# Found a Maxwell's demon that does not consume energy

JiaRun Deng, cmos001@163.com

## Abstract

The second law of thermodynamics has provided great assistance to the development of science and technology since its birth. However, we are skeptical about its universality. In this paper, we used 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

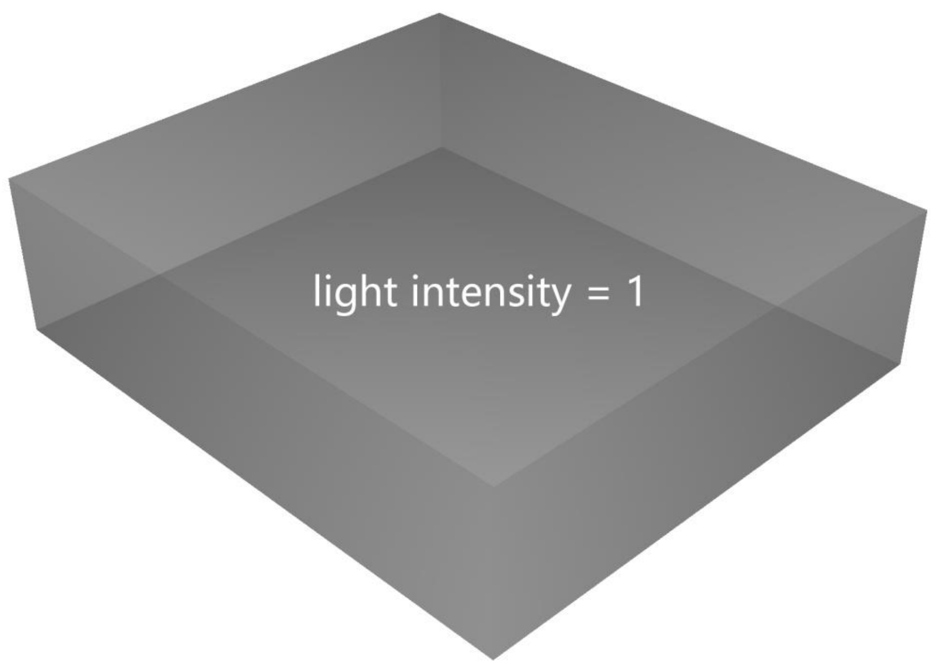


Fig.1 A box in thermal equilibrium.

As shown in Fig.1, an empty box in thermal equilibrium has the same temperature at any position inside the box, and the radiation inside the box has isotropic characteristics. The light intensity measured by placing the detector at any position is the same. We set this value to 1, which corresponds to the dotted line in Fig.3.

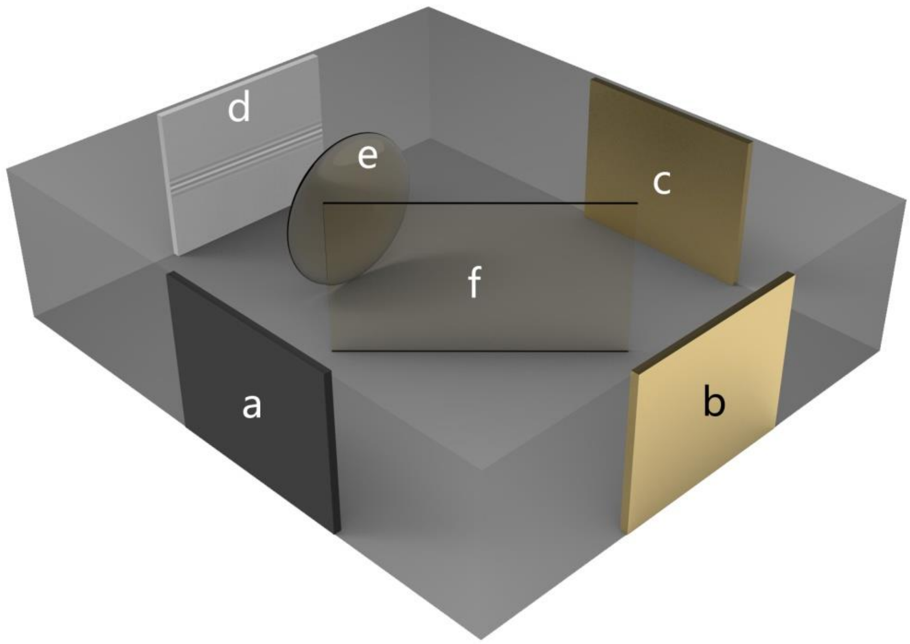


Fig.2 Add Michelson interferometer inside the box.

As shown in Fig.2, 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.

