A Maxwell's demon that does not consume energy

JiaRun Deng cmos001@163.com

Abstract

The second law of thermodynamics has provided significant assistance to the development of science and technology since its inception, but we are skeptical about its universality. In this paper, we use the Michelson interferometer as a Maxwell's demon and use the method of optical interference to demonstrate that the second law of thermodynamics can be violated.

1. Introduction

Maxwell’s demon, as one intelligent device assumed by James Clerk Maxwell, was proposed to indicate the possibility of violating the Second Law of Thermodynamics. But up until now, existing physical experiments have shown that the operation of Maxwell’s demon needs the consumption of energy or the increase of corresponding entropy.

Therefore, it's worth exploring whether there is one device that could play the role of Maxwell’s demon without energy consumption.

2. Methods and Discussion

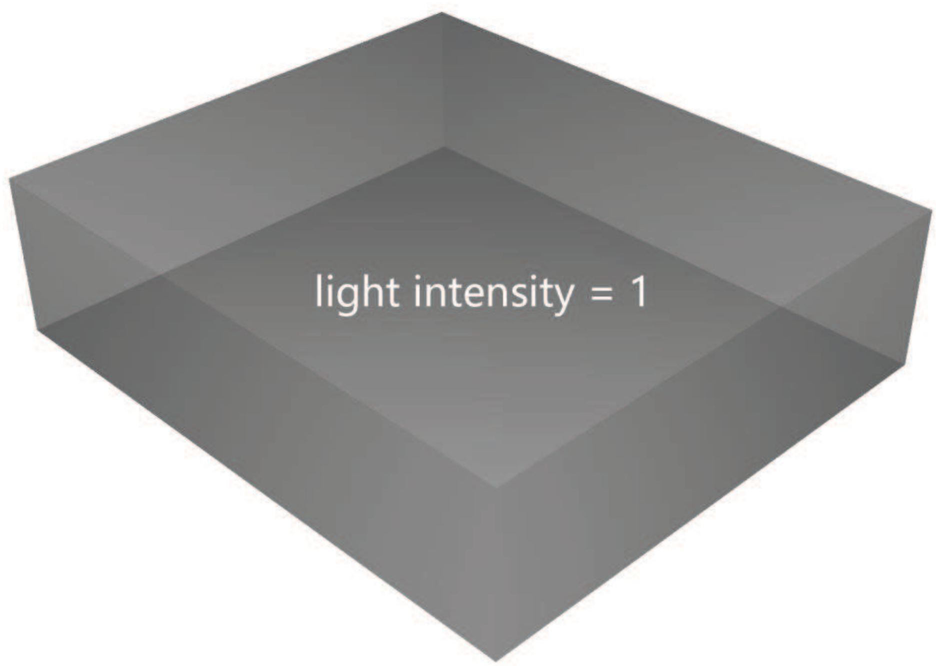

Fig.1 A box in thermal equilibrium.

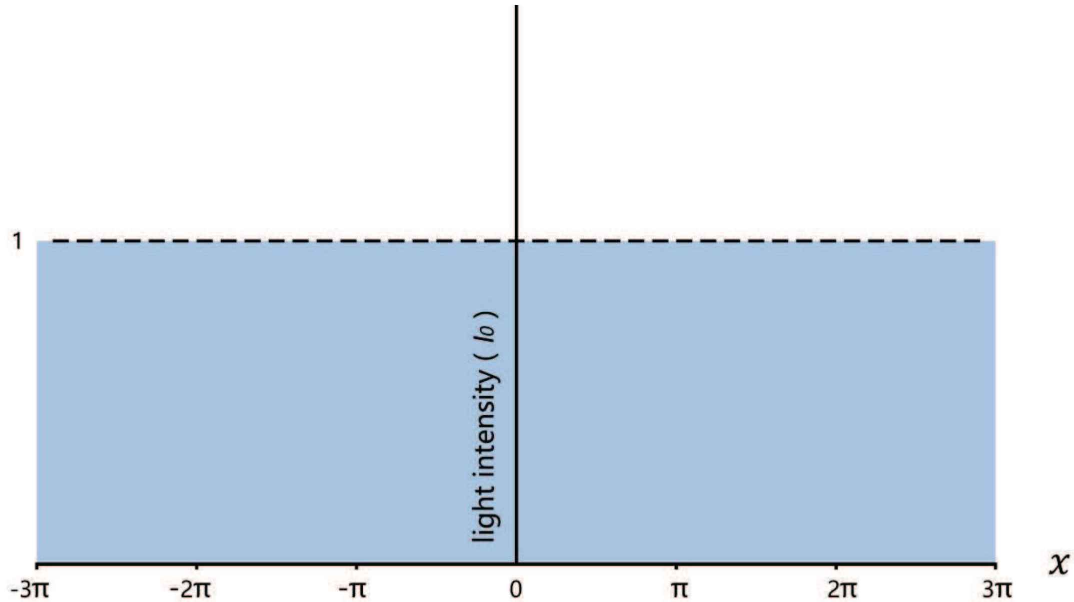

Fig.2 The image corresponding to formula (1).

