Tom's Demon Challenges the Second Law of Thermodynamics

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Abstract

This article describes a new demon of the second law of thermodynamics. We name it Tom's Demon. It acts on lines similar to those on which the famous Maxwell's demon acts. Tom's Demon sorts out salt and sugar particles from a mixture of the two without spending any energy. It reduces the entropy of an isolated system thereby reducing the entropy of the universe. and poses a challenge to the second law of thermodynamics just as Maxwell's demon does.

Key words

Second law of thermodynamics, Maxwell's demon, entropy, Tom's demon

Introduction

Ever since statistical thermodynamics usurped the coveted position occupied by equilibrium thermodynamics or classical thermodynamics among the scientific disciplines, thermodynamic demons started appearing in scientific discussions. Maxwell's demon[1] is the mother of all later demons. So we will make Maxwell's demon the representative of all thermodynamic demons. With time both the number and stature of the demons have grown. The second law group at the University of San Diego (USD) has advanced roughly a dozen challenges since the early 1990s says Sheehan[2]. These challenges are the demons. Their stature has grown from demons to zombies! Extensive literature is available in reference 2. We have discussed the story of Maxwell's demon elsewhere[3].

Description of Maxwell's demon

Maxwell's demon is a mythical being. It is famous in scientific circles because it challenges the invincible second law of thermodynamics. What it does, briefly is this: It sorts out molecules of an ideal gas into two categories – the fast moving ones and slow moving one much as a fruit seller sorts out his lot of mangoes into higher grade (priced higher) and lower grade (priced lower) ones.

Going into details of Maxwell's demon: Imagine an adiabatic (which doe not allow heat transfer from outside to inside and vice versa) vessel with rigid walls (see Fig. 1) enclosing a fixed mass of an ideal gas at temperature TK. Let it be separated into two chambers L and R of equal volume. Let the wall separating the chambers have a trap door. The randomly moving ideal gas molecules in each chamber keep hitting the walls of the container as well as the separating wall in it.

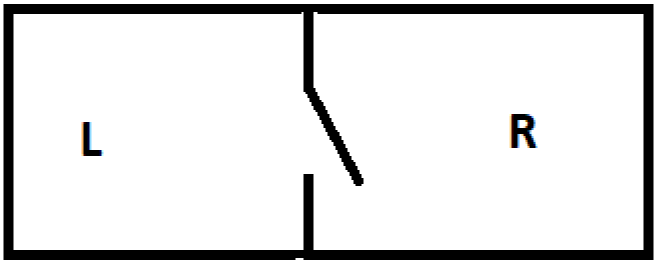

Fig. 1. Figure shows a rigid walled adiabatic container divided into two chambers L and R of equal volumes, by a separating rigid adiabatic wall. The wall contains a trap door. This trap door is operated (open or close) by Maxwell's demon.

The Maxwell's demon sits at the trap door of the separating wall and operates (opens or closes) it, *without doing any work*. It opens the trap door when a fast moving molecule from L approaches it and allows the molecule to go through from chamber L to chamber R. But when a slow moving molecule from L approaches the trap door, the demon closes the door and prevents its entry into R. Similarly, when a slow moving molecule from R approaches the trap door, the demon opens the trap door and allows the molecule to go through from chamber R to chamber L. However, when a fast moving molecule from R approaches the trap door, the demon shuts the door and prevents its entry into L.

In due course of time, the demon separates the fast moving category of molecules into chamber R and the slow moving category of molecules into chamber L. It is important to note that the demon spends no energy (or does any work) in the process of separating the molecules thus. It is also to be noted that the Maxwell's demon suffers no change what so ever while it does the separation.

Therefore, when the demon completes its job the only change that could be observed is that the fast moving molecules in R and slow moving molecules in L. The surroundings suffer no change since the system is adiabatic and the work done during the process is zero.

The speed of the molecules has a special significance here. The fast moving molecules are high temperature molecules and slow moving molecules are low temperature molecules. Therefore, we have a high temperature (hot) right chamber R and a low temperature (cold) right chamber L.

In thermodynamic jargon, the final result is that a source of energy (a temperature difference) is created where there was none initially, with no other change. In other words, the demon brings about a final state of order (all fast moving molecules into one chamber and all slow moving molecules into the other chamber) into an initially disordered state of randomly distributed molecules, thereby decreasing the entropy of the universe. This is violative of the second law of thermodynamics which demands ever increasing entropy of the universe just as an arrow head always points in the direction of 'future'.

Thus as long as the Maxwell's demon is alive, there is a threat to the second law of thermodynamics.

Description of Tom's Demon

Maxwell's demon is a high class demon, not easily grasped by non specialists. It requires a knowledge of an ideal gas (which itself is elusive) and the concept of absolute scale of temperature – another invention of the second law.

However, to understand the second law challenge of a demon, we don't need a Maxwell's demon; any demon would do, for example, a new demon that we name Tom's demon. So let us invite Tom's demon. The advantage of Tom's demon is that it does not insist on the concepts of either ideal gas or absolute scale of temperature. So, let us see what the Tom's demon does and how it challenges the second law of thermodynamics.

Let us assume a vessel containing a mixture of sand and sugar. Let it be divided into two halves L and R by a separator. Let us now invite Tom Demon. What Tom Demon does is this: It takes every sugar particle from L and puts it in R, similarly, it takes every salt particle from R and puts it in L. In due course it separates the mixture of sand and sugar into pure sugar in R and pure sand in L. For thus transferring the particles as described, this demon neither spends energy, nor expends any work. When Tom Demon finishes its job, the only change that can be observed is the separation of sand and sugar mixture into pure components.

This change however, decreases the entropy of the universe! The final state is an ordered state compared to the initial state. The entropy of the initial state is higher than the entropy of the final state. Therefore, Tom Demon violates the second law of thermodynamics by decreasing the entropy of the universe, with no other change.

Conclusion: Tom Demon, too, challenges the second law of thermodynamics!

Acknowledgement

I thank Mr. Arun Rajaram, Chennai, India for the immense help and support he extends to enable me to pursue my research.

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Statement of Conflict of interest (COI) Disclosure

There is no conflict of interest. I did not receive any funds from any source for this work.