Plenary Lectures

The first of the Plenary Lectures — *The Origin of the Universe* by **W. Kundt** — followed immediately after the preliminary formalities of the Opening Session. Cosmology has often had doubts raised about its status as a science (see, for example Bergmann, P. G., *Foundations of Physics,* **1** *1* (1970) 17-22), but Kundt set these aside in an exhilirating thesis about the origin of the universe. The singular solution which Kundt has developed envisages distinct eras in the evolution of the universe :

Time from origin	Matter described by
0 - 10^{-23} seconds	Quantum physics and special relativity
10^{-23} - 10^{-4} seconds	Hadron physics (concerned with strong nuclear interactions)
10^{-4} s - 10^{5} years	Electromagnetic theory
10^{5} years to present	Theory of matter

However, although this work has been successful in explaining features of the universe in these eras, a major weakness has been the absence of a theory of unified development from one era to the next. Kundt himself hopes that results from CERN and other high energy physics laboratories might well clarify the way to a singular solution.

Environment, Scientific Research and Economic Policy by **J. Tinbergen** was a lecture in complete contrast to that by Kundt. To guard against any danger of European physicists falling down a well whilst gazing at the stars, Tinbergen outlined aspects and problems of the human environment, the main functions of scientific research, and the role of socio-economic policy in bringing about the interaction between these two subjects. His view that the overwhelming importance of scientific work is its shifting of the frontier between knowledge and belief or intuition led him to consider what motivated research. Tinbergen concluded rather pessimistically that research tends to be done in the interest of the financing group or institution — generally for the large firms in rich countries. The important questions of science policy were — 'How much should be devoted to scientific education and research ?' and 'In what directions should research be stimulated ?' Tinbergen developed his thesis that 'world authorities' would be required to apply the techniques of socio-economics to match the possible scientific solutions to problems of the improvement of living conditions. He finished with the challenging remark to the assembled physicists :

'No scientist need be unemployed, although his income may have to be adjusted downwards'.

L. van Hove selected five topics for his talk on *Recent Developments in High Energy Physics.* Van Hove outlined the need for a theoretical technique of renormalization of field theories of charged vector bosons with non-vanishing mass — for use in theories of weak interactions — then went on to deal with four experimental topics :

Violation of time reversal invariance

On measurement of a number of decays for variable mixtures of neutral kaons (particles involved in strong nuclear interactions), results are compatible with violation of time reversal invariance. Although the effect is small, it is the first time it has been established in the basic interactions of physics.

Granular structure of the proton

Interpretation of experimental results of deep inelastic scattering at Stanford is that the electric charge of the proton is distributed in the form of point-like grains, known as 'partons'. Experiment does not resolve the differences between different models at this stage, but it does not seem to agree with the quark model.

High-energy hadron collisions

Van Hove devoted much of his talk to the subject of high-energy hadron collisions to which most of the experiments at the Intersecting Storage Rings (ISR) at CERN are allocated. The conclusions emerging are that multi-body collisions are dominated by exchange mechanisms similar to those in two-body collisions. Van Hove expressed the hope that clear recognition of three classes of outgoing particles at ISR energies had opened the road to development of theory for strong interactions.

Propagation of hadronic systems through matter

The final topic covered by van Hove was the surprising result obtained in a joint CERN/ETH Zurich experiment of propagation of hadronic systems of several pions (also particles involved in strong nuclear interactions) through heavy nuclei : the multipion system is absorbed no more strongly than a single pion.

Nonlinear Optics and Short Light Pulses, described in **W. Kaiser's** lecture, are two young fields in modern physics which are closely related. Nonlinear optical processes generate short light pulses which may be used to study different nonlinear optical phenomena. Kaiser reviewed a few of the wealth of new and interesting experiments that enabled him to predict that the field would remain an exciting one in the years to come.

Amongst the important features that Kaiser highlighted were the attainment of light pulses of duration as short as 10^{-13} s, whilst, for pulses of several 10^{-9} s duration, peak power values of 10^{12} W have been achieved. Also selected were : the use of power dependence of nonlinear polarization in classifying nonlinear processes ; the utility of spin-flip Raman lasers for spectroscopic analysis and pollution studies ; and laser studies of molecular vibrations in polyatomic molecules and in liquids.

In *Applications of Superconductivity*, **B.B. Goodman** had the difficult task of reviewing a subject which extends from the establishment of standards of voltage, length and time (using Josephson junction devices) through industrial engineering based on superconducting motors, generators and alternators, to consideration of superconducting cables for power transmission in the coming decades. Goodman adopted the sound engineering approach of emphasising the constraints within which applications of superconductivity have to be advanced. The transition temperatures of superconducting materials, choice of refrigeration fluid, operating temperature, cryogenic generators, environments, and superconductor degradation are problems which all have to be balanced for an optimal solution in any one application. In the industrial sphere, homopolar motors and generators have been constructed by International Research and Development Ltd in the UK, and Westinghouse in the USA have operated a 5 MW alternator under open current conditions. Goodman was specially drawn to mention the $100 million that Japan had committed to research and development for a superconducting levitating train for speeds of 500 km/hour. Electronic devices based on the Josephson junction seemed likely to find wide use in research and standards engineering. Amongst uses so far are magnetic field measurements down to 10^{-15} T, voltage down to 10^{-19} V, study of heart's magnetism, frequency mixing for laser wavelengths, and noise thermometry.

