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Heat Death of the Universe

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Abstract:- **Heat Death is a state of a Thermodynamic system having reached maximum entropy; Temperature is uniform throughout, and no energy is available to do work. So this theory is applied for the Universe where the Second Law of Thermodynamics states that Entropy that increases in an isolated system (in our case it's the Universe) Entropy, which is the number of ways in which a system can be arranged should never decrease, evolving to a state of maximum disorder (or thermodynamic equilibrium). When this happens, all energy will be evenly distributed throughout the cosmos, leaving no room for any reusable energy or heat to burst into existence. Processes that consume energy, which includes our very living on Earth, would cease or End.**

INTRODUCTION

Thermodynamics is a branch of physics concerned with heat and temperature and their relation to energy and work. There are 4 Laws in Thermodynamics, of which 2nd law of Thermodynamics is of more concerned to our concept of Heat Death.
The Second Law of Thermodynamics states that the state of entropy of the entire universe, as an isolated system, will always increase over time. The second law also states that the changes in the entropy in the universe can never be negative.
Heat Death is one of the phenomena which works according to the Second Law of Thermodynamics

HEAT DEATH OF THE UNIVERSE

The heat death of the universe is a plausible 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 increase entropy. 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 work. In the language of physics, this is when the universe reaches thermodynamic equilibrium (maximum entropy).

If the topology of the universe is open or flat, or if dark energy is a positive cosmological constant (both of which are supported by current data), the universe will continue expanding forever and a heat death is expected to occur,with the universe cooling to approach equilibrium at a very low temperature after a very long time period.

The hypothesis of heat death stems from the ideas of William Thomson, 1st Baron Kelvin, who in the 1850s took the theory of heat as mechanical energy loss in nature(as embodied in the first two laws of thermodynamics) and extrapolated it to larger processes on a universal scale.

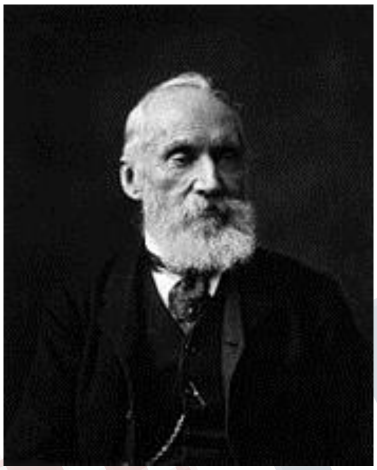
ORIGINS OF THE IDEA

The idea of heat death stems from the second law of thermodynamics, of which one version states that entropy tends to increase in an isolated system. From this, the hypothesis infers that if the universe lasts for a sufficient time, it will asymptotically approach a state where all energy is evenly distributed. In other words, according to this hypothesis, in nature there is a tendency to the dissipation (energy transformation) of mechanical energy (motion) into thermal energy; 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.

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 Jean-Sylvain Bailly 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.
The idea of heat death as a consequence of the laws of thermodynamics, however, was first proposed in loose terms beginning in 1851 by William Thomson, 1st Baron Kelvin, who theorized further on the mechanical energy loss views of Sadi Carnot (1824), James Joule (1843), and Rudolf Clausius (1850). Thomson's views were then elaborated on more definitively over the next decade by Hermann von Helmholtz and William Rankine.

HISTORY

The idea of heat death of the universe derives from discussion of the application of the first two laws of thermodynamics to universal processes. Specifically, in 1851 William Thomson (Lord Kelvin) outlined the view, as based on recent experiments on the dynamical theory of heat, that "heat is not a substance, but a dynamical form of mechanical effect, we perceive that there must be an equivalence between mechanical work and heat, as between cause and effect.



Lord Kelvin originated the idea of universal heat death in 1852.

In 1852, Thomson published On a Universal Tendency in Nature to the Dissipation of Mechanical Energy in which he outlined the rudiments of the second law of thermodynamics summarized by the view that mechanical motion and the energy used to create that motion will tend to dissipate or run down, naturally.The ideas in this paper, in relation to their application to the age of the sun and the dynamics of the universal operation, attracted the likes of William Rankine andHermann von Helmholtz. The three of them were said to have exchanged ideas on this subject In 1862, Thomson published "On the age of the Sun's heat", an article in which he reiterated his fundamental beliefs in the indestructibility of energy (the first law) and the universal dissipation of energy (the second law), leading to diffusion of heat, cessation of useful motion (work), and exhaustion of potential energy through the material universe while clarifying his view of the consequences for the universe as a whole. In a key paragraph, Thomson wrote:

The result would inevitably be a state of universal rest and death, if the universe were finite and left to obey existing laws. But it is impossible to conceive a limit to the extent of matter in the universe; and therefore science points rather to an endless progress, through an endless space, of action involving the transformation of potential energy into palpable motion and hence into heat, than to a single finite mechanism, running down like a clock, and stopping forever.

