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A geometric description of blackbody-like systems in thermodynamic equilibrium

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Abstract

Riemannian and contact geometry formalisms are used to study the fundamental equation of electromagnetic radiation-like systems, obeying a Stefan-Boltzmann's-like law. The vanishing of metric determinant is used for classifying what kind of systems can not represent a possible generalization of blackbody-like systems. In addition, thermodynamic curvature scalar $\mathcal{R}$ is evaluated for a thermodynamic metric, giving $\mathcal{R} = 0$, which validates the non-interaction hypothesis stating that the scalar curvature vanishes for non-interacting systems.

Keywords: thermodynamics, blackbody, metric, curvature
2010 MSC: 37D35, 53D10, 70G45, 82B26

1. Introduction

In a series of 5 papers, Weinhold studied the implicit relationship between the empirical laws of thermodynamics and the axioms of an abstract metric space, constructing some vectors and their operations in a similar way as in quantum mechanics for quantum states [1, 2, 3, 4, 5]. He used this for multiple reasons, one of them, for the creation of a Riemannian metric which was given by the Hessian of the fundamental equation as given by Gibbs [6], this work let Ruppeiner to construct another Riemannian metric by different considerations that is conformally equivalent to Weinhold's metric [7]. In this research Ruppeiner introduced an important hypothesis saying that, the metric can be interpreted as a measure of the thermodynamic interaction, in analogy with general relativity assumption. These works open the idea for a Riemannian geometric representation of thermodynamics.

Another important set of contributions were given by Mrügała, who constructed the thermodynamic phase space and showed that thermodynamics has an implicit contact structure [8]. Then he reformulated the whole thermodynamic theory [9] in terms of differential geometry for contact manifolds. Finally Quevedo presented a program that he called *geometrothermodynamics* [10] where he uses all of this contributions to construct a thermodynamic metric which is invariant under Legendre transformations, then he uses this metric to study how curvature is related to phase transitions for different systems [11, 12, 13].

In view of all of this contributions, a book was recently published that summarizes some

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