Gravitation: A Challenge to the Second Law of Thermodynamics

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Gases in gravitational fields approximate to an adiabatic temperature gradient. The resulting temperature difference can be used to gain mechanical energy. The common explanation to establishing the temperature distribution is a heat source located at the mass. The question arises, if the heat source is mandatory, or if there are mechanisms, that autonomously add to the temperature distribution without external heat source. This article shows that a single temperature in gases within a gravitational field is not a stable situation, and that it is possible to retrieve mechanical energy from the resulting temperature distribution. Establishing a temperature gradient from a single temperature gas in a gravitational field requires heat flow from cold to warm, and thus is in direct contradiction the second law of thermodynamics. Therefore, the establishing of a temperature distribution that is not just a single temperature comprises a counterexample to the second law of thermodynamics and demands review of the usage of this law in many scientific areas. Even though just one counterexample is explained, research to that topic showed, that similar effects also exist in solid materials and this is not just an isolated effect.

A common observation in reality is the temperature distribution in atmospheres, where the atmosphere typically has a higher temperature close to a planet, and a lower temperature when distant from the planet. At first sight, this does not go well with the second law of thermodynamics. This article discusses the physics behind the process with a simplified thought model.

This effort is not supported by a university or other scientific entities. This is just done out of enthusiastic interest for the topic. The original intention was to gain insights about thermodynamic processes, however indications for an issue with the second law of thermodynamics became more and more obvious during investigation. For the author, the turning point was to find out, that Ludwig Boltzmann in his „Vorlesungen über Gastheorie“ assumed that the molecules would move on straight lines unless bouncing against other molecules or walls, not considering gravitation for that movement.

The typical explanation to the temperature distribution in an atmosphere is, that for some reason, heat is generated at the surface of the planet. This could be from processes within the planet, or by means of radiation from outside. While the described processes are reasonable and can be used to explain the mechanics, the question remains, if a temperature distribution would also exist without an external heat source. There is a lot of variables involved in the real processes, and therefore, this article considers a much-simplified model, where no sources of heat, and no radiation are involved.

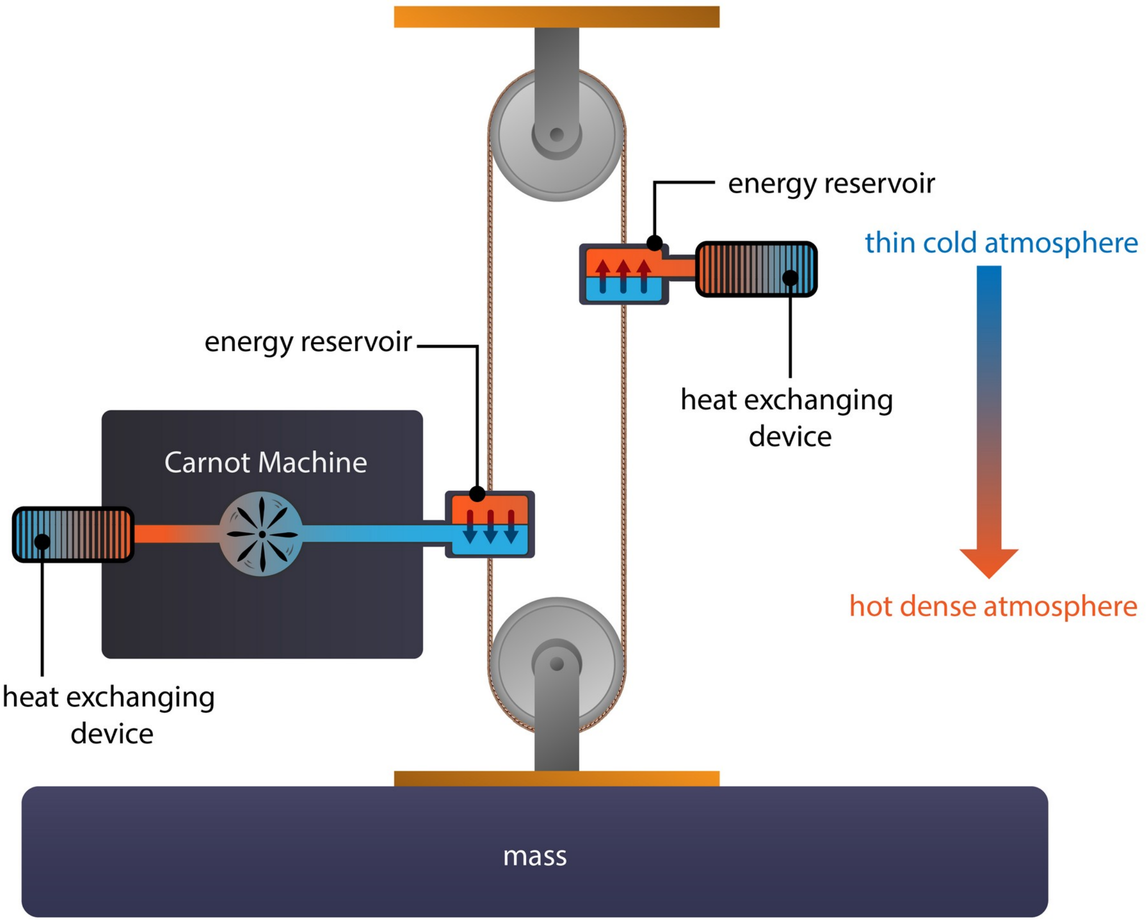
The article targets to examine the following main topics:

1. Clarify, if mechanical Energy can be retrieved from a temperature distribution even with distant energy reservoirs.
2. Investigate if a temperature distribution is recovered with gas in a gravitational field without external heat source.

Note, that both topics must have at least one credible explanation to create a full model. Since people have different backgrounds, and also to avoid trivial mistakes, each of the topics is looked at from several perspectives. To falsify this article (in contrast to the attempted proof), all of the perspectives of at least one of the two topics must be proven wrong.

1. Retrieving mechanical Energy from a temperature distribution

The first model to retrieve mechanical energy is relatively straight forward. The model to understand most easily is built similar to an Atwood machine as displayed here:

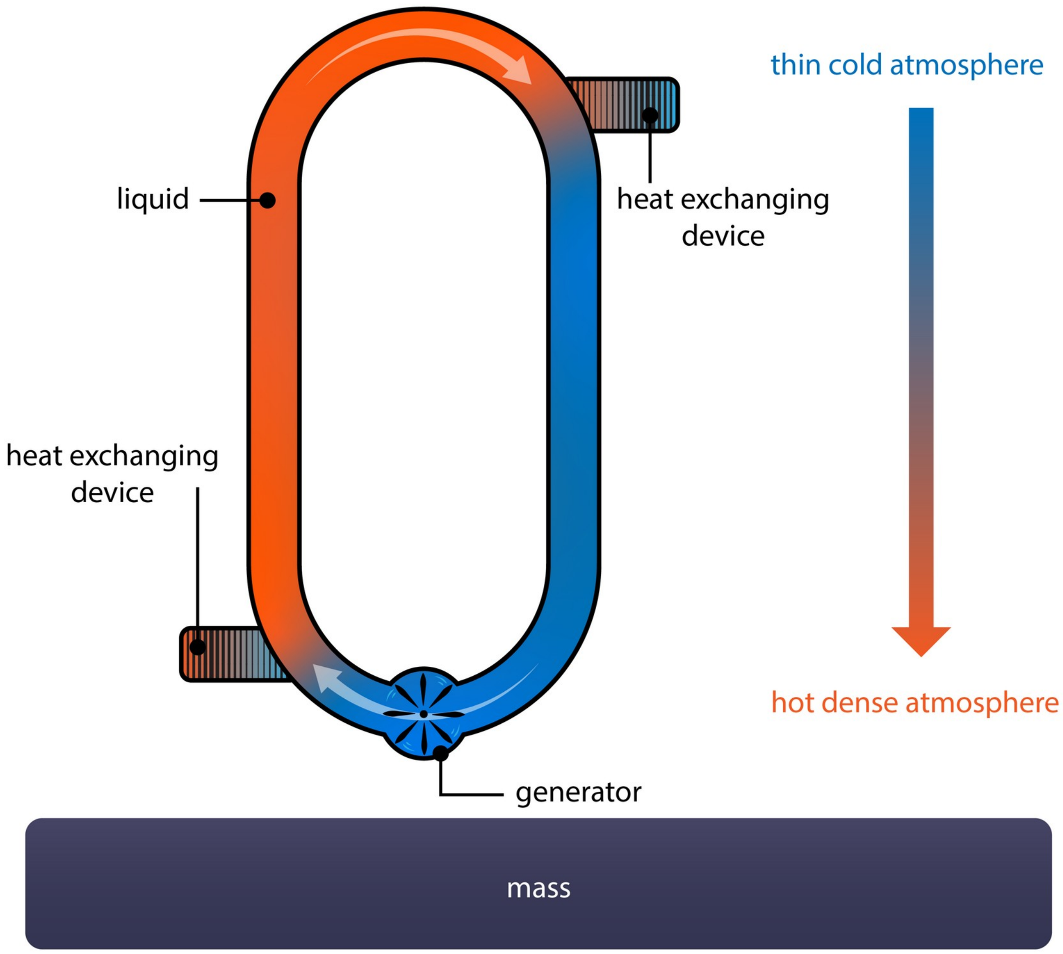


The machine contains two temperature reservoirs, that alternate between top and bottom. At the top, the reservoir will cool down to the environment temperature, at the bottom, it will provide the needed temperature reservoir to work a carnot machine.

Since the carnot machine just needs two different temperature reservoirs, it is obvious that the machine will work until the atmosphere has just a single temperature, assuming that the height of the machine can be modified in length or is used with different sizes.

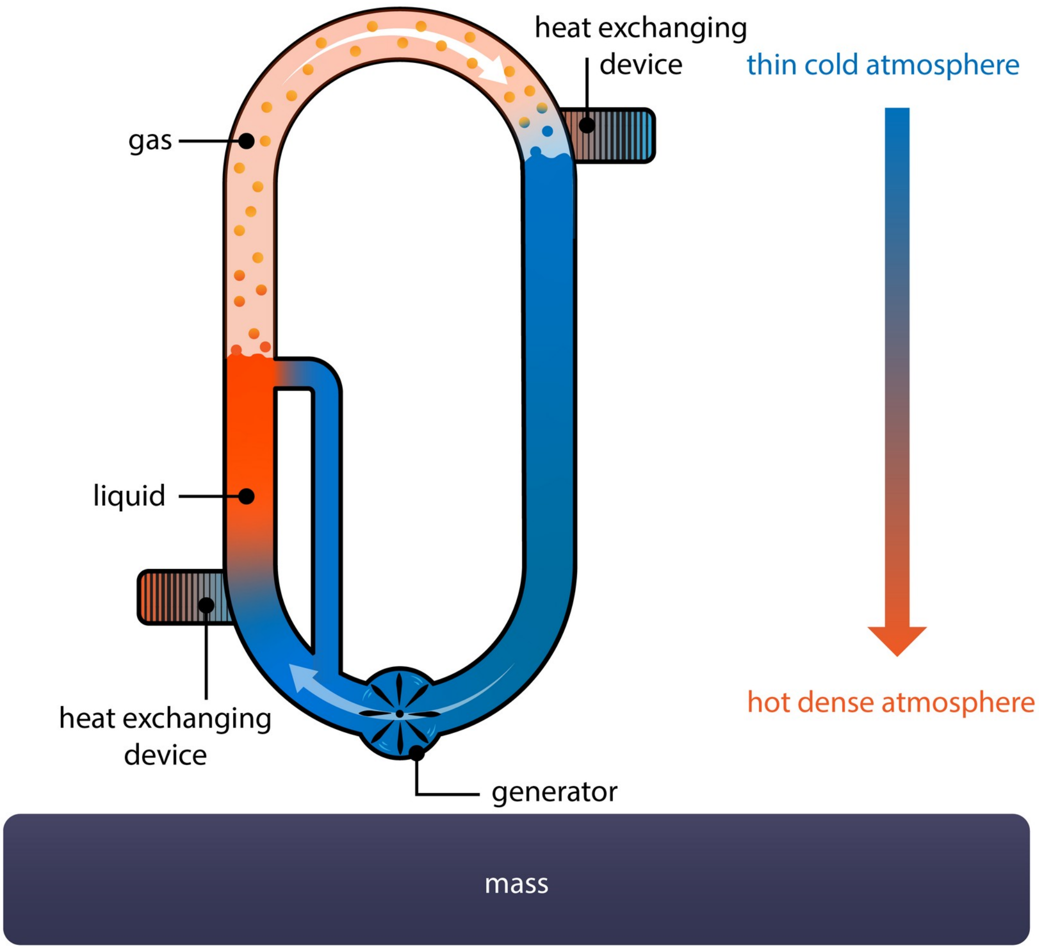
A second model of a generator of mechanical energy uses a liquid. This is not as straight forward, but still conclusive:

Let’s assume a completely isolated loop of a liquid, with just two heat exchanging devices, one at the bottom of the left side, one at the top of the right side. Lets describe this in a sketch:



Let’s also assume, that the liquid is fluid at both temperatures, and it behaves like a typical fluid, means, its density decreases with higher temperature. This means, that the liquid on the left side is warmer, and has a lower density than the liquid on the right side, which is colder. Therefore, the fluid will start to move clockwise, and can turn a generator located somewhere within the loop.

A variant of this loop would be suitable for increased transport of energy, however it is harder to understand, and led to more discussions during research. Change the pressure in the loop in a way, that the dew point of the fluid is reached just above the upper right heat exchanging device. The goal is to have the material in a gaseous state above the heat exchanging device, so that it can be condensed at this device.



Because the fluid on the left hand side has a higher temperature, it will at least partly evaporate, and therefore the fluid level on the left hand side will sink down with gas above. The inner loop that directs colder fluid back below the heat exchanging device is needed, because the evaporation heat cools down the liquid, which then must be reheated. The setup leads to different masses in the two sides of the loop and different pressure at the bottom. Together with the material transport in form of gas, the pressure difference can turn a generator.

First Result

The first result from this experiment is, that the heat distribution of a typical atmosphere contains exergetic energy. This can be used to gain mechanical energy.

Recovery of the Temperature Distribution

In the second part of this article, the recovery of the temperature distribution is discussed.

First, let’s assume that all energy is readded to the system after it has done some arbitrary work. The energy should not be stored in mechanical or chemical processes. The conservation of energy is still considered valid, and to achieve the same temperature distribution as at the beginning, the amount of energy in the system must stay constant.

Macroscopic Observations

In real world, all of the planets with atmosphere do have a heat distribution. This is true for all known planets with atmosphere that can be examined. The assumption is, that the temperature distribution in the simplified environment without external heat sources or radiation discussed in this article would follow an adiabatic distribution.

In an adiabatic pressure and temperature distribution, there will be no exchange of heat, if a gas package rises or sinks to a different level. The gas package itself will cool down if it rises, and it will heat up when it sinks, however the temperature on that new level would just be the temperature that is reached there.

Figure: rising and sinking balloons in an atmosphere: Decompresssion of the contained gas → cooler; compression → warmer display with atwood machine

Gas with single temperature

One of the common assumptions is, that the gas over a mass will cool down to all the same temperature if no external heat source is involved. Let’s have a closer look at that assumption.

With an even temperature across all of the volume, what happens when a gas package rises is, that the gas package cools down. However, since the surrounding temperature would be warmer than the package itself, the temperature on the new level would be reduced. The same happens with a gas package sinking to a lower level. When the gas package sinks to a lower level, it heats up. Because it is then warmer than the environment, the surrounding gas is heated up.

The only way that would allow just a single temperature is, that no material rises or sinks down. This requires, that there must exist layers of pressure that are as thin as just a single molecule. It also means, that the molecules must not move up or down, but just in horizontal direction. This however is not compatible with gases. If there is no movement in vertical direction, a layer above another layer of gas would not have any support from below, and thus fall down. Also, the horizontal movement of the molecules would have to be on discrete levels, to avoid that molecules get an impulse in z-direction after a collision.

Second Result

A single temperature within a gas in a gravitational field is not a stable situation.