As shown in Fig.1, an empty box in a state of thermal equilibrium has the same temperature at any position inside the box, and the radiation inside the box has an isotropic characteristic. The light intensity measured by the detector placed at any position is the same. We set the value of the light intensity I_0 to be 1, which corresponds to the dashed line in Fig.2.

$$I_0 = 1 \tag{1}$$

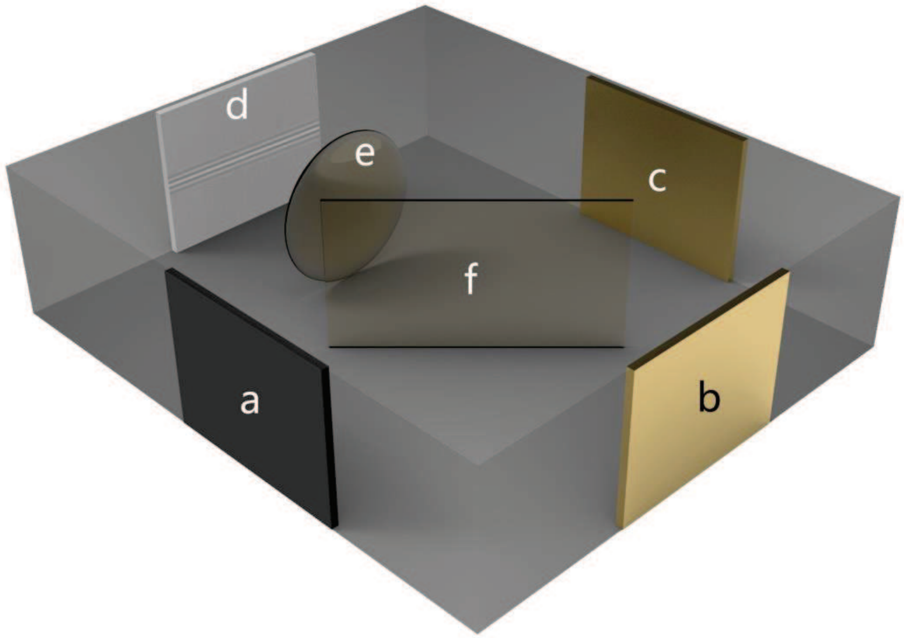

Fig.3 Add Michelson interferometer inside the box.

As shown in Fig.3, Michelson interferometer is added inside the box [1]. Plane “a” is an approximate blackbody material with strong absorption and radiation capacity [2]. In this device, we use plane “a” as an extended light source (the light emitted by the light source is not required to be parallel).

The infrared light radiated by plane“a” is split into two equal-amplitude beams by the spectroscope “f”. These two beams of infrared light are reflected by mirrors “b” and “c” and then reach the lens “e”, where they are focused and ultimately projected onto the plane “d”. When the optical path difference between the two beams approaches zero, interference fringes of alternating brightness can be detected on the plane “d”. This principle is the same as the Michelson white-light interference experiment that has been verified countless times.

