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ENTROPY PRODUCTION AND EQUILIBRIUM CONDITIONS IN GENERAL-COVARIANT CONTINUUM PHYSICS

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Abstract. Starting out with an entropy identity, the entropy flux, the entropy production and the corresponding Gibbs and Gibbs-Duhem equations of general-covariant continuum thermodynamics are established. Non-dissipative materials and equilibria are investigated. It is proved that equilibrium conditions only put on material properties cannot generate equilibria, rather additionally, the Killing property of the four-temperature is a necessary condition for space-times in which equilibria are possible.

1. Introduction

The special-relativistic version of Continuum Thermodynamics (CT) was founded by Eckart [2] in form of the special-relativistic theory of irreversible processes. CT is based (i) on the conservation laws for the particle number and the energy-momentum tensor and (ii) on the dissipation inequality and the Gibbs fundamental law. In order to incorporate CT in (or, at least, to harmonize it with) General Relativity, as a first step, one has to formulate it on a curved space-time, i.e., to go over to its general-covariant formulation. This step brings problems along that one has to solve before taking Einstein's gravitational field equations into consideration. This paper is devoted to some of these problems. In particular, it concerns questions as to the entropy production, the Gibbs equation and the definition of thermodynamic equilibrium.

As to thermodynamic equilibrium, vanishing entropy production is a necessary condition to be satisfied. It is well-known [1, 8], that this can be reached by two different requirements: either by assuming that the considered matter is a perfect fluid (then one need not impose any conditions on the properties of the underlying