

The Second Law, Entropy Increase and Bedini/Bearden

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Abstract.

The link between the Second Law of Thermodynamics and the claim that entropy can never decrease is examined afresh in the light of the fact that the entropy of classical thermodynamics does, in fact, decrease on many occasions. Traditional attempts to deduce the idea of entropy decrease will be looked at anew and conclusions will be drawn over the existence, or otherwise, of a general rule. Within the historical context offered, a mechanism for Bearden and Bedini's demonstrated over-unity energy gains is proposed that is based in the electromagnetic science of Maxwell. Implications for thermodynamics are then deduced.

1. Introduction.

Although based on concrete everyday examples, the subject of thermodynamics has caused students, and others, many problems of real understanding over the years. Much of the confusion has been associated with the quantity termed entropy; a quantity which first enters the subject on the introduction of the Second Law into the discussion. This entry takes different forms depending on the approach and language used but using mathematical terminology indicates that the change in this quantity is represented by a total differential, dS , which arises when an integrating factor is found for the inexact differential, $d'Q$, representing an amount of heat added to, or taken from, a system. Hence, in classical thermodynamics, any entropy change is linked irrevocably with a flow of heat via the relation

$$dS = d'Q/T,$$

where T is the absolute temperature and its inverse is, mathematically, the said integrating factor.

However, the discussion to this point in the development of the subject takes no account of the so-called irreversible processes which are prevalent in nature. One of the big stumbling blocks faced by many on their introduction to thermodynamics is the extension to cover these processes since, frequently, people tend to say that, when such processes are involved, the entropy cannot decrease and from this it is often concluded that the entropy can never decrease. Since in the above equation the heat change may be either positive or negative, it follows immediately that the entropy can, in fact, decrease under some circumstances. This raises the question as to when the entropy may be claimed to be non-decreasing?

Several answers have been advanced to this question and here these will be reviewed before an attempt is made to bring all the thoughts together to try and formulate a more general answer as well as enable a further examination of notions advanced by Bearden supposedly supported by experimental evidence for Second Law violations reported by an Australian team of researchers.

2. Traditional attempts to deduce the idea of entropy decrease.

(i) The approach of Landsberg¹.

Consider a system possessing three independent variables T , V_1 and V_2 and let this system be taken around a cycle. Suppose the initial state of this system is i and suppose it undergoes a non-static adiabatic process to a state f , where i and f are both assumed to be equilibrium states of the system. Then, the entropy change is

$$\Delta S = S_f - S_i.$$

During this process, a temperature change may, or may not, have occurred. Whether it has or not, now suppose the system undergoes a quasistatic adiabatic process $f \rightarrow k$ to bring its temperature to that of some arbitrary heat reservoir at temperature T . Since S_f and S_k are equal,

$$\Delta S = S_k - S_i.$$

The system may be brought into contact with the reservoir and caused to undergo an isothermal process $k \rightarrow j$ until its entropy is the same as it was initially. A quasistatic adiabatic process $j \rightarrow i$ returns the system to its initial state and, since S_j and S_i are equal.

$$\Delta S = S_k - S_j.$$

The only heat transfer, Q , that has taken place in the cycle is during the isothermal process where

$$Q = T(S_j - S_k).$$

Also, a net amount of work, W , has been done in the cycle where

$$W = Q.$$

From the Second Law, it is clear that the heat Q cannot have entered the system - that is, Q cannot be positive - for then, the performance of an equivalent amount of work.

Hence,

$$Q \leq 0,$$

from which it follows that

$$T(S_j - S_k) \leq 0$$

or

$$\Delta S = S_k - S_j \geq 0.$$

Here it has been assumed that an entropy change is associated with the original non-static adiabatic process. If this were not so, it would be possible to return the system to state i by one quasistatic adiabatic process. Since the nett heat transferred in this cycle is zero, the nett work would be zero also. Under these circumstances, the system and its surroundings would have been restored to their initial states without producing changes elsewhere - implying that the original process was quasistatic. This is contrary to the original assertion, and so the entropy of the system cannot remain unchanged.

Again, the system considered was assumed homogeneous and of uniform temperature and pressure. If this were not so, it would be necessary to subdivide the system into parts - each one infinitesimal in an extreme case - and to ascribe a definite temperature and pressure to each part, so that each part would have a definite entropy depending on its coordinates. The entropy of the system as a whole would be defined to be the sum of the entropies of the various parts. If it is possible to return each part to its initial state in the manner described earlier, using the same reservoir for each part, it follows that ΔS is positive for the whole system.

The final result is that the entropy of a system in a given state cannot be decreased adiabatically for a thermodynamics in which the absolute temperature is positive and heat tends to flow from high to low absolute temperatures. This is a statement of the principle of the increase of entropy of systems in *adiabatic enclosures* but it is definitely restricted to behaviour within *adiabatic enclosures* and doesn't obviously extend beyond this restriction.

