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Thermodynamic Verification of Dependency of Entropy of the Universe on Various Thermodynamic Parameters (Review Article)

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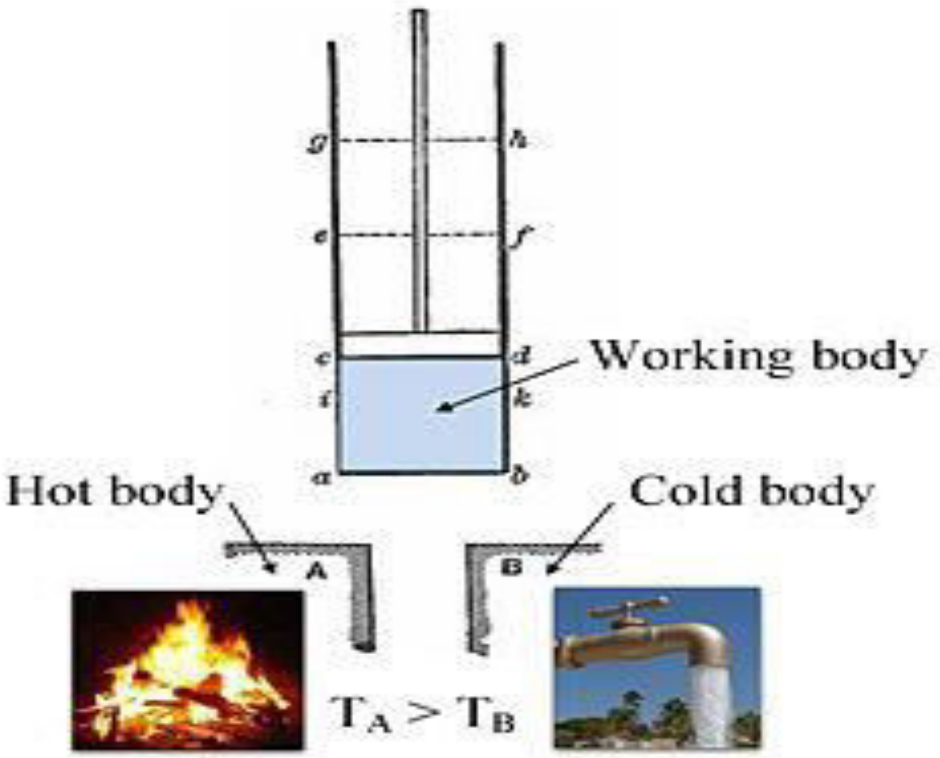
Abstract

The increase of entropy is just how a scientist talks about the fact that the universe tends to do the most likely thing. For example, if you throw a bucket of dice you'll find that about a sixth of them will be 1, about a sixth will be 2, and so on. This has the most ways of happening, so it's the most likely outcome, and for the same reason it's the outcome with the highest entropy.
Applying the concept of entropy to the universe as a whole is problematic, however in a stretch we might look at it as the amount of energy not available to do work in a general sense (not just thermodynamically), considering any overall thermal loss of a process as an increase in entropy. In that sense i disagree with the statement that structure formation implies a decrease in entropy because it becomes "more ordered". What we start with is a fairly homogeneous gas of mostly hydrogen with quite some gravitational potential energy. As hydrogen cloud collapses that gravitational potential energy gets released in heating up the gas, and a share of it gets radiated away by thermal radiation. This represents a loss in the amount of energy available for work and thus an increase in entropy, not a decrease. Likewise when a star fuses hydrogen into heavier elements this decreases the amount of energy available for work (when it was still hydrogen you could put it in a fusion reactor to power a town). When that star goes supernova a fraction of the gravitational potential energy of the core gets tied up in fissionable elements (which means available to do work), but there's another part that gets thermally radiated away, again amounting to a loss of overall energy available for work, and an increase in entropy.

Keywords: Entropy and spontaneity, Hydrogen cloud, gravitational potential energy, entropy equivalence

Introduction

The **heat death of the universe** is a historically suggested ultimate fate of the universe in which the universe has diminished to a state of no thermodynamic free energy and therefore can no longer sustain processes that consume energy (including computation and life). Heat death does not imply any particular absolute temperature; it only requires that temperature differences or other processes may no longer be exploited to perform action. The hypothesis of heat death stems from the ideas of renowned and award winner Scientists William Thomson and Baron Kelvin and who in the 1850s worked on as Energy required for mechanical work loss in nature (as embodied in the established and experimentally proved laws i.e. first law and second law of thermodynamics) and extrapolated it to larger processes on a universal scale.In a more recent view than Kelvin's, it has been recognized by a respected authority named Max Plank,on thermodynamics,[1], that the phrase 'entropy of the universe' has no meaning because it admits of no accurate definition.[2]

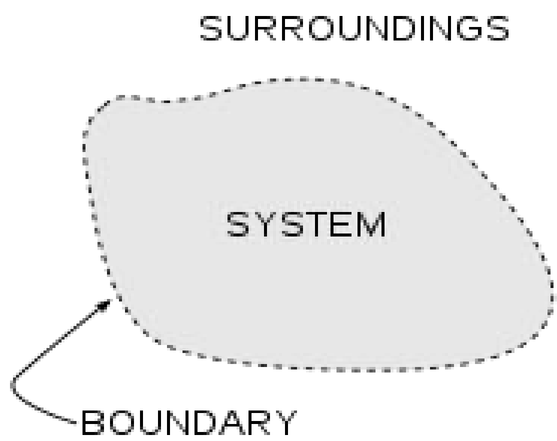


The idea of heat death stems from the second law of thermodynamics, which states that entropy tends to increase in an isolated system. If the universe lasts for a sufficient time, it will asymptotically approach a state where all energy is evenly distributed. In other words, in nature there is a tendency to the dissipation (energy loss) of mechanical energy (motion); hence, by extrapolation, there exists the view that the mechanical movement of the universe will run down, as work is converted to heat, in time because of the second law.

