gical education should be supplemented, the qualification to its recommendation for the establishment of one or more colleges of applied science must not provide an excuse for indefinite postponement of this new experiment. Even if the new institutes of higher technology are established immediately, they cannot be expected to make an important contribution to higher technological education within much less than a decade. With the new demands on material and human resources, it is inconceivable that they will ever be established unless such resources are allotted to them as part of a considered distribution in which due, but not exclusive, regard is had to the competing demands of universities and industry and government departments.

On the government organisation for scientific research, besides the observations on the Department of Scientific and Industrial Research already considered (see *Nature*, September 9, p. 410), the Advisory Council states that a report received last November has fully confirmed the hopes entertained that the appointment of a chief scientist in the Ministry of Fuel and Power could make a valuable contribution to the discharge of the Minister's scientific responsibilities. The record of the first year of work of the new Division amply justifies the view that the Advisory Council took in its first annual report of the importance of creating a scientific division in executive departments with scientific responsibilities, and shows how much vitality is infused into research when its organisation and direction are planned in relation to the needs of potential users. The Advisory Council has also considered the organisation and needs of the Colonial Research Service, and particularly the comparative isolation in which members of this Service would inevitably work and the consequent difficulty which might be experienced in recruiting the best scientific workers for the posts. The Advisory Council feels strongly that the success of any scheme of research in the Colonies will depend upon the extent to which co-operation with the centres of research at home is made effective and the secondment is facilitated of members of the staffs of the research councils and the universities for periods of service in the Colonies.

In regard to co-operation between centres of research at home and overseas, it has been agreed with scientific representatives of the Colonial Office that before a research institution in the United Kingdom is asked to undertake work on behalf of the Colonies, the research council responsible for the institution would, wherever possible, be consulted. Provided overlapping and wasted effort is thus avoided, the Advisory Council sees great advantages in a continuing and increasing use by the Colonies of the facilities for agricultural research available in the United Kingdom. The organisation of ecological research was also considered, and the proposed programme of work of the Nature Conservancy has been discussed with its chairman, director-general and other members. The Advisory Council hopes that the establishment of the Nature Conservancy will encourage public recognition of the importance of ecology and create openings for trained ecologists. The responsibilities of the Conservancy are limited to Great Britain; but similar problems arise on a vast scale in other parts of the Commonwealth, and it is urgent to direct attention to the value of ecological work in the universities and elsewhere.

During the year the Council was consulted by the director of the Scottish Seaweed Research Association regarding a proposed attempt to introduce into British waters the type of foreign seaweed known as *Macrocystis*, in view of the comparative ease and economy with which it can be harvested compared with existing methods of harvesting the native *Laminaria*. A special committee, under the chairmanship of Sir Edward Salisbury, which was appointed by the Council, advised against the experiment on the grounds of risks to navigation and inshore fishing, and these conclusions were endorsed by the Council. The Council was also asked to examine existing departmental arrangements for controlling the use of potentially toxic substances or processes in the preparation of consumer goods, and appointed a special committee, with Prof. S. Zuckerman as chairman, for this purpose. Various problems relating to scientific work overseas, including the Technical Aid Programme, were also handled by the Advisory Council.

PHYSICS AT LIVERPOOL

THE Physical Society's summer provincial meeting was held at Liverpool on July 7 and 8 under the chairmanship of Prof. R. E. Peierls. The meeting gave speakers from the Experimental and Theoretical Physics Departments of the University an opportunity of presenting to members of the Physical Society and other visitors a picture of the work being carried on there in two main fields: nuclear physics, experimental and theoretical, on one hand; and the theory of the motion of electrons in solids, on the other. Contributions to the discussion from members of the audience provided many valuable comments and suggestions, and in some instances made known investigations on similar or allied lines being pursued elsewhere.

