A Brief Case for an e^{th} Law of Thermodynamics

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1 The e^{th} Law of Thermodynamics

The Second Law of Thermodynamics states “the entropy of a system will tend to increase”, but is silent as to the rate of increase. Yet, the Second Law can be extended to state that “not only will entropy tend to increase, but it will tend to do so as quickly as possible.” In other words, entropy increase will not happen in a lazy, casual way. Rather, entropy will increase relentlessly and vigorously. This extension is called the ***e^{th}** of Thermodynamics*[2] or, more simply, *Fast Entropy*[3]. The **e^{th}** Law gives teeth to the Second Law.

The **e^{th}** Law is already widely utilized by astrophysicists and atmospheric scientists, although not by that name.[4] Whether a stellar or planetary atmosphere will be more likely to convect or radiate depends on which produces the greatest heat flow. The maximization of heat flow results in the maximization of entropy increase, so this scenario represents the **e^{th}** Law in action.

2 More Precise Statement of e^{th} Law

The e^{th} Law can be stated more precisely as "entropy increase shall tend to be subject to the Principle of Least Time."[5] One could even say that entropy

[1] The author is not a professional physicist, but rather runs a financial forecasting firm. The **e** th Law is used as a basis for financial modeling by this firm.

[2] e in e^{th} law referring to the transcendental number e, that is 2.718. The author’s primary use for the **e** th law is modeling exponential growth where thermodynamic potentials are involved..

[3] The term Second and A Half Law of Thermodynamics could improve pedagogy.

[4] A form of this extension is already in use by astrophysicists and meteorologists. When modeling atmospheres, their models will tend to choose the form of energy transfer that maximizes heat flow, such as convection versus conduction or radiation. See B. Carroll and D. Ostlie, An Introduction to Modern Astrophysics, 2nd Ed., Pearson Addison-Wesley, 2007, p. 315.

[5] The principle of least time is a general principle in physics that applies to diverse areas such as mechanics and optics. Snell’s Law of Refraction is an example.

increase is subject to the Principle of Stationary Action, at least indirectly, but the units must be handled carefully. The Principle of Least Time is more easily applied, and often sufficient.

3 Physical Examples

The e^{th} Law or Fast Entropy could be said to fall under non-equilibrium thermodynamics or transport theory discussed in some texts. Further, numerous engineers, who routinely deal with the application of time to real-life macroscopic systems, will find little new except the terminology. Nevertheless, a few simple examples can be offered to support the validity of Fast Entropy.

One example is heat flow through two parallel conductors each bridging the same two thermal reservoirs (Figure1). No matter what area, materials or other characteristic comprise each of the conductors, the percentage of heat that flows through each conductor is always that which maximizes total heat flow. In this case, when total heat flow is maximized, so too is the rate of entropy production maximized.

An example of such a system is shown below (Figure 1). Heat energy flows from a hot reservoir to a cold one through two conductive pathways, one of highly conductive copper and the other of less conductive iron. Copper is about 5 times as thermally conductive as iron. The faster that heat flows in this system, the faster entropy will be produced. As can be seen, 85% of the heat flows through the copper, and about 15% through the iron. This allocation allows for maximum heat flow.

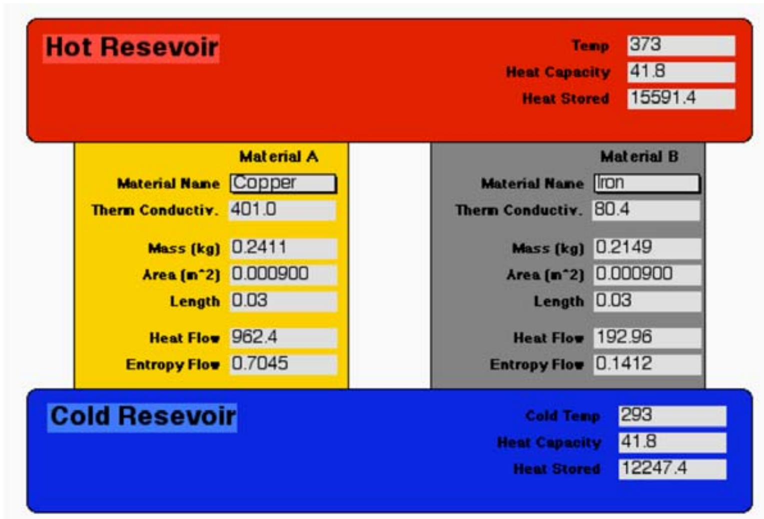

FIGURE 1 Parallel heat conductors

Another example is heat flow through conductors in series between a warmer and cooler heat reservoir. This example replicates the classic demonstration the applicability of the Principle of Least Time in optics (Snell's Law), but using thermal conductors in place of refractive material, and replacing the entrance point of light with a contact point with a warmer reservoir and the exit point of light with a contact point with a cooler reservoir (Figure 2).