(ii) The approach of Münster².

Having considered a homogeneous system and subsequently derived the equation

$$dS = d'Q/T$$

as the mathematical formulation of the Second Law for reversible processes, Münster then proceeds to consider a heterogeneous system, firstly with no heat exchange between phases and then with the different parts of the system possessing different temperatures. For simplicity, in the second case an isolated adiabatic system consisting of two parts was considered. The two parts were assumed to have temperatures T^α and T^β with

$$T^\alpha > T^\beta.$$

It was supposed that heat exchange between the phases was slower than heat equilibrium within a phase. It follows that each phase will be in internal equilibrium during the obviously irreversible process which will enable the two phases to come into thermal equilibrium with each other. In the approach to such equilibrium, one phase will lose an amount of heat while the other will gain the same amount, say dQ_i , where the suffix i indicates the fact that the process occurs internal to the system. If no external work is done, it is shown that the equation

$$dS = d'Q/T$$

holds for both parts of the system separately and, since the amount of heat lost by one part equals the amount gained by the other part, it follows that the total entropy change is given by the sum of the two separate entropy changes. After some trivial manipulation, this leads to

$$dS_i = dQ_i \left(\frac{1}{T^\beta} - \frac{1}{T^\alpha} \right).$$

Due to the above inequality, it follows that

$$dS_i \geq 0.$$

In other words, the change in entropy brought about by the irreversible process of heat conduction must be either zero or positive.

Münster then proceeds to generalise this result by noting that, in order to find the total entropy change, any exchange of heat with the surroundings has to be considered. He also noted that any such heat exchange with surroundings had to be shared between the two phases:

$$Q = Q_\alpha + Q_\beta.$$

He then commented that, if the increase of entropy due to absorption of heat from the surroundings is dS_a , the total entropy change will be given by

$$dS = dS_a + dS_i.$$

or, using earlier relations,

$$dS = \frac{dQ_\alpha}{T^\alpha} + \frac{dQ_\beta}{T^\beta} + dQ_i \left(\frac{1}{T^\beta} - \frac{1}{T^\alpha} \right).$$

By defining an 'effective temperature' and dQ' appropriately, Münster eventually writes dS in the form

$$dS = \frac{dQ}{T} + \frac{dQ'}{T}$$

and then shows that $dQ' \geq 0$. After further discussion, he shows that

$$dS \geq 0$$

for an isolated adiabatic system.

However, as with the particular case discussed here, questions may be raised as to the generality of the result as well as to whether entropy, as a function associated with classical thermodynamics, is even defined in the cases under discussion. Of course, this question relating to the definition of entropy is one of the biggest problems associated with irreversible thermodynamics. Again, though, it should be noted that Münster does restrict all his considerations to situations involving heat flow. Hence, the entropy function he discusses is always associated with changes of heat and, as such, remains fully within the orbit of classical thermodynamics; there is no mention here of statistical or information issues to cloud the issue.

3. Some further comments relating to irreversible thermodynamics.

Bearing in mind the above results due to Münster, it is interesting to note that, in discussions of irreversible thermodynamics^{3,4}, the effective starting point is to assume that the entropy change dS of a system is composed of two terms – firstly a term dS_e which arises due to a transfer of heat from external sources across the boundary of the system, and secondly a term dS_i due to changes within the system. It is often then claimed that the Second Law demands that dS_i must be greater than, or equal to, zero. It may be noted immediately that it is by no means obvious how this conclusion is reached since it seems, as illustrated above, that the inequality is derived purely for adiabatic processes. Also, it is important to realise immediately that the term felt necessary to be greater than, or equal to, zero is dS_i , not the classical thermodynamic entropy term arising from a transfer of heat. Again, this whole argument assumes that entropy itself is defined for these situations and this is by no means certain. This final point is one which is conveniently ignored on so many occasions but lies at the heart of the entire problem and is certainly a question recognised by such as de Groot and Meixner. However, possibly the most interesting outcome is to read what regularly follows in discussions of irreversible thermodynamics:

In de Groot's classic text³, the starting point of the discussion is to write the change in entropy in a certain interval as

$$dS = d_e S + d_i S = \frac{dQ}{T} + d_i S,$$

where $d_i S$ is the entropy produced inside the system by irreversible processes and dQ is the heat supplied to the system by its surroundings. As de Groot points out, the system under consideration is a closed one so there is only heat exchange with the surroundings; if there was matter exchange as well, there would have to be an additional term in $d_e S$. He then notes quite clearly that the term $d_e S$ may be positive, zero or *negative*, but then simply states that the term $d_i S$ is positive definite

