed in the near future to modify the synchrocyclotron (340 MeV.) to accelerate protons to 730 MeV. by increasing the field from 15 to 22 kilogauss. The rotating capacitor used to vary the frequency will be replaced by a vibrating reed system. J. R. Holt described the present stage of development of the Liverpool cyclotron, which is expected to give 400-MeV. protons, and Dr. S. E. Barden gave an informal talk on the Glasgow 300-MeV. electron synchrotron which at its present stage of development accelerates electrons to 200 MeV. Max Hoyaux (Charleroi) discussed the problem of radial focusing and the variation of optimum frequency with energy in very long heavy-particle linear accelerators.

Cosmic Radiation

The use of stacks of stripped emulsions is providing much new information about heavy unstable particles. D. H. Perkins (Bristol) described the methods of search. τ-, θ^{0}- and Λ^{0}-particles can be found by tracing π-mesons from rest to their point of origin in the stack. Nine two-prong stars appear to be produced by the decay of Λ^{0}-particles to a proton and a π-meson with a Q-value of $37·0 \pm 0·3$ MeV. Two τ-mesons have also been found.

The tracing through the stack of particles from stars containing two or more shower particles may give K-mesons and charged hyperons. This work has yielded one charged hyperon and seven K-particles with mass in the neighbourhood of 1,000 m_e which come to rest and decay. Protons with β in the range of 0·5–0·85 in general do not stop in the emulsion, but particles with velocities in this range can be identified from scattering and blob counting. One charged hyperon decaying in flight and two particles of mass 1,000 m_e have been noted. Earlier work of Daniel and Perkins seemed to show the emission from stars of particles with mass about 1,400, and at the conference last year in Bagnères de Bigorre the discrepancy between this mass value and that of the K-particle was pointed out. Further work has failed to show the existence of systematic error in the measurements, and the problem of the existence of this set of mass values between the K and proton mass is still unresolved.

Up to now, very few negative K-particles have been observed to come to rest and interact. J. V. Major described two interactions of K-particles at rest found by the Manchester group. In one case a π-meson and an evaporation proton are observed, and in the second case there are three short-range secondaries.

D. J. Hughes (Brookhaven) announced that the cosmotron group, continuing its work with the diffusion cloud chamber on pair production of heavy unstable particles, has observed three additional examples of Λ^{0}-particles which must have been

accompanied by θ^0-particles that did not decay in the chamber and one further example of the simultaneous production of a Λ^- and K^+-particle in the collision of a π^--meson with a proton. Dr. Hughes also discussed the Brookhaven results on the total cross-section for the scattering of $\pi^{\pm}$-mesons by protons. The π^- cross-section shows peaks at about 200 MeV. and 1 GeV., and the π^+ cross-section shows only the peak at 200 MeV.

K. H. Barker described an event found by the group from the Imperial College of Science and Technology, London, in which a heavy negative particle interacts in lead to give a Λ^0-particle. Momentum and ionization measurements suggest that the primary particle is probably a heavy meson. He also discussed the problem of improving the accuracy of the momentum-ionization method of measuring mass in cloud chambers. O'Ceallaigh (Dublin) described improvements in the gap-range method of mass measurement in emulsions and the optimum development conditions for discriminating between the masses of particles coming to rest in emulsions. J. McConnell (Maynooth) summarized his calculations on the probability of a negative proton being present in a shower caused by a nucleon–nucleus collision, the energy of the incoming nucleon being greater than 7 GeV. If the nuclear force coupling is pseudoscalar, the probability is about 2 per cent for a nitrogen and 4 per cent for a silver or bromine nucleus. If, as seems more likely from meson–nucleon scattering experiments, the coupling is pseudovector, the order of magnitude of the probability is about one in a thousand.

B. G. Owen described work in progress at Manchester on the energy spectrum of μ-mesons at sea-level. The differential spectrum follows a law $dN = E^{-\gamma} dE$, in which γ varies with energy from 1·7 at 0·6 × 10^{10} eV. to 3·0 at 5 × 10^{10} eV. The existence of a short-range non-electromagnetic interaction between μ-mesons and nucleons has been inferred from the supposed existence of an anomalous non-Coulomb scattering of μ-mesons. J. McDiarmid (Manchester) described work at a water-equivalent depth of 26 m. with a multi-plate cloud chamber. A comparison of the results with the theories of Molière and Olbert suggests that no appreciable anomalies in the scattering exist.

