

Theory of Shock Waves in Relativistic Magneto-Fluid-Dynamics

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1. Introduction. The object of this paper is to derive formulae which determine the “jumps” in the various physical quantities as we go from one side to the other of a relativistic shock wave, the latter being regarded as a 3-space Σ_3 (hypersurface) in the space-time of general relativity. We assume that the matter present in space-time is an infinitely electrically conducting mixture of perfect gases, possibly in chemical nonequilibrium, but a macroscopic description is valid. The treatment accounts for thermal radiation effects also. However, the possibility of Σ_3 being a detonation wave is excluded. It is also assumed that matter and radiation are both sufficiently dilute, so that the interaction between the two is negligible and the total pressure, energy, and heat flux are simply the sum of the usual expressions for the pressures, energies, and heat fluxes of the two constituents [1]. Further, it is known that, in electrochemical phenomena, the electrical non-neutrality of the matter does not have a very significant effect on the field of chemical thermodynamics, this being true for many a physical situation [2]. Also, the only other parameters of the electromagnetic field which depend on matter are the magnetic permeability, the dielectric constant, and the electrical conductivity. Thus, regarding these parameters as absolute constants, we may assume that the presence of chemical reactions neither directly affects, nor is affected by, the electromagnetic field. (It might be recalled that, whereas the electromagnetic phenomenon is purely a field phenomenon, that is, it carries full sense even when there is no matter, chemical thermodynamics is associated with matter and matter only.) Finally, we assume that the coordinate system (admissible) used is such that the metric tensor of the space-time is continuous throughout [3].

The discussion of this paper is based not on EINSTEIN's field equations, but on the usual relativistic conservation laws of rest mass, energy, and momentum, and MAXWELL's equation of electromagnetism, including an OHM's law type relation for infinite electrical conductivity. Unlike the usual practice, we have employed a four-vector in place of the second rank skew-symmetric tensors of electromagnetic theory. It produces some simplifications in algebraic computations. This vectorial form of the fundamental equations and the other necessary