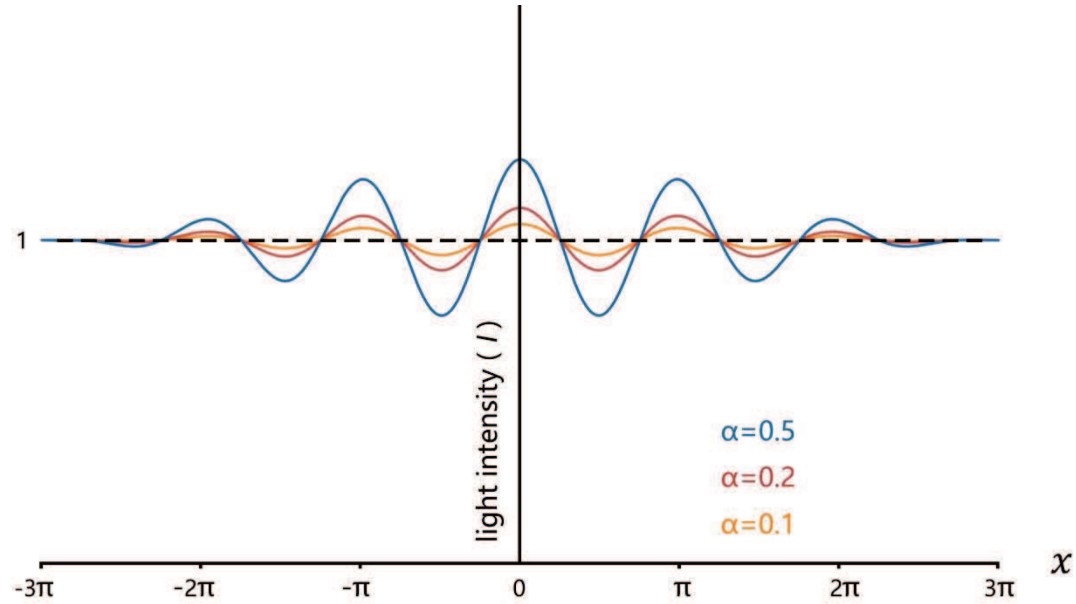

Fig.4 The image corresponding to formula (2), with n=3.

The light intensity distribution of the interference fringe can be approximated by the following formula:

$$I = \left(1 + \cos\frac{x}{\mathrm{n}}\right)\frac{\cos(2x)\alpha}{4} + 1 \qquad (0 < \alpha < 1, \qquad -\mathrm{n}\pi < x < \mathrm{n}\pi) \qquad (2)$$

In formula (2), the value of I is the sum of the brightness of interference fringes and the background noise (brightness of stray light). From -nπ to nπ indicates the visible range of the interference fringe. The value of n is usually very large in monochromatic spectra, but since blackbody radiation is a continuous spectrum, the value of n is very small. Here, we set n to be 3.

In formula (2), the value of α represents the proportion of the radiation amount of plane “a” in the entire device. As shown in Fig.4, the curve represents the sum of the brightness of interference fringes and the background noise (brightness of stray light). The higher the value of α, the higher the contrast of interference fringes, and the lower the value of α, the lower the contrast of interference fringes.

As shown in Fig.4, it can be seen that the light intensity at different positions may be greater than or less than 1, which can be regarded as a fluctuation phenomenon. However, this fluctuation is constant, and it has an essential difference from the random fluctuations of general thermodynamic systems.

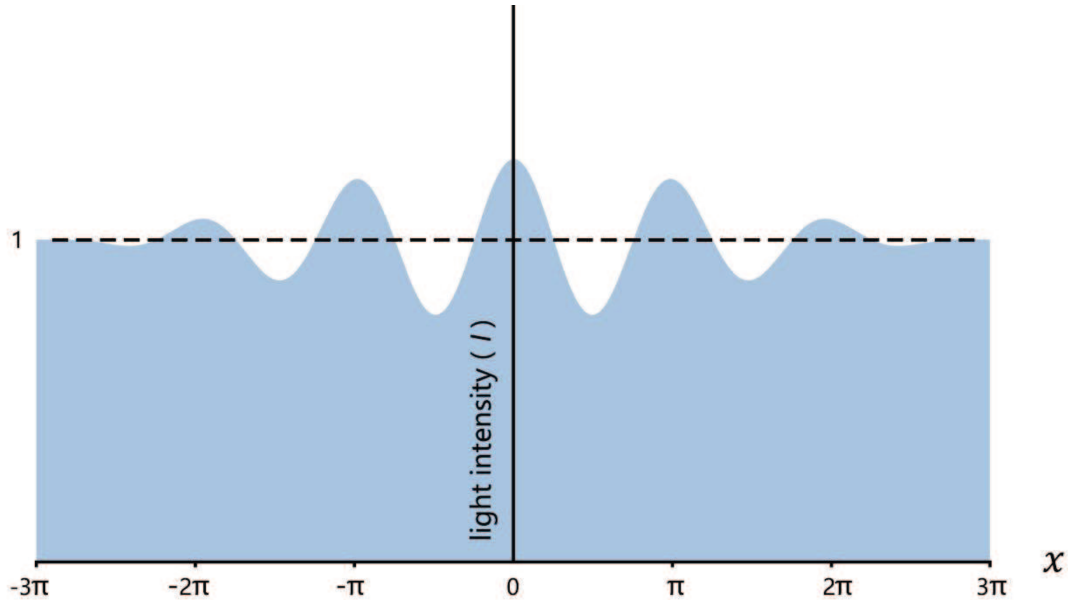

Fig.5 The image corresponding to formula (3), with n=3, α=0.5.

$$\int_{-3\pi}^{3\pi} \frac{I}{6\pi}\, dx = 1 \tag{3}$$

As shown in Fig.5 and formula (3), with a statistical range from -3π to 3π, the calculated average value of the light intensity is 1. This indicates that the light intensity is uniform within this statistical range.