In the years to follow both Thomson's 1852 and the 1865 papers, Helmholtz and Rankine both credited Thomson with the idea, but read further into his papers by publishing views stating that Thomson argued that the universe will end in a "heat death" (Helmholtz) which will be the "end of all physical phenomena" (Rankine).

CURRENT STATUS

Proposals about the final state of the universe depend on the assumptions made about its ultimate fate, and these assumptions have varied considerably over the late 20th century and early 21st century. In a hypothesized "open" or "flat" universe that continues expanding indefinitely, a heat death is expected to occur. If the cosmological constant is zero, the universe will approach absolute zero temperature over a very long timescale. However, if the cosmological constant is positive, as appears to be the case in recent observations, the temperature will asymptote to a non-zero, positive value and the universe will approach a state of maximum entropy.

The "heat death" situation could be avoided if there is a method or mechanism to regenerate hydrogen atoms from radiation, dark energy or other sources in order to avoid a gradual running down of the universe due to the conversion of matter into energy and heavier elements in stellar processes.

TIME FRAME FOR HEAT DEATH

From the Big Bang through the present day, matter and dark matter in the universe are thought to have been concentrated in stars, galaxies, and galaxy clusters, and are presumed to continue to be so well into the future. Therefore, the universe is not in thermodynamic equilibrium and objects can do physical work. The decay time for a supermassive blackhole of roughly 1 galaxy-mass (1011 solar masses) due to Hawking radiation is on the order of 10100 years,so entropy can be produced until at least that time. After that time, the universe enters the so-called Dark Era, and is expected to consist chiefly of adilute gas of photons and leptons.With only very diffuse matter remaining, activity in the universe will have tailed off dramatically, with extremely low energy levels and extremely long time scales. Speculatively, it is possible that the universe may enter a second inflationary

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epoch, or, assuming that the current vacuum state is a false vacuum, the vacuum may decay into a lower-energy state.It is also possible that entropy production will cease and the universe will reach heat death. Possibly another universe could be created by random quantum fluctuations or quantumtunneling in roughly years.Over an infinite time, there would be a spontaneous entropy decrease via the Poincaré recurrence theoremthermal fluctuations,and Fluctuation theorem.

EXTERNAL DETAILS

Max Planck wrote that the phrase "entropy of the universe" has no meaning because it admits of no accurate definition.More recently, Grandy writes: "It is rather presumptuous to speak of the entropy of a universe about which we still understand so little, and we wonder how one might define thermodynamic entropy for a universe and its major constituents that have never been in equilibrium in their entire existence."According to Tisza: "If an isolated system is not in equilibrium, we cannot associate an entropy with it."Buchdahl writes of "the entirely unjustifiable assumption that the universe can be treated as a closed thermodynamic system".According to Gallavotti: "... there is no universally accepted notion of entropy for systems out of equilibrium, even when in a stationary state." Discussing the question of entropy for non-equilibrium states in general, Lieb and Yngvason express their opinion as follows: "Despite the fact that most physicists believe in such a non-equilibrium entropy, it has so far proved impossible to define it in a clearly satisfactory way." In the opinion of Čápek and Sheehan, "no known formulation [of entropy] applies to all possible thermodynamic regimes."In Landsberg's opinion, "The third misconception is that thermodynamics, and in particular, the concept of entropy, can without further enquiry be applied to the whole universe. ... These questions have a certain fascination, but the answers are speculations, and lie beyond the scope of this book."

A recent analysis of entropy states that "The entropy of a general gravitational field is still not known," and that "gravitational entropy is difficult to quantify." The analysis considers several possible assumptions that would be needed for estimates, and suggests that the visible universe has more entropy than previously thought. This is because the analysis concludes that supermassive black holes are the largest contributor.Another writer goes further; "It has long been known that gravity is important for keeping the universe out of thermal equilibrium. Gravitationally bound systems have negative specific heat—that is, the velocities of their components increase when energy is removed. ... Such a system does not evolve toward a homogeneous equilibrium state. Instead it becomes increasingly structured and heterogeneous as it fragments into subsystems."

CONCLUSION

We have put forward the concept of Heat death of the Universe which works under the principle of second law of Thermodynamics. As the law explains that in an isolated system the entropy increases evolving to a state of maximum disorder.However British physicist Lord Kelvin, who proposed the idea in the 1850s, referred to the loss of mechanical energy as the theory of heat.When this happens, all energy will be evenly distributed throughout the cosmos, and there will be no reusable energy and hence coming an end to the existence of living.In fact, it has been suggested that the more the Universe expands, the cooler it gets.

This is the timeline of the Universe from Big Bang to HeatDeath scenario. The different eras of the universe are shown. The heat death will occur in 10103 years, if protons decay.

The "heat death" situation could be avoided if there is a method or mechanism to regenerate hydrogen atoms from radiation, dark energy or other sources in order to avoid a gradual running down of the universe due to the conversion of matter into energy and heavier elements in stellar processes