PRAMANA
—journal of
physics

Vol. 50, No. 4,
April 1998
pp. 295–305

On the construction of an extended thermodynamic framework for irreversible processes

ANIL A BHALEKAR*,† and LEOPOLDO S GARCÍA-COLÍN†,§
* Department of Chemistry, Nagpur University, Amravati Road, Nagpur 440 010, India
† Departamento de Física, Universidad Autónoma Metropolitana-Iztapalapa, Apdo. Postal 55-534, México D.F. 09340, México
§ Aslo at El Colegio Nacional, Luis González Obregón No. 23, México D.F. 06020, México

MS received 26 July 1996

Abstract. It is shown that the practice in extended irreversible thermodynamics of raising the physical fluxes, such as **q**, the heat flux density, etc. to the status of independent thermodynamic variables does not meet the basic thermodynamic requirements nor in a real situation by keeping them constant one can vary the other thermodynamic independent variables. To elucidate this point the phenomena of rigid body heat conduction is used as an illustrative example. It is argued that the thermometric temperature of systems whether in equilibrium or in nonequilibrium is the same physical entity.

Keywords. Irreversible thermodynamics; heat conduction; thermodynamics; thermodynamic processes; thermodynamic properties and entropy.

PACS Nos 05.70; 44.10; 44.60; 65.50

1. Introduction

The recent decades have witnessed the evolution of extended irreversible thermodynamics (EIT) [1–7]. It is claimed by the proponents of EIT that the classical irreversible thermodynamics (CIT) of Onsager–Prigogine–Meixner–de Groot [8–13] is not adequate enough to encompass all nonequilibrium thermodynamic situations. From the monographs and review articles on EIT [1–7] one gathers a long list of phenomena suggested as not falling within the fold of CIT. A preliminary as well as a striking example quoted is that of temperature waves. A simple mathematical description of the wave propagation of heat is the Maxwell–Cattaneo–Vernotte (MCV) equation [14], namely

$$\mathbf{q} = -\tau \frac{\partial \mathbf{q}}{\partial t} - \lambda \nabla T, \tag{1}$$

where $\mathbf{q}$ is the heat flux density, τ is the relaxation time, λ is the coefficient of thermal conduction, T is the temperature and t is time. Notice that the MCV equation is a constitutive equation and not a thermodynamic one. However, in EIT a thermodynamic derivation of it is presented and then it is claimed as a justification of the used thermodynamic framework. This approach of EIT shakes its very thermodynamic basis.