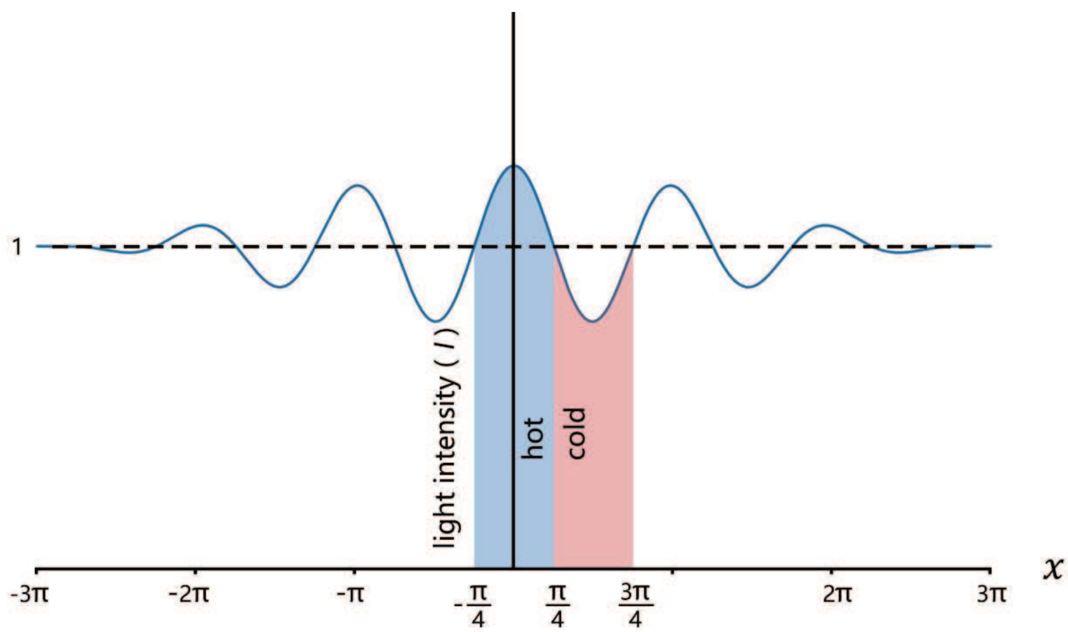

Fig.6 The image corresponding to formula (4), with n=3, α=0.5.

As shown in Fig.6, if the statistical range is reduced and the average value of the light intensity is calculated again, the result may be greater than or less than 1. This can be described by an inequality:

$$\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \frac{2I}{\pi}\, dx > 1 > \int_{\frac{\pi}{4}}^{\frac{3\pi}{4}} \frac{2I}{\pi}\, dx \tag{4}$$

In formula (4), 2π is the central wavelength of blackbody radiation in the thermal equilibrium state, from -π/4 to π/4 belongs to the area of bright stripes, and from π/4 to 3π/4 belongs to the area of dark stripes. Its physical meaning is that it describes constant fluctuations, which have an essential difference from the random fluctuations of general thermodynamic systems.

Obviously, the light intensity received in the area with bright stripes is greater than that received in the area with dark stripes, which will cause a temperature difference between the two areas. Importantly, the temperature difference generated between the two regions does not require input of energy from the outside to maintain, which clearly violates the second law of thermodynamics.

If we place one end of the thermocouple in the area of bright stripes and the other end of the thermocouple in the area of dark stripes, the thermocouple will generate a constant current, which means we can obtain free energy from the surrounding environment.

Here, the Michelson interferometer is like a Maxwell's demon, which transforms disordered uniform radiation into ordered non-uniform radiation. Importantly, the Michelson interferometer operates spontaneously, and we do not need to provide it with extra energy.

3. Conclusion

The second law of thermodynamics has provided significant assistance to the development of science and technology since its inception, but we are skeptical about its universality. In this paper, we use the Michelson interferometer as a Maxwell's demon and use the method of optical interference to demonstrate that the second law of thermodynamics can be violated. The beneficial effects of this conclusion include improving the efficiency of converting thermal energy into electrical energy, humans being able to obtain free energy from the surrounding environment (although with a very low power density), and making revisions to the theory of cosmic evolution.

References

[1] Michelson, Albert Abraham, and Edward Williams Morley. "On the relative motion of the earth and the luminiferous ether." *American journal of science* 3.203 (1887): 333-345.

[2] Planck, Max. "On the law of the energy distribution in the normal spectrum." *Ann. Phys* 4.553 (1901): 1-11.