

Conceptual Analysis of Clausius Statement to Prove it is Erroneous

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Abstract: *In the middle of 19th century, there was a significant growth in research with respect to the influential work in the field of thermodynamics from physicists such as Sadi Carnot, Lord Kelvin, James Joule, James Maxwell, August Kronig and Rudolf Clausius. The law that interests us here is the second law of thermodynamics, which was first given light by Carnot in 1824 [1]. In this paper, we are focusing on Clausius Statement of second law of thermodynamics that states 'heat can never pass from a colder to a warmer body without some external support' [2]. Here we are making an effort to prove, through theoretical analysis, that a cold body and a warm body radiate heat in all directions and thus the Clausius Statement is erroneous.*

1. Introduction

Thermodynamics and its understanding has been decoded since the last 150 years but considering human history we have always been dependent on thermodynamics' understanding. The first modern stride in thermodynamics began perhaps with James Watt's steam engine, which gave motivation to what we now know as the Carnot cycle. In 1824 Sadi Nicolas Carnot, published his only scientific work, a treatise on the theory of heat.

After Carnot many physicists, such as Joule, Clausius, Kelvin and many more, did noteworthy work focusing thermodynamics and mainly the second law of thermodynamics. The second law has 21 formulations from which we will be focusing on the Clausius Statement [1]. In Section I we have discussed in brief about thermodynamics and its statements that we are focusing on, along with this in Section II concepts in conjunction with heat are explained.

2. Thermodynamics

Thermodynamics is the branch of physics that deals with the relationships between heat and other forms of energy. In particular, it describes how thermal energy is converted to and from other forms of energy and how it affects matter. Thermal energy is the energy a substance or system has due to its temperature, i.e., the energy of moving or vibrating molecules. The second of law thermodynamics states that, "the state of entropy of the entire universe, as an isolated system, will always increase over time."

There are various statements of this law, the one that we are interested in is the Clausius statement that states 'heat can never pass from a cold to a hot body without some external support'. According to this statement heat is transferred from the hot body to cold body and the reverse cannot happen. To understand this there are some concepts to be known which are expressed in the next Section III.

3. Heat

Heat is nothing but concentrated emission of electromagnetic radiation, mainly consisting of infrared radiation [3]. Heat is measured in terms of temperature that

is in degree celcius (°C). Temperature is a measure of the average kinetic energy of the particles in a sample of matter, expressed in terms degrees designated on a standard scale.

All bodies, whether they feel hot or cold, emit infrared radiation [4]. Hot and cold are relative terms. A so-called hot body radiates energy faster than the human body, while a cold body radiates energy at a slower rate than human bodies do. This means that the cold and the hot body emits radiation in all direction, due to the nature of electromagnetic radiation.

From this we can conclude that there is a transfer of heat, thus the energy, from hot body to cold body and also from cold body to hot body. This is not in harmony with the Clausius Statement according to which the energy transfer is only from hot body to cold body.

4. Inference

The theory presented in the Section II helps us understand that heat is presence of electromagnetic radiation which may or may not have a specific direction for flow of energy. Thus we are concluding that there is a flow of heat from cold body to hot body, similar to the flow of heat from hot body to cold body and thus the Clausius Statement is erroneous.

References

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