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(SUMMARIES)

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# INFINITY SUPPRESSION IN GRAVITY-MODIFIED ELECTRODYNAMICS

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Field-theoretic infinities - first encountered in Lorentz's computation of electron self-mass - have persisted in classical electrodynamics for seventy and in quantum electrodynamics for some thirty-five years. These long years of frustration have left in the subject a curious affection for the infinities and a passionate belief that they are an inevitable part of nature; so much so that even the suggestion of a hope that they may after all be circumvented - and finite values for the renormalization constants computed - is considered "irrational".

As is well known, the infinities result from a lack of proper definition of singular distributions which occur in field theory. One of the major obstacles to progress in the subject has been the uncertainty of whether these singularities have their origin in the circumstance that a perturbation expansion is being made or whether it is the form of the Lagrangian - assumed to be polynomial in field variables - which is at fault. An important suggestive advance in resolving this uncertainty has been the work of Jaffe and Glimm [1)] who, working with exact and mathematically well-defined solutions of polynomial Lagrangian field theories (in two and three space-time dimensions) have shown that infinities persist even in exact solutions. If their conclusions may be extrapolated to physical four-dimensional space-time, it would seem that the origin of the infinities is not so much in the bad mathematics of the perturbation solution. Rather, the fault lies with the bad physics of the assumed polynomiality of the electromagnetic interaction.

Now non-polynomial Lagrangian theories have been studied since 1954 (in fact they date back to the Born-Infeld non-linear electrodynamics of the 1930's) and it is well known that a variety of these do indeed possess perturbation solutions free of infinities. However, in modifying electrodynamics to a non-polynomial version one has been presented with two dilemmas:

1) There are a million non-polynomial ways of "completing" the conventional polynomial version. Which represents physics?

2) Since the methods developed for solving non-polynomial theories are radically different from those for polynomial theories - for example, they involve analytic continuation procedures in an essential manner - one would wish to be sure that the field theory solutions thus defined do satisfy the conventional canons of good field theories, like appropriate analyticity, unitarity, positive-definiteness and Froissart-boundedness.

In respect of the first problem, i.e. that of discovering the missing (non-polynomial) physics, which should complete conventional electrodynamics, we revived in a series of earlier papers the conjecture of Landau, Klein, Pauli, Deser, DeWitt and others [2] which suggested it may be the neglect (of the intrinsic non-polynomiality) of tensor gravity - and the associated curvature of space-time produced by an electron or a photon in the space surrounding it - which may be the direct cause of the electron's and photon's self-mass and self-charge infinities.

In respect of the second problem, an advance has just recently been made by Lehmann and Pohlmeyer [3] and Taylor [4] who have shown rigorously that the analytic procedures developed in earlier papers by Volkov, Filippov, Salam, Strathdee and others [5)-7] do indeed define good field theories, good in the perturbational sense, provided the associated non-polynomial theory falls into the localizable class, satisfying the principle of microcausality.

The advance of Lehmann and Pohlmeyer [3] and Taylor [4] is a major one. Of peculiar relevance to our work is their insistence on localizability, microcausality and their consequences. In an earlier paper [8], following Efimov and Fradkin [9], we had worked with non-localizable non-polynomial theories. This had led to a number of serious shortcomings which were noted in Ref.8. Although we were able to show by actual computation that, when tensor gravity effects were properly taken into account, the conventional logarithmically infinite expressions $|\alpha \log 0|$ for self-charge and self-mass do become realistically regularized to $|\alpha \log(\kappa^2 m^2)|$ where $16\pi\kappa^2$ is the newtonian constant $G_N$ , there were still a number of problems the computation left unresolved:

Mathematically:

1) The results were not (electromagnetic) gauge invariant.

2) In obtaining the results, use was made of a Borel summation of a divergent series - a procedure open to ambiguities.

3) The results were obtained using a particular choice of the gravitational field variables - viz. the one which treated the contravariant field $g^{\mu\nu}$ as the fundamental field with the covariant field $g_{\mu\nu}$ expressed in terms of it. Since field-theoretic equivalence theorems would seemingly permit either field being treated as basic, the role of such transformations was not clear.

Physically:

It was not clear whether it was true tensor gravity which was responsible for the finite computation of the renormalization constants or whether it was some scalar version of it.

In a recent paper [10] it was shown that these shortcomings of the earlier papers are circumvented, provided we work with a localizable, visibly microcausal version of Einstein's gravity theory. Notwithstanding this change, it turns out that our numerical results to the order we computed are unaltered.

The chief remaining problem left for us to examine is the gravitational gauge-invariance of our numerical results. Indications are that $\delta m/m$ to the order $\alpha \log \kappa^2 m^2$ is also unchanged if calculations are performed in gauges other than de-Donder gauge for graviton propagators. This is a very preliminary result which needs much more work before we can formally present it.

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