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Unification of Transport Phenomena based on General Relativity

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Abstract: ***The vision to conduct the unification of transport phenomena based on general relativity is given. No matter what kind of transport phenomena, there is an upper limit for the transport. It is light speed. As to a heat engine working between two heat reservoirs with two different temperatures, there is an upper limit of the thermal efficiency. The heat-work structure in thermodynamics is analogical to the space-time structure in general relativity. For the three modes of transport including conduction, convection, and radiation, they may be able to be described by one mathematical framework in which the light-based axiom (light speed is a constant) plays a crucial role.***

Keywords: unification, transport phenomena, general relativity, space-time structure, heat-work structure

Transport phenomena which mean movements (from here to there) are encountered everywhere. In the fields of engineering and physics, the movements of mass, momentum, electrical charge, energy, et al. are involved. In the field of finance, the movement of investment and money are the key points considered. No matter what kind of movement, there is a fundamental question: what is the fastest speed can it move with? It was not until the theory of relativity was widely accepted that many people believed that an entity can be accelerated to the speed as large as being wanted.

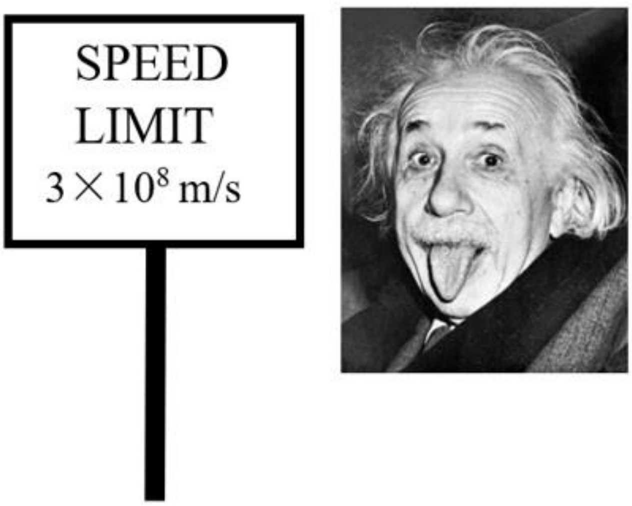

Figure 1: Speed limit sign and Albert Einstein

Einstein's relativity theory [1-2] (including special relativity published in 1905 and general relativity published in 1915) demonstrates that there is an upper speed limit in this universe, that is light speed (3×10^8 m/s). As to light, it is untouchable and unseen, but it reveals truth. That light is untouchable is easily accepted. However, that light is unseen is not accepted by many people. The point is how to define 'see', when we say we see something such as table, basketball, tree, et al, we mean that we can speak out the geometrical aspects (such as shape and size) of the things we see. However, no one can speak out the size and shape of light. The truth may be that when a person says he or she sees light, what is going on is that light let him or her see things other than light. It is light that let us see, not that we see light. There is something that let us see but we cannot see it. What is it? The answer is light. And number $3\times10^8$is a magic number, and it can be expressed by two numbers of 0 and 1, as shown in equation (1). 0 represents nothing, and 1 represents the first thing. Equation (1) indicates that light is the first thing (that is linked to the first principle), and it reveals the possibility of creating something from nothing.

$$3\times10^8 = \sqrt{\frac{1}{0.00000000000000001111111\cdots}} \quad (1)$$

Light speed in vacuum can be obtained from Maxwell equations, as shown in system of equations (2).

$$\begin{cases} \nabla\cdot E = \dfrac{\rho_e}{\varepsilon_0} \\ \nabla\cdot B = 0 \\ \nabla\times E = -\dfrac{\partial B}{\partial t} \\ \nabla\times B = \mu_0(J+\varepsilon_0\dfrac{\partial E}{\partial t}) \end{cases} \quad (2)$$

where E is static electrical field, B magnetic field, ρ_e electricity density, J electrical current, ε_0 and μ_0 vacuum permittivity and vacuum permeability respectively, and the values of the permittivity and the permeability are:

$$\varepsilon_0 = \frac{1}{4\pi\times9\times10^9}[\,C^2/(N\cdot m^2)\,] \quad (3)$$

$$\mu_0 = 4\pi\times10^{-7}[N\cdot s^2/C^2] \quad (4)$$

Here we ask a question: why the properties (measured by the permittivity and permeability) of vacuum are linked to a number π (3.141592653589793 $\cdots$). Many people never think about this and feel surprised when being asked. A brief reason provided here is that vacuum is isotropic, and this let the properties of vacuum be linked to number π.

