TIME AND THE SECOND LAW

Re the thermodynamic arrow of time. (After Zemanski)

The second law of thermodynamics is empirical/experiential and phenomonological. The gents who expressed it never proposed it was universally applicable. Those who have not studied its origins frequently misuse it.

Here is some background. Judge for yourselves.

Firstly, thermodynamics deals only with systems in equilibrium, that is, systems which, on a macro scale, are not changing with time. The coordinates of thermodynamic systems are time invariant.

The observation leading to the second law was" No engine has ever been developed that converts the heat extracted from one reservoir into work without rejecting some heat to a reservoir at a lower temperature. "

Kelvin said "It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects." Plank said " It is impossible to construct an engine which, working in a complete cycle, will produce no effect other than the raising of a weight and the cooling of a heat reservoir." Kelvin and Plank together means " It is impossible to construct an engine that operating in a complete cycle, will produce no effect other than the extraction of heat from a reservoir and the performance of an equivalent amount of work."

An engine is a device that takes a working substance through a cycle, in the course of which heat is absorbed and rejected Accordingly, the law does not apply to open ended processes. The law simply denies the possibility of using energy in a particular way, continually using the internal energy of only one heat reservoir, and does so on the basis of observations in a localised environment.

Clausius recognised that work is always necessary to transfer heat from a cold to a hot reservoir. (refrigeration) Clausius' formation of the Law is "It is impossible to construct a device that, operating in a cycle, will produce no effect other than the transfer of heat from a cooler to a hotter body." Clausius' and the Kelvin Plank statements are in all respects equivalent.

It is a consequence of the second law of thermodynamics that all the observed natural processes are such that at the conclusion of the process, the system and the local surroundings cannot be restored to their initial states. The observed natural processes are all irreversible.

In the engine of classical thermodynamics, the system/process is considered to be directly coupled to a weight that can be raised or lowered , doing or absorbing work, and a series of heat resrvoirs which may be brought to the system and are used to characterise the flow of heat to and from the system. The weight and the reservoirs which can interact directly with the system are called the systems' local surroundings. Other devices and and reservoirs which might interact with the system are called the rest of the universe and this has absolutely no cosmic or celestial implication. Universe means a finite portion of the world consisting of the system and those surroundings that might interact with them.

Skipping the detail, it was then shown via either Kelvin/Plank and Clausius Law, or the work of Caratheodory, that there was an entropy function. Simple logic leads to the deduction that when a reversible process is performed the entropy of the universe remains unchanged. (The universe being the sum of the system, the local surroundings and the devices and reservoirs that might interact with the system; and, a reversible process being one which is performed in such a way that, at the conclusion of the process, both the system and the local surroundings may be restored to their initial states.)

This then lead to the Entropy Principle which says that when a system executes a reversible process the entropy of the universe is unchanged, and that when a system executes a natural and therefore irreversible process the entropy of the universe increases.

The second law and the entropy principle together establish in which direction a process will proceed naturally. This will be the direction which causes an increase in the entropy of the universe. In the case of an isolated system it is the system which has its entropy increased. If the system is not isolated, other parts of the rest of the universe may also have an increase in entropy.

Is it perhaps a rather courageous step to apply the 2nd law of thermodynamics to a realm way beyond the realm of the original empiricism and propose that the entropy of the cosmological universe is always increasing; and to further propose that the direction of time can be identified by the direction which produces an increase in the entropy of the universe, even though, quantitatively, thermodynamic systems are time invariant..

Alan