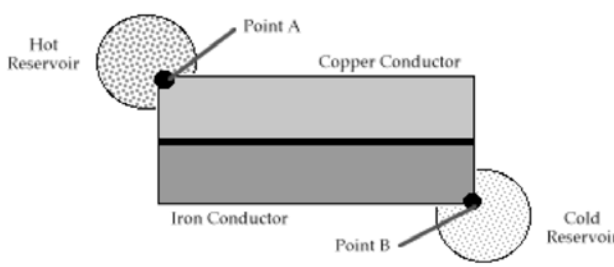

FIGURE 2 Heat conductors in series

While heat flow tends be a nebulous affair, the path of maximum heat flow can be ascertained. This can be accomplished by noting perpendicular paths to isotherms indicated by placing temperature sensitive color indicator film upon the conductors (Figure 3). Note: although convention is to represent hot as red and cold as blue, temperature sensitive color indicator film is just the opposite. Blue represents high temperatures, red cold temperatures, and brown for intermediate temperatures.

The greatest color change gradient represents the path of maximum heat flow. Observations show that the path of maximum heat flow is consistent mathematically with Snell's Law (which is based upon the principle of least time but usually reserved for light rays). In Figure 3, the dark lines represent isotherms, and the yellow line the path of maximum heat flow. The lines are intentionally a bit messy, because heat flow itself can be messy unless carefully controlled.

This example is reasonably easy to replicate. The author used a copper bar and an iron bar. Artist's small metal paint pots were used to hold ice water for the cold reservoir and hot (but not dangerously hot) water for the hot reservoir. The range of the temperature sensitive color indicator film should be selected to clearly show the range of temperatures involved. If set up correctly, you will soon see this result until the hot reservoir cools. The reservoir pots need to be firmly touching the metal bars. An ice cube can be substituted for the cold pot if you don't mind the resultant water mess. It may be easier to run this experiment if the hot reservoir is touching the copper bar (i.e. higher thermal conductivity bar).

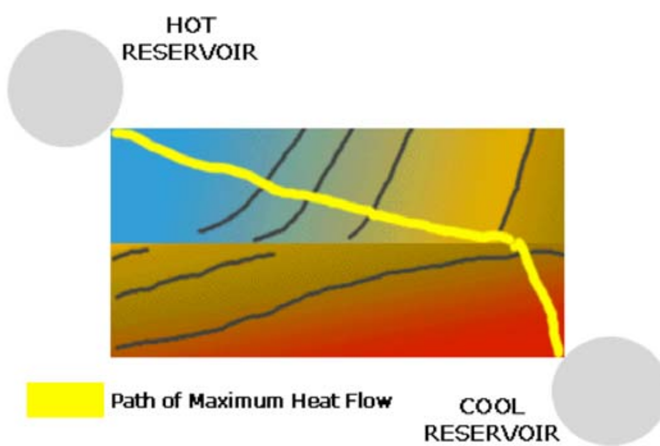

FIGURE 3 **Heat conductors in series with isotherms**

As mentioned above, a third example is well known to atmospheric scientists. Here, in an atmosphere where heat is flowing from a warm planetary or stellar surface, whether thermal radiation or conduction will occur tends to be dependent upon whichever produces the greatest heat flow. Whichever produces the greatest heat flow tends to produce the entropy most quickly.

REFERENCES

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References

References (also see footnotes and appendices)

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Note on references:

The author independently conceived the statements made in this pamphlet. However, so many people have written on thermodynamics, that the author does not claim the statements are new. Nevertheless, to the author's knowledge, the author is the first to synthesize all of these statements into an integrated whole. The author has subsequently been introduced to relevant the prior work of J. A. Burt, M. K. Hubbert, Meadows, R. Swenson and I. Prigogine who have themselves discovered some of the major pieces.

Points of Contact

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