ABSORBER THEORY OF RADIATION IN EXPANDING UNIVERSES

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Abstract

The Wheeler-Feynman absorber theory of radiation of the symmetric combination of retarded and advanced potentials, originally developed in a static universe model, is applied to asymptotic boundary conditions for an *action-at-a-distance* electro dynamic framework of a Quasi-Steady State Universe; which as discussed is in opposition to the broad class of Bigbang cosmologies.

1. Introduction

The subject of electricity and magnetism started with Coulomb laws which were similar to the Newtonian inverse square law of gravitation. Both laws were action-at -a-distance laws and they worked well till the mid-nineteenth century when the studies of rapidly moving electric charges brought out the inadequacies of instantaneous action at a distance. In 1845, Gauss (1867) in a letter to Weber hinted that the solution to the problem may come via the concept of delayed action at a distance wherein the interaction travels with speed of light. In restrospect one can say that the concept of action at a distance as developed by Newton and Coulomb was not relativistically invariant and Gauss's idea was to make it so.

Gauss's suggestion remained unattended for several decades and in the meantime in the 1860s a satisfactory picture of electrodynamics was given by the field theory of Maxwell. A relativistically invariant action at a distance formulation became available only in the early part of this century and it was given independently by K. Schwarschild (1903), H. Tetrode (1922) and A.D. Fokker (1929).

While formally this met the required criteria and produced equations that resembled those of Maxwell and Lorentz, the theory had a major practical defect: it treated the advanced interactions on an equal footing with the retarded interactions. Thus electric charges interacted via past directed signals as well as the future directed ones, the field of a typical charge being described by a symmetric combination

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$$F^a_{sym} = \frac{1}{2}\left\{F^a_{ret} + F^a_{adv}\right\} \tag{1}$$

instead of by the observed . The question was : how can such an acausal theory describe reality which seems to respect the causality principle.

2. The Wheeler-Feynman Theory

In a couple of papers, J.A. Wheeler and R.P. Feynman (1945,1949) found an ingenious way out of this difficulty by appealing to thermodynamic and cosmological considerations. They demonstrated a general result that in a universe well filled with electric charges, where all locally produced and outward propagating electrodynamics effects get eventually absorbed, the net effect is to produce only the full retarded signals. Thus, we find in this type of universe, which these authors called "a perfect absorber", the net effect on a typical charge *a* of all other charges in the universe is

$$R^a = \frac{1}{2}\left\{F^a_{ret} + F^a_{adv}\right\} \tag{2}$$

We may term this the "response" of the universe to the local acceleration of charge *a*. This is the field which acting on the charge *a* produces the well known radiative damping, as first appreciated by Dirac (1938). Further, when (2) is added to (1) we get the full retarded field in the neighborhood of charge *a.* This theory was called by the authors the absorber theory of radiation.

Thermodynamics entered the absorber theory through time asymmetry of absorption process which in a subtle way introduced asymmetry of initial conditions.

3. The Asymmetry of Expanding Models

Later Hogarth (1962) demonstrated that in an expanding universe the time asymmetry is automatically incorporated, a point missed in the Wheeler-Feynman discussion which was centered on static universes.

Since the expanding world models are described in Riemannian spacetimes, it was necessary to express the absorber theory and the basic framework of action at a distance in such spacetimes. Further, as pointed out by Feynman, Hogarth's use of the collisional damping formula to decide the absorption properties was inappropriate as it depended on thermodynamic asymmetry that Hogarth was trying to avoid. It was thus necessary to do calculations with an absorption process whose origin was purely electrodynamic. Hoyle and Narlikar (1963) carried out these tasks and demonstrated that Hogarth's claims were broadly correct.

These results go against the broad class of the popular big bang models in the sense that in these models the response of the universe does not have the correct value given by (2) above but it is the exact opposite! The result is that it is the advanced rather than the retarded signals that manifest themselves in all electrodynamic processes. On the other hand, the steady state model of Bondi, Gold and Hoyle and the recently proposed quasi-steady state model of Hoyle, Burbidge and Narlikar (1993) give the correct response.

4. The Quantized Version

Later work by Hoyle and Narlikar (1969,1971) showed how these concepts can be extended from the classical to quantum electrodynamics. The notion of action at a distance can indeed be described within the path-integral framework mechanics. The following results then follow:

(I) The phenomenon of spontaneous transition of an atomic electron can be described as the interaction of the electron with the response of the universe. Provided the universe gives the correct classical response, it will then give the correct result for this phenomenon also.

(ii) Instead of being independent entities called “fields” with uncountably infinite degrees of freedom, here we have only the degrees of freedom of the charges and the collective response of the universe. Thus the formal divergences associated with field quantization are avoided.

(iii) When path integral formulation is extended to the relativistic domain, the above method can be generalized to include the full quantum electrodynamics of interacting electrons including such phenomena as scattering, level shifts, anomalous magnetic moment, etc.

Recently Hoyle and Narlikar (1993,1995) have found that the infinities that require renormalization of integrals in quantum field theory do not appear in the quantum absorber theory provided we are in the right kind of expanding universe. Thus the event horizon in the future of the steady state or quasi-steady state theory produces a cut-off at high frequencies of the relevant integrals which therefore are finite. It is thus possible to talk of a finite bare mass and bare charge of an electron.

5. Concluding Remarks

These investigations of the absorber theory in the expanding universe therefore tells us that
provided the universe has the right kind of asymptotic boundary conditions, the action-at-a-distance framework of electrodynamics has the following advantages over the field theory:

(I) It links the time asymmetry in cosmology to time asymmetry in electrodynamics and thus helps us to better understand the local principle of causality as a consequence of the large scale structure of the universe.

(ii) It explains quantum electrodynamics with fewer degrees of freedom.

(iii) It is free from divergences that beset quantum field theory.

There is an additional possibility not yet fully investigated, namely, the response of the future absorber to any microscopic experiment in the laboratory. Could it be that we are unable to predict the outcome of an experiment with classical certainty, because not all variables are local? As in spontaneous transition, there is the response of the universe which may enter into the dynamics in an unpredictable way. Thus concepts like the collapse of the wavefunction, Bell's inequality, the EPR paradox, etc. may receive alternative interpretation in this action-at-a-distance framework.

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