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Faraday Transport in a Curved Space-Time

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Abstract. A covariant expression is given for the Faraday transport of electromagnetic radiation in a curved space-time.

I. Introduction and Notation

It is our purpose here to derive a covariant expression for the propagation of the polarization vector of a linearly polarized electromagnetic wave through a magnetic interstellar or intergalactic plasma (Faraday transport).

We shall consider the wave in the eikonal approximation and the plasma in the 3-fluid approximation.

Let ϱ, p, n, u^μ be the density, pressure, number density and 4-velocity of the electron component and let n_i, u_i^μ be the number density and 4-velocity of the ion component. We suppose that the electron component is a perfect fluid. Its energy-momentum tensor is therefore of the form $t_{\mu\nu} = (\varrho c^2 + p) u_\mu u_\nu - p g_{\mu\nu}$. We neglect collisions between the electrons and the ions and the molecules and we suppose that the degree of ionization remains constant.

We shall consider the wave to be a perturbation of the background potential A_μ of the form

$$\tilde{A}_\mu = A_\mu + \varepsilon A'_\mu . \tag{1.1}$$

The parameter ε characterizes the order of magnitude of the amplitude of the wave. We shall suppose that $\varepsilon \ll 1$ and we shall neglect quantities quadratic in ε.

In the presence of the wave all of the quantities which describe the electron fluid will be perturbed from their former value by a small amount of the order of ε. We shall write all perturbed quantities in the form (1.1).

Because of the relatively large mass of the proton, we shall suppose that the ionic component remains unperturbed in the presence of the