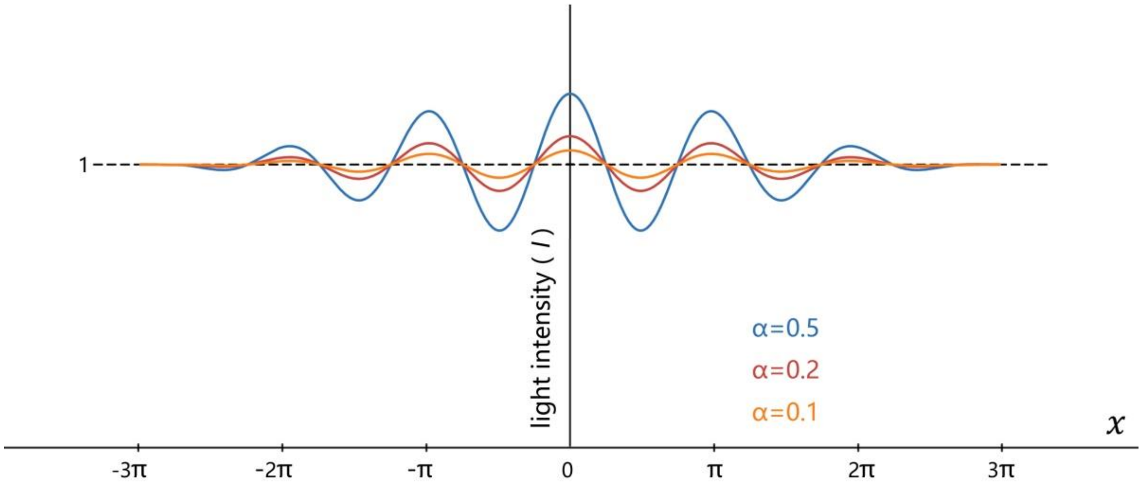


Fig.3 The image corresponding to formula (1), with n=3.

The energy distribution of interference fringes can be approximated using the following formula:

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

In formula (1), the range from -nπ to nπ represents the visibility of the interference fringe. α represents the absorption coefficient of plane “a”.

It is known that the absorption coefficient of plane “a” is greater than 0. According to formula (1), interference fringes can be produced as long as the absorption coefficient of plane “a” is greater than 0. An increase in the value of α corresponds to an increase in the contrast of the interference fringes, while a decrease in the value of α corresponds to a decrease in the contrast of the interference fringes.

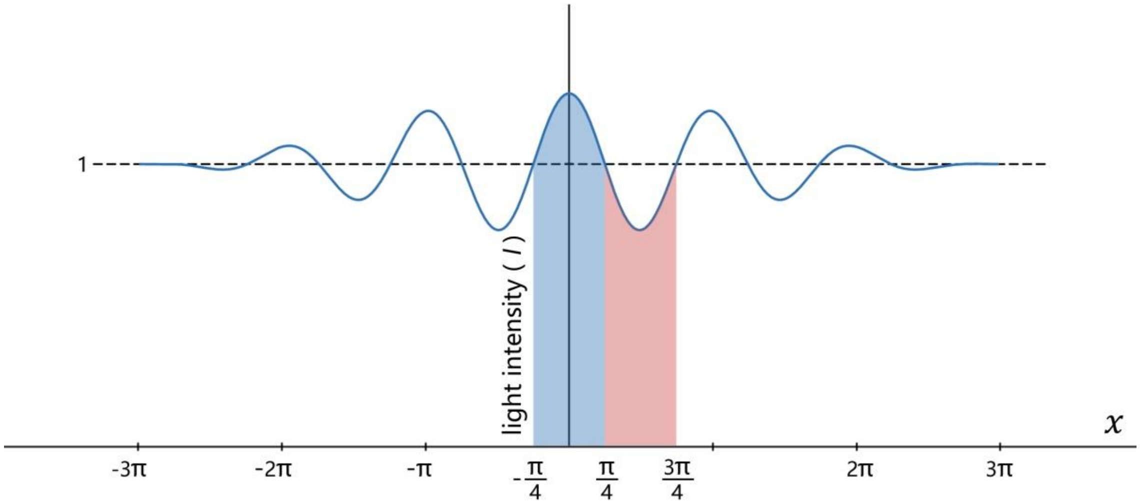


Fig.4  The image corresponding to formula (2).

The existence of interference fringes indicates that the energy distribution is non-uniform. The energy distribution of bright and dark fringes can be described using an inequality:

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

In formula (2), 2 π 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 3 π/4 belongs to the area of dark stripes.  As long as the absorption coefficient of plane "a" is greater than 0, formula (2) is true. Its physical meaning is to describe the transformation of blackbody radiation from isotropy to anisotropy.

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 the disorderly and uniform radiation into orderly and uneven radiation. It is important that we do not need to provide energy for the Michelson interferometer.

## 3. Conclusion

The second law of thermodynamics has provided great assistance to the development of science and technology since its birth. However, we are skeptical about its universality. In this paper, we used 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.