History and Idea of the concept

The conjecture that all bodies in the universe cool off, eventually becoming too cold to support life, seems to have been first put forward by the French astronomer _ in 1777 in his writings on the history of astronomy and in the ensuing correspondence with Voltaire. In Bailly's view, all planets have an internal heat and are now at some particular stage of cooling. Jupiter, for instance, is still too hot for life to arise there for thousands of years, while the Moon is already too cold. The final state, in this view, is described as one of "equilibrium" in which all motion ceases.[3]

The idea of heat death as a consequence of the laws of thermodynamics, however, was first proposed in loose terms beginning in 1851, who theorized further on the mechanical energy loss views of Thomson's views were then elaborated on more definitively over the next decade.



The question of how the observed evolution of organized structures from initial chaos in the expanding universe can be reconciled with the laws of statistical mechanics is studied, with emphasis on effects of the expansion and gravity. Some major sources of entropy increase are listed. An expanding "causal" region is defined in which the entropy, though increasing, tends to fall further and further behind its maximum possible value, thus allowing for the development of order. The related questions of whether entropy will continue increasing without limit in the future, and whether such increase in the form of Hawking radiation or radiation from positronium might enable life to maintain itself permanently, are considered. Attempts to find a scheme for preserving life based on solid structures fail because events such as quantum tunneling recurrently disorganize matter on a very long but fixed time scale, whereas all energy sources slow down progressively in an expanding universe. However, there remains hope that other modes of life capable of maintaining themselves permanently can be found.

We have discussed what specific entropy is and how gravitational entropy works, but we have not explained what entropy actually tells us about the universe we live in.

The conventional view is that we live in a low entropy universe. This idea is supported by the fact that our planet hosts complex life, the stars are pouring out energy, in fact all the visible universe is fantastically intricate. As entropy increases, more and more energy will become unavailable heat, stars will burn up and be swallowed up by black holes; the universe as we know it will die a heat death.

Specific entropy, on the other hand, gives a vastly different view. Over its life span, the sun will produce an increase of about 106 photons for each proton within it. The universe at present has 1010 photons per proton. This is ten thousand times as much specific entropy as the entire sun has or will ever produce. When we compare the amount of entropy that is produced now to the vast quantities which were produced in the past, we must conclude (in all but the smallest details) that the 'heat death' has already occurred.

Interactions of thermodynamic systems			
Type of system	**Mass flow**	**Work**	**Heat**
Open	Right	Right	Right
Closed	wrong	Right	Right
Thermally isolated	wrong	Right	wrong
Mechanically isolated	wrong	wrong	Right
Isolated	wrong	wrong	wrong

By counting the abundance of different elements in our sun, scientists believe there can only have been (at most) two or three stars before the current set of stars. This indicates that the entropy increase today is only marginal, compared to what it was in the past, and that entropy was increased by a different mechanism then compared to now.

However, the question remains - whatever state of entropy we have at present, the entropy of a black hole is much greater, so why isn't there a black hole here? Although they take time to form, there have been at least 15 million years available (current estimate according to the big bang theory, though estimates vary from a thousand years to infinitely long). The best explanation is the anthropic principle. If there was a black hole here, no humans would be there to question its absence - so there can't be a black hole.

Conclusion

A good model of the universe has to explain a number of physical effects. I do not want to dwell on these, yet I will briefly mention all the main effects and how the big bang theory explains them, as this is the most accepted theory.

The red-shift is the most important physical evidence, and is discussed in greater depth further on. In essence, it shows us that all the stars in the sky are moving away from us. This implies that all stars are receding from each other, so the universe was denser in the past than it is now. This laid the groundwork for models showing an expanding universe.

The infra-red background radiation is uniform heat radiation found everywhere in space. The big bang theory states it is the light from the big bang red-shifted to a fantastic extent.

The helium abundance has its origin in nuclear synthesis (formation of the elements in the stars). Stars create all elements naturally during their lifetime, in the proportions that are close to those existing in the universe (which in turn suggests they formed these elements), but there is too large a proportion of helium, lithium and other light elements. The big bang theory claims these were formed in the heat of the big bang.

Additionally, a good model of the universe should have several particular features. It should ideally only use existing and experimentally proven physical laws (there is no point in creating new laws that may or may not exist). The big bang theory is in accordance with this, in that it logically follows on from Einstein's theory of relativity and a small number of assumptions. Secondly, the theory behind a good model should not contravene any accepted fundamental physical laws (a model, for example, which demands something moving faster than light-speed would be suspect). Finally, it should be capable of making predictions which can then be tested (it is all very well to theorise about the moon being made of green cheese, but if the theory cannot be proven or disproven, it is useless).

Although it is so far having been only mentioned how the big bang model would explain these effects. Many comprehensive models of the universe explain most if not all of them equally well. Finally the Big Bang theory proves that the entropy of the universe increases with thermodynamics parameters.

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