tion seems sometimes to be absorbed by an atom and cause a jump to perform itself backwards; but I certainly believe that some essential element of irreversibility must eventually be discovered in atomic action, because the older kinetic theory as developed statistically leaves irreversibility essentially unexplained.

Where is the fallacy of the time-idea in our notion of frequency? Look at a swinging pendulum and count its movements in a measured time. This you can do, and you thus find the frequency. Similarly, let me ask you to look at a hydrogen atom in a steady state and count the number of revolutions of the electron in a measured time. This sounds logical enough, but the atom in a steady state does not radiate, and there may be a fundamental fallacy in even imagining that one might look at such an atom. As we see things, so we think of them, and our see-thinking may be absurd when carried over to things which are essentially un-seeable; essentially un-seeable, mind you, not merely too small to see.

Or suppose you look at the "kinks" (waves?) of the emitted radiation as they come out of an atom when it jumps from Bohr state to Bohr state and count the number of kinks in a measured time. This also sounds logical enough, but after the jump the atom is in a steady state and no time elapses in the atom, and once a radiation is established the radiation is itself a steady state and no lapse of time can reside in the radiation. The idea of frequency would seem to be applicable to radiation only when the radiation has stretched out in our large-scale world and has come into relation with large-scale things where time is a legitimate idea. Our intuitive notion of time, as it seems to me, is tenable only in large-scale physics, or macro-physics, but untenable in small-scale physics, or micro-physics.

My suggestion that time does not exist in a purely mechanical system refers only to what we think of as continuous time or time flow, it is not intended to deny the reality of coincidences in time.

All, or nearly all, of our time and space experience grows out of coincidences in time and coincidences in space. Even the measurement of a length depends wholly on coincidence observations. A yard stick is fitted to the successive parts of the distance to be measured and each such "congruence operation" involves two coincidence observations, one at each end of the yard stick. The measurement of a time interval also consists almost wholly of coincidence observations. Furthermore, the vast complex of everyday life in its sense aspects involves little else than coincidence observations. But even men of the street are accustomed to express time and space experiences in terms of quantitative ideas, and this purely mental habit has come about, no doubt, because to express these experiences in purely experimental terms would be extremely tedious. Our quantitative notion of time as a continuum of duration and our quantitative notion of space as a continuum of extension come wholly, it would seem, from our mathematical predilections. No one, as it seems to me, could maintain that these quantitative notions of space and time are essential in the most complete sense-orientation of a man in any situation in life; but it would be impracticably and even unintelligibly tedious to talk about space and time experiences without using quantitative ideas. Herein lies the reason why any point of view which is contrary to our ideas of continuous space and continuous time is unwelcome. Our mathematical bias, note that I now use a stronger word than predilection, is wholly in favor of continuous mathematics and wholly opposed to discontinuous mathematics, and the reason of this bias is evident to those who have attempted to develop a discrete or discontinuous mathematics!

I am convinced that the qualifications of our ordinary notion of time which I have suggested[2] contain nothing whatever that is inconsistent with experience, and, however absurd these qualifications may seem to be, it must be admitted, as it seems to me, that the quantum puzzle becomes more clearly defined as a puzzle in terms of these qualifications.

If the Planck and Bohr postulates contain some new thing that is essential for the description of atomic action, and no one who is familiar with the amazing developments that have been made on the basis of these postulates can doubt that they do contain something new which is essential, then we must expect soon to see a more wonderful transformation of our conceptions of the physical world, a vastly more wonderful transformation, than that which has resulted from the relativity theory.

WM. S. FRANKLIN
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SCIENTIFIC EVENTS

EXHIBIT OF THE ROYAL SOCIETY AT THE BRITISH EMPIRE EXPOSITION[1]

ONE of the most fascinating and impressive sections of the British Empire Exhibition, though admittedly one that is essentially specialist, is the exhibition of pure science arranged by the Royal Society. In connection therewith the Royal Society has now issued a handbook which is a great deal more than a mere catalogue, and is, indeed, a volume which might well be secured by students of pure science and amateurs,

[2] This suggestion was first made in a paper on "Entropy and time" in the *Physical Review*, Vol. XXX, pp. 766–775, June, 1910.

[1] From the London *Times*.

and preserved by them as a text-book long after the exhibition has been closed.