In his lecture on *Physics and Society*, EPS President **H.B.G. Casimir** contrasted views on the role of physics and the relative importance of different aspects. For example, he quoted his correspondence in 1945 with Pauli who regarded a paper by Onsager on order-disorder transitions as more important than all the work that had been done in the USA in the previous years on, for example, nuclear weapons. Casimir described the growing interaction between physics and technology as the *science-technology spiral*, in which advances in physics lead to technological developments which, in turn, inspire new progress in physics. This imaginative concept can be viewed optimistically or pessimistically. However, the interesting feature of the analysis as presented by Casimir was the *inexorable* character of the science-technology spiral. In the face of this situation, Casimir formulated his recommendations for survival, amongst which the following stood out:

'No scientist in an academic position should of his own free will be active in or advise on military technology.'

A. Schluter kindly replaced L.A. Artsimovich who had been unable to come from Moscow to lecture. Schluter gave a talk *On the Way to a Fusion Reactor.* It was interesting to contrast Schluter's lecture with the paper by Artsimovich (*Nature*, 1 September 1972, pp 18-22). Schluter stressed the difficulties in engineering, and the ecological and environmental problems that are important. Artsimovich, although admitting that engineering problems lay ahead, emphasized the social relevance of controlled nuclear fusion : 'I have consistently been of the opinion that the problem of controlled nuclear fusion will be solved not later than when it is necessary for the further development of civilization on Earth — if only our children and grandchildren have enough intellect and will to resist the instincts of hostility and destruction.'

The attractive visual aids that **S. van Houten** used in his lecture on *Physical Aspects of Displays* brought life to his subject. Choosing the example of liquid crystals as a phenomenon for critical examination by physical techniques, van Houten demonstrated how the material was characterized and its possible uses were evaluated. In summing up, he compared glow discharge tubes, injection electroluminescence and dynamic scattering in liquid crystals as display phenomena.

The adroit footwork of the skilled and imaginative physicist through the research system was well described by **A. Abragam** in his fine lecture *Polarized Neutrons and Nuclei : Nuclear Pseudomagnetism.* (Nuclear pseudomagnetism reflects itself in the interaction between a beam of slow neutrons and a nuclear target, and more specifically in the part dependent on the relative orientation of the spins of the neutrons and of the nuclei.) By his persistence, Abragam used steady pseudomagnetic resonance and an rf pseudomagnetic field to demonstrate the physical reality of nuclear pseudomagnetism. He proposed a programme of experimental measurements of pseudomagnetic nuclear moments of nuclei — to be used to test predictions of various nuclear models. In his final remarks, Abragam acknowledged the priority due M. Podgoretzki for the theoretical concept of nuclear pseudomagnetism which Abragam had been able to redevelop independently and to realise experimentally.

The Origin of Biological Information was, according to **M. Eigen**, an appropriate problem for the physicist to tackle. From considerations of possible mechanisms of reproduction of protein molecules, Eigen was able to construct one solution on the basis of their autocatalytic property. He believed that, by deducing such a solution, he was able to confound the critics who doubted the validity of the 'physics' explanation of the origin of life.

G. Fiocco, in *Lasers and the Atmospheric Sciences*, dealt with the application of laser devices to control of pollution. Fiocco outlined how diffusion parameters and detection of temperature inversions could feasibly be used in pollution control and meteorology. The technical requirements were highly stable lasers with very monochromatic output for measurement of small Doppler shifts, and tunable lasers for excitation of resonant transitions in atmospheric constituents.

C. Cohen-Tannoudji, in his lecture on *Atoms 'Dressed' by Photons*, developed the general idea that an atom irradiated by non-resonant photons can absorb and re-emit them virtually. The physical properties of such atoms dressed by optical and rf quanta differ from those of isolated atoms. Cohen-Tannoudji proceeded to describe a magnetometer, based on the properties of atoms dressed by rf quanta, with a sentivity of $10^{-9} - 10^{-10}$ gauss and time constant of 3 s.

V.L. Telegdi (Chicago) gave a spectacular lecture on *Exotic Atoms*, which are formed by replacing the positive nucleus of an ordinary atom by any positive particle, and replacing electrons by negative particles. Since the experimental techniques and theoretical analyses are borrowed from atomic, nuclear and high-energy physics, Telegdi considered them to be a particularly suitable topic for the Wiesbaden Conference.

The difficulties of approaching the subject of *The Computer and the Teaching of Physics* were amply demonstrated by **Y. Le Corre**. If one is aiming at real Computer Assisted Instruction (CAI), a dialogue with the computer is necessary. The formulation of suitable questionnaires has still room for improvement. It was clear from Le Corre's lecture that the use of the computer in teaching physics is still very much in the experimental stage, although it may be appropriate to introduce the techniques to students undergoing teacher training at the moment.

On a tour of the Physics Exhibition after the opening (from left to right): **W. Buckel**, President of the German Physical Society; **U. Dihle**, Chairman of the Local Organizing Committee; **R. Schmitt**, Mayor of Wiesbaden; **W. Martienssen**, Chairman of the Programme Committee