The meeting commenced with papers on the theory of solids. Recent developments arising from the work which Prof. H. Fröhlich and his collaborators, associated with the British Electrical and Allied Industries Research Association, have been pursuing over a number of years, on the interaction of moving electrons with the lattice vibrations in a solid, were surveyed by Prof. Fröhlich himself and Dr. H. Pelzer. The latter dealt mainly with conduction electrons in dielectrics, using a classical model for illustration. The excitation of lattice vibrations by the field of an electron moving in a known path can be calculated, the polarization being found at every point. Dr. Pelzer showed how the resulting rate of loss of energy by the electron can be evaluated as the total polarization energy produced in a layer of the medium lying far behind the electron and normal to its path, and of thickness numerically equal to the speed of the electron. A formula has been obtained[1] which is similar to one derived differently by A. Bohr. Also, the self-energy of the electron due to the interaction can be calculated, by integrating the interaction-energy density in the field over all space. This energy can be used to define an effective interaction mass, to be added to the ordinary mass of the electron. The interaction mass is proportional to the inverse cube of the velocity, and so diverges at zero velocity. However, a quantal theory would be expected to remove this divergence, owing to the diffuseness of the wave representing the electron. Dr. Pelzer referred briefly to a completely quantal treatment of the problem by Fröhlich, Pelzer and Zienau[2]. This permits recalculation of the quantities previously obtained classically. The total effective mass of the electron turns out at low velocity to be very little greater than the ordinary mass. This was put forward as an argument against the Landau concept of self-trapping of an electron. Finally, Dr. Pelzer pointed out that in ionic and non-polar crystals, notably semiconductors, free electrons acting as intermediary agents could lead to absorption of electromagnetic radiation by the longitudinal lattice vibrations, although this is normally forbidden.

Prof. H. Fröhlich explained how the application to metals of such considerations of the interaction between electrons and the lattice vibrations has led him to a theory of superconductivity. He claimed that the problem of finding a mechanism which can separate two distinct states, the normal and the superconducting, by an energy of the known extremely small magnitude, is thus solved. However, the electromagnetic properties of the superconducting state have not yet been fully investigated. The calculations adopt the simple Fermi gas model for the unperturbed motion of the electrons, while the lattice vibrations are handled by methods familiar in quantum field theory. Interaction results in the excitation of virtual vibration quanta by the electrons. This can be considered as producing self-energy of the electron gas, which is calculated by the second-order perturbation method. Part of the self-energy is expressible as an interaction energy between pairs of elements of the cloud of electrons in momentum space. At absolute zero the distribution in this space should ideally be chosen to minimize the energy: some distortion of the Fermi sphere would in general be expected. Prof. Fröhlich has considered a family of distributions obtained by displacing outwards a thin shell of electrons from the Fermi surface. A minimum of total energy is obtained for a small displacement if a number F measuring the strength of the electron-lattice interaction is sufficiently large; but otherwise zero displacement gives the lowest energy. Superconductivity of the metal is identified with the condition of distorted ground-state, and its existence thus depends on F. This quantity can be estimated from the high-temperature conductivity. It is found to be of the required order of magnitude, and also its value for different metals seems to be roughly correlated in the correct way with the existence or otherwise of superconductivity. The properties of different isotopes of the same metal are simply related on this theory. Thus the superconductive transition temperature is inversely proportional to the square root of the isotopic weight. Recent experiments on mercury[3,4] have confirmed this dependence. In the discussion, Prof. R. E. Peierls expressed the opinion that the isotopic effect is strong evidence in favour of the theory; and he and others emphasized the desirability of carrying out experiments with more isotopes.

A paper by Dr. K. Huang dealt with the theory of F-centres, which are of particular interest as the simplest example of impurity centres. They have been carefully investigated experimentally by Pohl and his collaborators, but the theoretical discussion of many aspects has hitherto been only qualitative and tentative. Dr. Huang has set out to analyse more thoroughly two properties of F-centres, namely, (1) the shape of their absorption bands, which show broadening with rise of temperature, and (2) the photoconductivity, which falls off very rapidly when the temperature drops below a certain point. Accepting the general ideas which have been put forward to account for these phenomena by way of the interaction of the F-centre electron with the lattice vibrations, Dr. Huang presented a quantitative development of the theory. He has calculated transition probabilities using wave functions for electron plus lattice, analogous to those of Born and Oppenheimer for molecules, and treating the lattice approximately as a dielectric continuum. Absorption spectra at different temperatures, which he has plotted with the assistance of Miss A. Rhys, were shown to fit measured curves closely. The treatment of photoconductivity was not described in detail, but evidence was presented of a broad agreement with experiment.

Dr. B. Szigeti discussed the dielectric and elastic properties of ionic crystals. He proposed a model which would be consistent with the observed dielectric constant and would also conform to the Cauchy relations between the elastic constants, and to a newly derived relation between the compressibility and absorption frequency. Both the relations mentioned are experimentally well fulfilled for alkali halides. The essential feature of the model proposed is to take into account the distortion of the electron cloud of the ions due to the short-range repulsive forces. In an elastic deformation conditions are such that, even when this distortion is admitted, the restoring forces are effectively central, so that the Cauchy relations hold. As indicated above, the model also leads to a satisfactory relation between the compressibility and the absorption frequency. In an electric field, the distortions caused by the repulsive forces explain qualitatively the deviation of the experimental value of the dielectric constant from the value obtained if the polarization is attributed to the Lorentz force only. The model, in contrast to previous ones, gives the correct sign for this deviation of the dielectric constant.

