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# Gauge Independent Gravitationally-Coupled Electromagnetic Field

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**Abstract.** We give a totally 3-covariant formulation of the gravitationally coupled electromagnetic field (with a source) in terms of physical 3-covariant variables, keeping the correspondence with the A.D.M. formulation of the problem. We introduce a 3-covariant time derivation which allows us to discuss the spreading of the transverse and longitudinal components of the electromagnetic field.

Then we present the second-order propagation equation and the Hamiltonian 3-covariant equations in a complete electromagnetic gauge independent fashion using the well-known elliptic operator $\Delta(g_{ij})$ and we also discuss the dynamical impossibility of disentangling the transverse and longitudinal modes.

Thereafter we extend the 3-covariant formulation to the gravitational field and consider the problems of the initial conditions for the full system, as done by York for the vacuum case.

Finally, we apply the formalism to the merostatic sourceless problem, showing the connection between the merostatic and the static cases.

## I. Introduction

Recently [1] it has been shown in a 4-convariant formalism that one cannot have both a simple propagator and a simple auxiliary condition to determine the gauge.

On the other hand, from a dynamical point of view, it seems very natural to analyse this point, following the lines applied by Arnowitt, Deser and Misner [2] to study the interaction of the electromagnetic field with the tensorial gravitational one; emphasising the role of the physical variables $(A_i^T, \mathscr{E}_i^T)$ of the Maxwell field and the gauge covariance (or invariance) at the different levels of the reduction process.

Thus, in the next sections we shall carry out the process of reduction of the 4-covariant action in a totally 3-covariant way in order to obtain the equation of propagation of the electromagnetic transverse waves in terms of the 3-metric $g_{ij}$. Moreover, we shall study the dynamics and the

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