Microscopic Observations

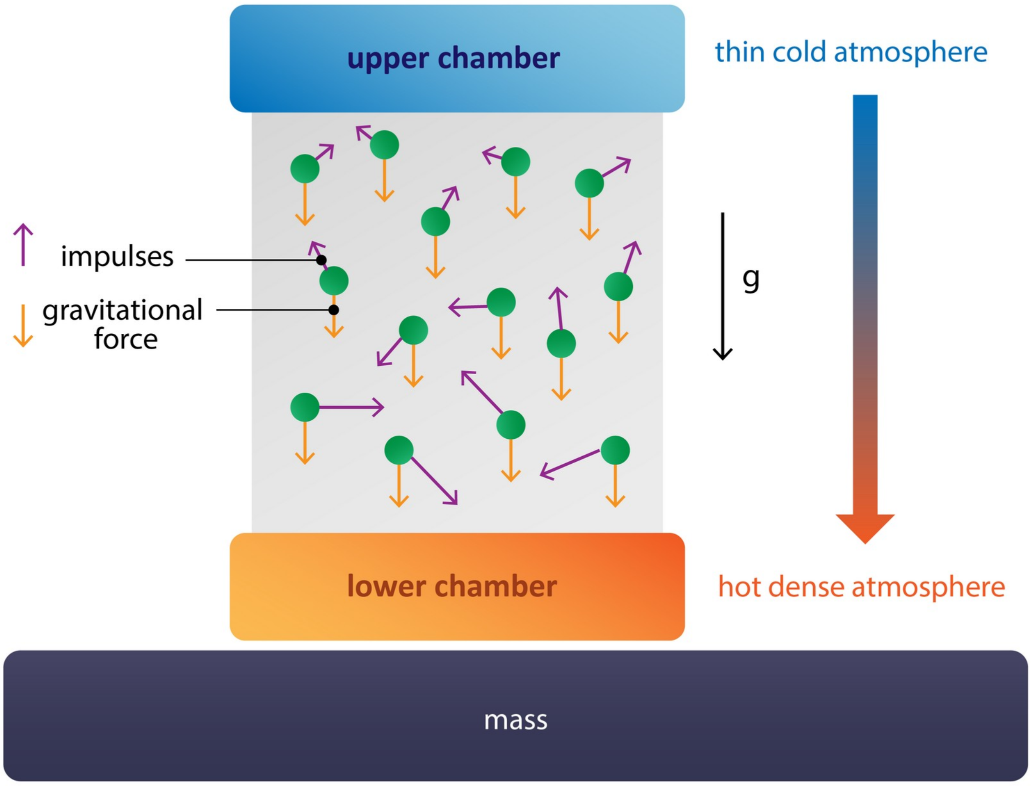
In science, there has been a major discussion about Maxwell's Demon. In that thought experiment, a demon lets pass fast gas molecules through a door between two chambers in one direction, and slower molecules to the opposite direction. This would cause different temperatures in the two chambers, and thus violate the second law of thermodynamics. Science has concluded that the demon must generate more entropy by segregating the molecules than it could eliminate.

Maxwells Daemon Reloaded: The Puppet Player

Let’s add gravitation to the thought experiment, and do some changes to have a similar effect without the effort of segregating the molecules.

Instead of having two chambers next to each other, separated by a door, let’s put the chambers above each other, and just connect them with a vertical cuboid. Now, gravitation pulls on each of the molecules from below with a close to constant force. This means, the vertical component of thehttps://youtu.be/DxL2HoqLbyA?t=974

impulse is increased if a molecule sinks down, and it is decreased when the molecule raises. This also means, that the speed, and thus the temperature, of molecules going upward is reduced, while the speed and temperature of molecules sinking down is increased.



This leads to two different temperatures in the two different chambers, with the high temperature being close to the mass, and low temperature being distant. In this thought experiment, there is no need to measure the speed of molecules, and thus no additional entropy is generated. This however is a violation of the second law of thermodynamics. Note, that this model also hints at a stable temperature distribution even within solid material, even though that is not in the focus of this article. While the adiabatic mechanisms in gases limit the temperature gradient, the gradient in solid material may be much different.

Summary

Since we already know, that it is possible to gain mechanical energy from that setup, the complete thermodynamic cycle would look like this:

1. Wait for a gas in a gravitational field to develop an adiabatic temperature distribution
2. Gain mechanical energy from that temperature distribution
3. Readd the energy to the system in form of thermal energy by doing arbitrary work
4. go to 1

The actual contradiction to the second law of thermodynamics is found at the buildup of an adiabatic temperature distribution in a gas if that gas is in a gravitational field. To create this temperature distribution from a single temperature, energy must flow from a colder to a warmer area which would not be allowed with the second law of thermodynamics. While radiation or other physical properties of the real world might have an adverse effect, the mechanism described will still cause a temperature distribution that is not the identical temperature. The consequence to this is, that while the second law of thermodynamics is valid in many circumstances, the requirements to that law will have to be researched, and it is not universally applicable.

Competing Interest Declaration: There is no affiliation with any institution. This article has been created purely because of enthusiastic interest in the topic.

Coauthors: No other authors than the main author has been writing on this article.