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On the Formulation of Variational Principles of Irreversible Thermodynamics in Presence of a Magnetic Field

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Abstract

We show that the matrix of coefficients in a set of linear phenomenological equations can be symmetrized also for systems with magnetic fields. This is due to a suitable choice of the spaces of thermodynamic forces and fluxes. Therefore the usual variational formulations of thermodynamics of irreversible processes also can be applied to systems with magnetic fields.

In recent years several variational principles of thermodynamics of irreversible processes have been formulated [1–3]. None of these formulations take into account odd parameters such as the magnetic field. Therefore those principles only make use of the simple Onsager reciprocal relations

$$L_{ik} = L_{ki} \tag{1}$$

and in general of the linear phenomenological equations

$$J_i = \sum_k L_{ik} X_k \tag{2}$$

between the components J_i of the fluxes and the components X_k of the forces.

It should be noted that these variational principles remain valid in special non-linear cases [1–3].

As is well known [4] in the presence of a magnetic field **B** (1) must be replaced by the Onsager-Casimir reciprocal relations

$$L_{ik}(\mathbf{B}) = \epsilon_i \, \epsilon_k \, L_{ki}(-\mathbf{B}) \,, \tag{3}$$

where $\epsilon_i = \pm 1$, depending on whether the component X_i of the forces is even or odd with respect to reversal of motion. Our aim is to show how the variational principles mentioned above can be generalized to those processes which require the application of (3) instead of (1).