PHYSICS

## Action at a Distance Electromagnetism (ADE)

THERE are two ways of looking at electromagnetism. The older concept, due to Coulomb, regarded electricity and magnetism as manifestations of action at a distance between electric charges and magnetic poles and dipoles. This picture could not describe adequately the effects of rapidly moving electric charges. Gauss, back in 1845, suspected that the fault lay in the basic assumption that the influence between charges and poles travelled at infinite speed and was thus instantaneous. He, however, did not correct the fault.

In the picture evolved by Maxwell in the 1860s, an additional entity, the electromagnetic field, which conveys the influence between charges and poles at the speed of light, was introduced. The Maxwellian picture was successful not only in classical physics but also in the quantum description of the electromagnetic phenomena.

In the early decades of this century several workers tried to revive ADE by introducing 'delayed' action at a distance, the action again propagating at the speed of light. However, this encountered an obstacle in Newton's Third Law of motion that action and reaction are equal and opposite. The law meant that if the action of charge A was felt *later* by charge B, the reaction of charge B would be felt *earlier* by charge A, thus violating the principle of causalty that causes precede effects. In other words, influences were required to propagate with the speed of light, not only forward in time but also backwards.

The difficulty was partially resolved by two American physicists, John Wheeler and Richard Feynman in two research papers published in 1945 and 1949. They pointed out that when a typical charge A moves, it excites not only the charges in its neighbourhood but also distant charges all over the universe. All these charges send back their reactions which, travelling backwards in time, arrive at A at the instant it started moving! Provided certain conditions are satisfied by the universe, this reaction cancels the non-causal (that is, past directed) component of the influence of A and reinforces its causal (that is, future directed) component (see SCIENCE TODAY, June 1969, p. 11).

But Wheeler and Feynman worked with the model of a static universe and this resulted in certain ambiguities. Later work by Jack Hogarth in 1962 and by Fred Hoyle and myself in 1963 removed these ambiguities in the framework of the expanding universe. We also showed that ADE can be made to work in the quantum domain. The universe we conceived would totally absorb all electromagnetic signals travelling into the future and in the remote future its matter would be thermodynamically cold. Only the steady state model of the universe met these requirements.

There was still one gap left in the argument. Does ADE possess gravitational properties? According to Einstein's General Theory of Relativity, any form of energy, including electromagnetic field energy, must attract gravitationally. Does ADE without field preclude gravitational influence? The earlier work of Hoyle and myself had demonstrated that the presence of electric charges in a medium does modify its gravitational properties through their action at a distance. However, this work contained an error which led to some non-causal effects even when the universe satisfied the conditions mentioned above. Recently, I have repeated the calculations with canonical tensor instead of Frenkel tensor and have shown that the non-causal effects are indeed absent (*Journal of Physics, A, Vol.* 7, 1274, 21 July 1974). Thus, on formal grounds, ADE can now be considered on equal footing with the conventional Maxwellian field theory, or even better, because it reproduces the same results without having to invoke the existence of fields.

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GERONTOLOGY

## Resistance against Infection Falls in Old Age

THE biological basis of ageing is still under dispute. A team of four doctors at the Walter and Eliza Hall Institute of Medical Research and Royal Melbourne Hospital, Melbourne, Australia, on the basis of immunological tests on very elderly people, have concluded that death in old age is