

**Thermodynamics and Relativity:
An attempt to explain their close link in one page***

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Abstract: As shown below, the compatibility between the first and second laws of thermodynamics raises a problem. It can be solved inserting the Einstein mass-energy relation in the thermodynamic theory.

Keywords: Thermodynamics, energy, entropy, reversibility, irreversibility, relativity, mass-energy relation

Let us consider a given amount of gas contained in a vessel of fixed volume. If the gas is heated from its initial temperature T_1 to a final temperature T_2 , we have $dW = -P_e dV = 0$ and therefore $dU = dQ$.

According to the first law of thermodynamics, which postulates $dU_{\text{irr}} = dU_{\text{rev}}$, we get:

$$dQ_{\text{irr}} = dQ_{\text{rev}} \quad (1)$$

According to the second law, the change in entropy is given by the relation:

$$dS = dQ/T_e + dS_i \quad (2)$$

where dS_i is positive and T_e (the external temperature) too, being an absolute temperature.

Multiplying each term of eq. 2 by T_e leads to the corresponding energy equation:

$$T_e dS = dQ + T_e dS_i \quad (3)$$

whose precise meaning is:

$$dQ_{\text{irr}} = dQ_{\text{rev}} + \text{positive term} \quad (4)$$

implying the inequality:

$$dQ_{\text{irr}} > dQ_{\text{rev}} \quad (5)$$

Obviously, there is a contradiction between eq. 1 and eq. 5

To solve the problem, it can be imagined that the positive term $T_e dS_i$ represents an energy created inside the system by disintegration of mass. Such a suggestion was impossible for the creators of the thermodynamic theory, since the Einstein mass-energy relation was not known at that time. This is probably the reason why, in the usual conception, the priority is given to eq. 1 (basic postulate concerning the first law), with the consequence that the entropy equation 2 is not considered as physically equivalent to the energy equation 3.

Nevertheless, it seems that the thermodynamic theory gets clarified and extended by admitting this equivalence and substituting eq. 1 by eq. 5. It leads to unify the first and second laws under a global equation which can be written $dQ_{\text{irr}} = dQ_{\text{rev}} - c^2 dm$, and more generally:

$$dU_{\text{irr}} = dU_{\text{rev}} - c^2 dm \quad (6)$$

In eq. 6, $c^2 dm$ is the differential of the Einstein relation and the minus sign expresses the idea that a positive value of the energy term $T_e dS_i$ is linked to a decrease in mass ($dm < 0$).

• Further details can be found in "Thermodynamics and Relativity: A Pedagogical Message to Science Students".
The General Science Journal, June 2008. <http://wbabin.net/science/tane3.pdf>