Two papers on extensive air showers were contributed by the Harwell group. J. V. Jelley described some very interesting work on light pulses associated with showers. The light is found to be polarized and is undoubtedly Čerenkov radiation, presumably from the cores of the showers. The radiation is highly directional, and this property has been used to search for localized sources of cosmic rays. There is no correlation between the direction of the radiation and point radio-sources in the galaxy. W. Galbraith described the Harwell extensive shower-set (Cranshaw and Galbraith) which detects showers of energy 10^{10}–10^{17} eV. The primary particle spectrum seems to obey an integral power law $N(> E) \sim E^{-\gamma}$ up to 10^{17} eV. with γ about 1·7. No obvious marked variation with solar or sidereal time has been found, though there is some evidence for a possible sidereal variation at higher energies.

The polarization of scattered protons observed at Rochester, N.Y., gives information on nuclear tensor or spin-orbit forces. T. C. Randle gave information about the Harwell experiments of Dickson and Salter in which protons scattered by carbon at 20° are scattered a second time by carbon at 20°. There is a considerable difference between the number of protons to the right and the left in the second scattering. The asymmetry is most marked at higher energies of about 140 MeV., and the maximum polarization observed for protons elastically scattered from carbon is between 75 and 100 per cent. The Brookhaven high-speed chopper for neutron spectroscopy by the time-of-flight method was described by D. J. Hughes. The neutron detection is by boron trifluoride counters over a path of 20 m. in helium, and a hundred separate velocities are recorded simultaneously. The high resolution makes possible a very detailed and accurate study of the radiation and particle widths of levels and of level densities for comparison with the predictions of various nuclear models.

To conclude this part of the meeting, J. L. Synge (Dublin) discussed certain considerations relating to the relativistic theory of the collisions of particles which possess angular momentum.

Excitation and Collision Phenomena

A group of papers, mainly on excitation and collision processes, were contributed from the Departments of Applied Mathematics (D. R. Bates) and Physics (K. G. Emeléus) of The Queen's University, Belfast. In the opening paper, A. Dalgarno gave a general review of the phenomenon of auto-ionization, the radiationless transition into the continuum which can occur when an energy-level of an atom is above the lowest ionization potential. This process broadens the corresponding spectrum lines, and widths as great as 500 cm.$^{-1}$ occur. Great interest is attached to doubly excited levels of helium and beryllium, and Dr. Dalgarno stressed the need for further experimental work.

Two papers dealt with the application of the Landau–Zener formula for transition probabilities. The first paper (D. R. Bates and B. L. Moiseiwitsch) dealt with charge transfer processes, $H + X^{++} \rightarrow H^+ + X^+$ ($X = $ Be, Si or Mg), arising from the pseudo-crossing of the potential energy curves of the initial and final systems. The cross-sections associated with these processes have been calculated for a wide range of impact energies. The second paper (D. R. Bates and J. T. Lewis) described the modification of the formula for application in the case of degeneracy. The degeneracy may greatly alter the dependence of the probability on the radial component of the velocity of relative motion at the crossing-point.

U. Öpik discussed the Layzer approximation for the treatment of collisions of electrons with atoms based on first-order perturbation theory. Results for the excitation of the 2^2S level of hydrogen and the 1$s2s^1S$ and 1$s2s^3S$ level of helium were compared with those obtained by other methods. The agreement seems sufficiently promising to justify further work with the view of establishing means of obtaining cross-sections for slow incident electrons correct to within a factor of two. The application of the Born approximation to the study of rotational and vibrational excitation of molecular hydrogen by electron impact was treated by T. R. Carson. The choice of the interaction potential has a marked influence on the vibrational excitation function in the low-energy region.

D. T. Stewart described experimental techniques of determining excitation functions of nitrogen band spectra using electron beam sources. A photomulti-

plier in conjunction with a tuned a.c. amplifier seems to give more accurate results than photographic photometry. The excitation functions of N_2^+ have broad maxima for the Meinel bands at electron energies of 90 eV. and for the first negative bands at 95 eV.