The meeting passed on to topics in experimental nuclear physics. Mr. D. G. E. Martin gave a brief summary of the technique of the magnetic spectrometer for the measurement of the energy and intensity of β- and γ-radiation. He pointed out the importance of careful design of the apertures inside the instrument, so as to ensure that the minimum area of the internal surfaces of the spectrometer box is exposed to the view of both the source and the detector. Where the β-particles enter the detector they usually have to penetrate a thin foil, and absorption and scattering in this foil can lead to serious distortion of the spectrum in the region of small energies. Thin foils of 'Zapon' have been used, supported on copper mesh; but this arrangement is not satisfactory at the larger energies because the β-particles begin to penetrate the copper. When two counters are used in a coincidence arrangement in order to reduce the background counting-rate due to γ-radiation, the loss in the counting-rate due to the window is much greater for a particular energy of the β-radiation, because a β-particle scattered through a small angle in the window may not reach the second counter. Distortion of the spectrum may be produced also by scattering from the foil carrying the source itself, or by self-absorption in the material of the source. For measurements at an energy of 5 keV., the total thickness of foil and source should be less than 5 μgm./cm.^{2}. Various methods were described for the preparation of such sources. Mr. Martin went on to discuss the different types of detector which can be used with a magnetic spectrometer, including the scintillation counter and the photographic emulsion. He then outlined the problems involved in the measurement of the intensity of γ-radiation and of internal conversion coefficients. The discussion was illustrated by reference to work done in the laboratory on the radiations from a thorium-active deposit[5,6].

Mr. B. Collinge gave an account of his work on the dead time of self-quenching counters. The limitations to the performance of self-quenching counters were briefly discussed, and the work of Simpson[7] and Hodson[8] on reducing the dead time of argon-alcohol counters was described. Their method is to attempt to collect the positive ions formed during the discharge on the central wire after each count. To do this, a circuit is used which switches the wire potential to a negative value with respect to the cathode for a few micro-seconds after each count. It was pointed out that there may be a different explanation of the reduction in dead times so obtained. Experimental evidence was given to show that a sudden reduction of the wire potential causes the ion sheath to be confined to the part of the counter wire close to the place where the particle has passed. The remainder of the wire, not being involved in the discharge, is sensitive to further ionizing events as soon as the wire potential is restored to the working value. By using a very short counter, so that localization of the discharge does not occur, it has been shown that a reduction in the dead time can also be achieved by ion collection in the way suggested by Simpson and Hodson. Results showing the effect of causing localization of the ion sheath on the dead time of a counter were presented. The dead time of a counter 30 cm. long was found to be 20 μsec. and independent of the counting-rate up to $1 \cdot 8 \times 10^6$ counts per minute.

Some recent work with the 37-in. cyclotron by Holt and Young and also by Hughes was described. This was concerned with the determination of the angular distribution of the disintegration particles from targets bombarded with deuterons of energy up to 8 MeV. In one investigation[9] a differential ionization chamber was used to detect protons from the reaction $^{27}Al(d,p)^{28}Al$. The protons from a target of aluminium foil emerged from the target chamber through a curved window of 'Cellophane'. Thus the angle between the detector and the beam of deuterons could be varied continuously from 25° to 145°. At each setting of the angle of the detector the spectrum of the protons was determined by the use of calibrated absorbers. The intensity of the protons belonging to a particular group was measured by finding the area beneath the peak in the spectrum belonging to that group. Results were shown for seven groups of protons and for bombarding energies of 4·6, 5·8 and 7·5 MeV. These indicate a general tendency for the intensity of the protons to increase towards the forward direction. In the case of the proton group of longest range, a number of maxima and minima occur in the curve showing the angular distribution. An extension of these experiments in which intensities could be measured at small angles indicates a large peak in the forward direction in the case of the group of longest range with a deuteron energy of 7·5 MeV. The intensity decreases by a factor of 30 between 0° and 25° in this particular case.