As a foreword to the handbook shows, this exhibit was organized, at the request of the government and out of funds provided through the Department of Overseas Trade, by the Royal Society. The council of that body appointed a British Empire Exhibition Committee, under the chairmanship of Sir Richard Glazebrook, to carry out the task. In the majority of cases the exhibits are shown by the scientific men actually engaged in the work, supplemented by instruments lent by some of the leading firms of scientific instrument makers. Arrangements have been made, wherever possible, to demonstrate the use of the instruments and apparatus in the methods in which they have been employed by the authors whose work is illustrated. Demonstration benches, fitted with gas, water and electricity, are provided, and a staff of scientific assistants is in attendance. Owing to the limited space available it has been necessary to arrange for the rotation of certain of the exhibits, particularly those shown on the demonstration benches.

The handbook is arranged in two parts. The first is a series of articles by well-known authors, intended to give some indication of the state of science at the time of the opening of the exhibition, while the second is a descriptive catalogue. In certain cases the Royal Society has been instrumental in arranging exhibits which are shown in the scientific section of the chemical hall in the palace of industry. Descriptions of these exhibits are given in the catalogue, but the fact that they are shown elsewhere is indicated. The following is a list of the articles in the handbook, together with the names of the contributors:

"The genesis of the Royal Society," Dr. Irvine Masson; "The electron," Sir Joseph Thomson, O.M.; "X-rays and crystal structure," Sir William Bragg; "Electricity and matter," Sir Ernest Rutherford; "Atoms and isotopes," Dr. F. W. Aston; "Verification of the theory of relativity," Sir Frank Dyson; "The interior of a star," Professor A. S. Eddington; "The origins of wireless," Sir Richard Glazebrook; "Thermionic valves," Professor J. A. Fleming; "The origin of spectra," Professor H. Fowler; "Helium gas and its uses," Professor J. C. McLennan; "The principles of fine measurement," Dr. J. E. Sears; "The circulation of the atmosphere," Sir Napier Shaw; "The water in the atmosphere," Dr. G. C. Simpson; "Weather forecasting," Lieutenant-Colonel E. Gold; "Atmospheric electricity," Dr. C. Chree; "The origin of man," Dr. A. Smith Woodhead; "The circulation of the blood," Professor E. H. Starling; "The biological action of light," Professor D. T. Harris; "Muscular work," Professor A. V. Hill and Professor E. P. Cathcart; "Insect mimicry and the Darwinian theory of natural selection," Professor E. B. Poulton; and "The origin of the seed plants," Dr. D. H. Scott. Sir Richard Glazebrook (physics), Sir Napier Shaw (geophysics), and Mr. Tate Regan (zoology and botany) have written in the descriptive catalogue of exhibits.

FRENCH UNIVERSITY MISSION TO MOROCCO

WITH the purpose of stimulating interest in the French undertakings in Morocco and spreading a true knowledge of the country, the administration of the Protectorate arranged for a French University Mission to visit the country in October, 1923. According to the British *Journal of Geography* the mission was not confined solely to geographers, but numbered among its members geologists, jurists and historians. An entire number of *Annales de Géographie* (May 15, 1924) is given up to an account of the tour, and to articles both by members of the mission and by government officials. From October 9 to 26, a considerable area was covered, partly by motor, partly by varying local means of transport. Landing at Casablanca, the party visited Marrakesh, Rabat, Meknes and Fez, besides other places further from the beaten track, and reembarked at Oran. The first article in the *Annales,* by J. Célérier, gives a detailed account of the country traversed, with particular attention to the physical features and regions and the position of the towns: its geology is detailed separately by J. Savornin. Proofs of the desiccation of a portion of Morocco are advanced by E. de Martonne and others in the course of a morphological study of the Rehamna massif. Here the change in the hydrographic *régime* has been related to deforestation. The present condition of the vegetation of Morocco is detailed by M. Sorre, who, by constructing a provisional vegetation map, has shown its close relation to the rainfall, particularly in the coincidence of the "Mediterranean" area of the Atlantic coast with that of heavy rains. The native population of Morocco is analyzed by MM. A. Bernard and P. Moussard, who correct the impression that it may be divided upon a language basis into Arabs and Berbers, for a great part of the Arab-speaking people are racially Berbers. The distribution of the Berber-speaking population follows very closely the physical relief of the country. As would be expected, the Berbers inhabit the mountains, the Arabs the plateaux and plains, with intermediate bi-lingual areas. As to the French civil population, it appears from a note by G. Jacqueton on "La colonisation français au Maroc," that at present it numbers about 55,000. A census, taken in March, 1921, showed that of the total civil population of 49,000, 41,000 were living in the towns, notably Casablanca and Rabat. After deducting officials, artisans, and business men from the remainder, the number of agricultural colonists and their families would seem to be little more than 3,000. To improve this state