The Maxwell equations (2) results in the equations (5) and (6) below:

$$\frac{\partial^2 E}{\partial t^2} = \frac{1}{\mu_0 \varepsilon_0} \cdot \frac{\partial^2 E}{\partial x^2} \quad (5)$$

$$\frac{\partial^2 B}{\partial t^2} = \frac{1}{\mu_0 \varepsilon_0} \cdot \frac{\partial^2 B}{\partial x^2} \quad (6)$$

The general wave equation is the following:

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2} \quad (7)$$

Comparing equations (5) and (6) and (7), we can calculate the light speed in terms of the permeability and permittivity of vacuum (free space); it is shown in equation (8):

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \quad (8)$$

In the field of heat transfer [3], the heat diffusion equation is written as the following:

$$\frac{\partial y}{\partial t} = \alpha \frac{\partial^2 y}{\partial x^2} \quad (9)$$

The difference between equation (7) and equation (9) is that equation(7) describes the physical process in which signal travels with finitely large speed, and equation(9) describes the physical process in which signal travels with infinitely large speed.

A direct consequence of the upper limit of any kind of transport phenomena is simultaneity. In fig.2 it gives an example of image-capturing, the nose of the person is closer to the camera than the eyes are. So, the nose and the eyes are not simultaneous in the image, and the nose is younger than the eyes are in the image.

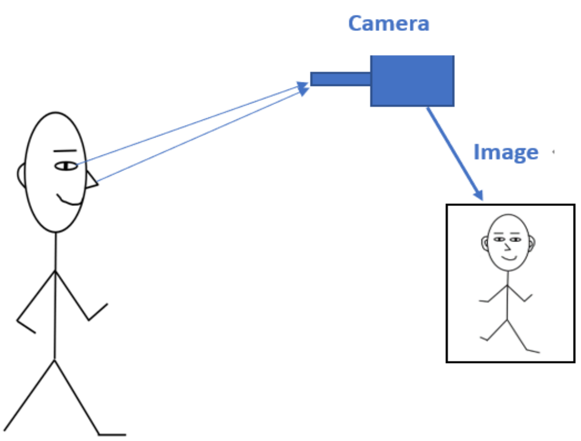

Figure 2: A person and his image captured by a camera

In thermodynamics, it is known that the upper limit (shown in fig.3) of a heat engine [4] working between two heat reservoirs with two different temperatures T_{low} and T_{high} is determined as $1 - T_{low} / T_{high}$, and this limit is independent of the material of the heat engine and the heat reservoirs.

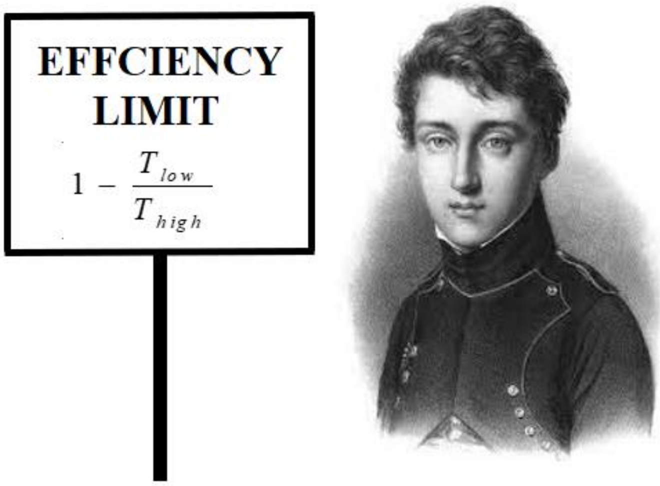

Figure 3: Efficiency limit sign and Nicolas Léonard Sadi Carnot

Mathematically, for any two variables *X* and *Y*, there exists a relativistic relationship between them if dY / dX has an upper limit c. In general relativity, the space-time structures in different reference frames (both the inertial and the non-inertial) are investigated. Recent discoveries of the ergodicity of the behaviour of time [5-8] (time dilation, time contraction, and time conservation are all possible to happen in moving frames) indicates that anything is possible in general relativity, and the reason why some patterns are thought of as being strange and irregular is that we do not view them in different reference frames. In many cases, we always think that we are in an inertial frame. In the field of thermodynamics, different heat-work structures in different reference frames (with coordinates of heat and work) can be revealed. Regarding heat-work structures, heat in thermodynamics acts like time in relativity, and work in thermodynamics acts like space in relativity. As to the three modes of transport including conduction, convection, and radiation, they may be able to be described by one mathematical framework in which the light-based axiom (light speed is a constant) plays a crucial role. Radiation is the transmission of electromagnetisms (they are actually lights), and conduction and convection may be able to be described by space-time structures under the circumstances that the transport speed is much lower than light speed.

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