The angular distributions of the neutrons emitted from light elements bombarded with 8-MeV. deuterons have also been measured. A thick polythene layer proton recoil chamber was used to detect the neutrons. On account of the increase in sensitivity with increasing neutron energy, this method of detection gives more weight to the higher-energy neutron groups. In all cases the neutron distribution showed a pronounced forward maximum in intensity. The half-widths of the forward peaks were of the order of 30–40°, tending to decrease as the atomic number of the element increased. The forward neutron intensity also decreased as the atomic number increased, but not monotonically. In the cases of beryllium, lithium, magnesium and aluminium, there was evidence of a peak at a small angle to the forward direction, with actually a shallow minimum in the forward direction; this tendency became pronounced as the threshold on the detector was increased so as to limit detection to the highest energies. The forward neutron intensity was found to decrease by a factor of three, and the half-width to increase slightly for beryllium, magnesium and aluminium when the deuteron energy was lowered to 7·2 MeV. In the case of magnesium the distribution was isotropic at about 5·5 MeV. bombarding energy. Taken together, these results seem to provide strong evidence for a 'stripping' reaction, the deuteron being split up by the nuclear collision. This process would be expected to lead to a strong forward peak of either protons or neutrons, whereas the type of process involving an intermediate nuclear state would lead to a more or less isotropic distribution.

In the field of nuclear theory, Dr. R. Huby spoke on certain nuclear reactions which are supposed to proceed by a direct transition from initial to final state, without the intermediate formation of a compound nucleus, as in the Bohr theory. Direct processes were expected often to be distinguished by a forward maximum in the angular distribution of the emitted particles. As an example, he discussed calculations by A. B. Bhatia and K. Huang to account for the above-mentioned (d,p) and (d,n) observations by Holt and Young, and Hughes. By handling a modified 'stripping' process with the Born approximation, an angular distribution is obtained having roughly the correct forward maximum. In the discussion, Prof. Peierls referred to calculations made on the same problem at Birmingham, which lead to apparently similar results by a rather different technique. Another direct process mentioned by Dr. Huby was the inelastic scattering of charged particles by nuclei, owing to the electrostatic interaction. He and Mr. H. C. Newns obtain a formula which predicts cross-sections up to about 10^{-26} cm.^{2} for excitation of a single level, and which is in approximate agreement with certain experiments.

Two speakers dealt with the nuclear explosions occurring when a fast particle passes through, or a meson is absorbed by, a nucleus. Dr. K. J. Le Couteur spoke on his work relating particularly to heavy nuclei, for which the Bohr statistical model is assumed to be applicable, and Miss S. N. Ruddlesden on her and Mr. A. C. Clark's study of meson absorption by light nuclei, taking account of the initial configuration of the constituent nucleons in the nucleus. Dr. Le Couteur considered the relatively slow charged nuclear particles ejected in explosions. These are supposed to be evaporated from the excited nucleus, in a process which can be dealt with thermodynamically. Their statistical distribution can be calculated for given excitation energy of the nucleus. Simple approximate expressions have been obtained for (i) the mean energy of the charged particles as function of the excitation energy, (ii) the relation between their mean number and mean energy, (iii) the relation between the standard deviation of the number and that of the energy. The fluctuations in the number are sufficiently small for this alone to give a good indication of the excitation energy. The calculations of negative meson capture by light nuclei, reported on by Miss Ruddlesden, lead to the relative probabilities of different modes of disintegration of the nucleus, and also to the energy spectrum of the charged particles ejected. Two types of meson-nuclear interaction have been considered. The lightest nuclei producing charged particles, namely, helium-3 and -4, were dealt with first, and later carbon and other α-particle nuclei. The energy spectrum of α-particles issuing from carbon can be made to agree quite well with experimental results from Bristol[10], by adjustment of one available parameter.

The final afternoon of the meeting was occupied with an inspection of the new Nuclear Physics Laboratory and the George Holt Physics Laboratory, after an introductory talk by Prof. H. W. B. Skinner on the layout and purpose of the former. He stated that the new Laboratory has been designed to accommodate two particle accelerators, a large synchro-cyclotron and a Cockcroft–Walton generator. Started in the middle of 1948, the main part of the building was completed by the end of 1949. It is hoped that the large cyclotron will be running by the end of 1951. The one-million-volt high-tension set which is now nearly complete follows conventional design. Two new features are incorporated: the ion source is of the radio-frequency type suggested by Thonemann, and the magnet used to deflect the beam through 90° is of the permanent type. This has a motor-driven shunt which enables the magnetic field to be varied between zero and a maximum of 10,000 gauss. The synchro-cyclotron is designed to accelerate protons to an energy of 400 MeV. The electromagnet has poles 156 in. in diameter and contains 1,640 tons of steel, which have already been delivered. The two energizing coils are wound from 1½-in. square-section aluminium and are cooled by passing water through a ⅝-in. diameter hole in the centre of the conductor. The coils weigh 30 tons each. The magnet will produce a field of at least 18,000 gauss at an input power of 840 kW. The cyclotron is surrounded by a concrete wall 6 ft. thick. Additional screening is effected by means of a bank of pulverized sandstone 15 ft. thick. A concrete wall of at least 12 ft. effective thickness, part of which will be constructed in removable blocks of loaded concrete, will separate the cyclotron from the experimental room. Easy access will be provided by means of a 30-ton cylindrical door which may be raised or lowered as required. Above the cyclotron room and separated from it by a concrete roof 5 ft. thick is the equipment room which will house most of the auxiliary gear. The control room will be situated in the main laboratory block.