In a discussion of the relation of nitrogen atoms to active nitrogen, P. Gribbon pointed out that uncertainty still exists about many features of the production and persistence of nitrogen atoms in discharge tubes and the upper atmosphere. W. Hayes (Dublin) discussed the interpretation of the high-multiplicity bands of the manganese halides in the near ultra-violet and gave an account of new work on these spectra which has resulted in the discovery of many new band systems.

T. E. NEVIN

SCIENTIFIC COUNCIL FOR AFRICA SOUTH OF THE SAHARA

REPORT FOR THE YEAR 1952–53

THE second report of the Scientific Council for Africa South of the Sahara, which covers the year July 1952–June 1953*, refers to the marked tendency for certain major problems to be considered sub-regionally. There are now soil problem committees meeting in three out of four sub-regions, and this pattern is expected to be followed as collaboration in other subjects develops. Although the mode of operation of the Council has become better defined, the establishment of the secretariat was only completed towards the end of 1952, and in some directions scientific collaboration has made slow progress.

At the third session of the Council during August 11–14, 1952, at Bukavu (Costermansville), Belgian Congo, special attention was paid to maps and survey, geology, meteorology, zoology, fisheries and social studies. A specialist meeting on fauna research was held during October 1952 in Nairobi, and an inter-African conference on fauna and flora, convened at Bukavu for October 1953, was scheduled to review the international convention of 1933 in the light of subsequent experience and to consider whether any modifications in policy concerning wild-life are required. A meeting of specialists in planning social research was held at Makerere College, Uganda, during February–March 1953, which listed a number of joint projects and statements on organizations and institutes engaged in social research in Africa and on work in progress which are being prepared for the participating countries or sub-regions. A symposium on African hydrobiology and inland fisheries was held at Entebbe, Uganda, in October 1952, and a report including summaries of the papers and discussions is appearing as C.S.A. Publication No. 6.

Much effort has been devoted to the preparation of a comprehensive list of maps available for the whole region, and this list, including special subject maps as well as topographical maps, has been issued as C.S.A. Publication No. 4. A meeting to discuss the possibility of greater co-ordination, particularly in special subject maps, was to be convened after the fourth session of the Council in August 1953. Good progress is reported in the co-ordination of geological

work in the various sub-regions, and full agreement is anticipated on the appointment of a geological scientific correspondent to maintain touch with and assist the many geological surveys and other organizations for geological investigation in the region. A project has been developed for the preparation of a climatological atlas of Africa, but it is expected that two or three years will be required to collect and analyse all the data available on rainfall, temperature and winds, etc., and prepare the series of maps. The "Flore du Congo Belge" and the "Flora of East Africa" were enlarged during the year by further publications, and information has been collected for a comprehensive list of taxonomists who are engaged on African problems in the many different groups of plants and animals. During the year particulars of two hundred and forty scientific and technical libraries in Africa south of the Sahara were published in C.S.A. Publication No. 3, and particulars are being collected of the holdings of periodical literature in the libraries of the sub-regions. Publication of a list of these holdings is to be followed ultimately by the preparation of comprehensive catalogues, at least for the major libraries. Steps have also been taken towards the preparation of a directory of scientific institutes and organizations in the region.

CACAO RESEARCH DURING 1952–53

THE report of the West African Cacao Research Institute for 1952–53* is brief, giving little more than notes on the many lines of investigation that are being followed. Studies of the swollen shoot virus are, as usual, prominent, and many of them are systematic observations that have been going on for several years. These include the recording of symptoms produced in young seedlings by new virus strains (which are still being found) and cross-protection tests with the view of classification. The search for new alternative hosts goes on, and it is hoped that eventually all species related to *Theobroma cacao* occurring in the Gold Coast will be tested for susceptibility. Transmission trials with possible new vectors are linked up, on the entomological side, with equally systematic examination of mealybugs and their parasites and predators, and with extensive screening of systemic insecticides for control of vectors.

The chemistry section is attempting, by paper chromatography, to discover differences in composition between healthy and diseased tissues, analysing also the secretions of mealybugs that have fed upon healthy and diseased tissues. The botany section has cultured cambial tissues *in vitro* from healthy and diseased trees, so far without finding any differences in growth pattern or histology. Other diseases and pests of the cacao tree are receiving attention, especially capsids and the black pod disease caused by *Phytophthora palmivora* Butler. It is noted that dusting against capsids with DDT seems to have no important deleterious effect on pollinating insects. One dusting machine among a number tried merits further attention. Long-term