R. Huby

[1] Fröhlich, H., and Pelzer, H., E.R.A. Report, Ref. L/T 184 (1948).
[2] Fröhlich, H., Pelzer, H., and Zienau, S., *Phil. Mag.*, **42**, 221 (1950).
[3] Maxwell, E., *Phys. Rev.*, **78**, 477 (1950).
[4] Reynolds, C. A., Serin, B., Wright, W. H., and Nesbitt, L. B., *Phys. Rev.*, **78**, 487 (1950).
[5] Martin, D. G. E., and Richardson, H. O. W., *Proc. Roy. Soc.*, A, **195**, 287 (1948).
[6] Martin, D. G. E., and Richardson, H. O. W., *Proc. Phys. Soc.*, A, **63**, 223 (1950).
[7] Simpson, J. A., *Phys. Rev.*, **66**, 39 (1944).
[8] Hodson, A. L., *J. Sci. Instr.*, **25**, 11 (1948).
[9] Holt, J. R., and Young, C. T., *Proc. Phys. Soc.*, A, **63**, 833 (1950).
[10] Menon, M. G. K., Muirhead, H., and Rochat, O., *Phil. Mag.*, **41**, 583 (1950).

ROYAL GREENWICH OBSERVATORY

ANNUAL REPORT

THE report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory, presented at the annual visitation of the Royal Observatory, held on June 3, refers to the period from May 1, 1949 to April 30, 1950, and exhibits the state of the Observatory on the latter date. Although a certain amount of progress has been made, things are still far from satisfactory, and the public should realize the serious difficulties under which the Royal Greenwich Observatory is struggling at present.

The temporary repair to the two large domes by placing tarpaulin inside them is only a partial success, and rainwater is able to percolate. The famous Octagon Room, Flamsteed's observatory, is without glass and requires a considerable amount of internal repair; meanwhile, further deterioration is taking place in historic buildings—a condition of affairs which has given rise to much adverse comment. Equally unsatisfactory are the housing conditions for the staff at Herstmonceux. Although the council houses made available through the Ministry of Health are sufficient for the needs of the junior and industrial staff, they are unsuitable for the senior staff, and the lack of houses for the latter is a serious handicap to recruitment for senior grades. It is pointed out that the only solution is for the Admiralty to build houses which are suitable to the status of the officers concerned. The proposal has been made to the Admiralty that houses should be built for the senior observing staff, who could thus reside fairly close to the Observatory; but unfortunately no decision has yet been given on the proposal. This is a matter of grave urgency, and, unless it is attended to forthwith, the work of the Royal Greenwich Observatory will be very seriously handicapped.

In addition to these drawbacks to the personnel, there is great disappointment at the slow rate of progress in the construction of new buildings for the instruments at Herstmonceux, and delays in this work are partly due to the remarkable decision that detailed requirements for every new building must be known before the construction of one of them can be commenced. A ray of hope illuminates a doubtful future—if these delays are not cumulative in their effect and if the new construction (when it commences) is sufficiently accelerated, the whole of the removal to the new site will be completed by the end of 1953.

Among a number of satisfactory features may be mentioned the move of the Solar Department and also, in part, the section of the Magnetic and Meteorological Department which was at Greenwich, and of the Nautical Almanac Office from Bath. The adaptation of the Great Hall of the Castle as a library is making good progress, and the conversion of the permanent chronometer rating and storage rooms under the Great Hall has been completed, the rooms now being in use.

It is impossible in the limited space available here to deal in detail with the report, which should be read by all who are interested in the future of the Royal Greenwich Observatory, and many will be specially interested in the plans for the installation of the Meridian Group and also the Equatorial Group. The latter will have three isolated domes for the 26-in., 28-in. and astrographic refractors, a three-dome building being in front of them to take the