However, when calculating entropy production, dS_i , he points out immediately that two assumptions have to be made, one of which is that the entropy production is positive definite. In the text due to Yourgrau, van der Merwe and Raw⁴, it is pointed out that 'the assertion that the entropy production in any process is zero or positive constitutes one of the basic postulates of irreversible thermodynamics' or, in other words, it forms a basic assumption. De Groot continues by explaining that the second fundamental assumption is that the relation

$$TdS = dU + pdV - \sum_i \mu_i dM_i$$

where U is the energy, V the volume, p the pressure, and M_i the mass and μ_i the chemical potential of the i th component of the system, is assumed valid even outside equilibrium. It follows immediately that this means that the entropy, S , is an explicit function of only energy, volume and concentrations. De Groot then proceeds to consider the validity of these assumptions. He points out that, from the statistical standpoint, the first assumption is just a result of the H -theorem. Immediately, therefore, it is seen that this theory goes outside the realm of classical thermodynamics in that a statistical element is introduced from the very beginning. He then notes that validation of the second assumption is model dependent and he draws on the Chapman-Enskog theory of non-uniform gases to justify it. As a consequence he shows that, with this model, limitations on the validity of the assumption are exposed.

This whole approach to unravelling the problems associated with the thermodynamics of irreversible situations highlights a number of points of confusion over the whole idea of entropy. Possibly most importantly it raises again the question of whether the function referred to as entropy in several branches of physics is, in fact, one and the same function. Here, in this very brief review of the situation obtaining at the outset in irreversible thermodynamics, it is seen that statistical ideas are introduced immediately and it follows that this moves considerations away from the subject of macroscopic classical thermodynamics. However, in some ways, the biggest question raised relates to what is really meant by the term 'entropy'?

4. Further thoughts on 'entropy'.

Entropy has been the source of much confusion and uncertainty in various areas of science for many years; indeed probably from the point where it was first introduced. However, possibly the first and most important point to note is that it first arose in classical thermodynamics. There, it arose from considerations of the Second Law which led to the idea that, mathematically, the inexact differential representing an amount of heat given to, or taken from, a system at a particular temperature possessed an integrating factor. Hence, this quantity of heat multiplied by its integrating factor was an exact differential which was denoted by dS , and this was termed a change in entropy. Hence, a change in this classical thermodynamic entropy was associated quite specifically with a *flow* of heat into, or out of, a system; it was definitely *not* associated with the specific system as a property of that system. Hence, the entropy of classical thermodynamics must be seen to be a different quantity from those other 'entropies' which are properties of the systems themselves. It might be noted at this point that, in the above considerations relating to so-called irreversible thermodynamics, the change in entropy is assumed to consist of two parts – one due to a flow of heat, the other due to changes within the system itself. Of course, these internal changes could be brought about by heat flow within the system but, if not, the question of what they are must arise. Further, if the internal changes are not due to heat flow, the question of whether or not they bring about entropy changes, in the sense of changes in the classical thermodynamic entropy, arises also.

This is a huge question whose answer must have far reaching consequences for science, especially as far as true understanding is concerned. One extra problem must be that the theory in place seems to have worked in practice extremely well for many years but, if truth be told, this has always been against a background of a fuzzy understanding of the basic ideas involved. There is no doubt that, within the established boundaries of statistical theory and information theory, the notion of an entropy function is securely established and is undoubtedly a valid notion. However, this function is usually taken to be identical with the entropy function of classical thermodynamics. This almost automatic assumption has been found to work, seemingly, on many occasions so that it has not been questioned and, nowadays it is not really seen as an assumption, if it ever was, but as an established scientific fact. The above considerations show this to be, in fact, an incorrect assumption since, as shown, the two entropies refer to totally different entities – the classical thermodynamic entropy being linked irrevocably with a heat flow and *nothing else*; the other entropies being linked to systems or distributions and, therefore, being properties of the actual system.

There are at least two further important points which need to be taken into consideration. The first refers to the use of all that has been said of the notions of ‘reversible’ and ‘irreversible’ processes. This point has been discussed at length previously⁵ and there seems little point in reiterating what has been said before. Suffice it to say that here the two words have simply been used to conform with the terminology of earlier work but it should be remembered that use of these two terms generally can lead to complications. The second point to contemplate concerns the implication in much of what has been written that the ‘entropy’ is a state function. It is this assumption which allows a result for purely adiabatic processes to be generalised to include all processes. The idea is that entropy is seen to increase for an irreversible adiabatic process but such a process links two states of a system and, therefore, if entropy is a function of state, any other process linking the two states must be accompanied by the same change in entropy; that is, by an entropy increase. As has been pointed out previously⁶, although entropy is undoubtedly a function of state in some circumstances, doubts have been raised over the claim that this is always so. For example, from the first and second laws it is seen, in the usual notation, that

$$d'Q = dU - d'W$$

and

$$TdS = d'Q$$

which combine to give

$$TdS = dU - d'W$$

However, for irreversible processes

$$TdS > d'Q$$

or

$$TdS > dU - d'W$$

This final equation might be written

$$TdS - TdS' = dU - d'W$$

It then follows that dS' is *not* of normal thermodynamic origin and is something intrinsic to the system undergoing the irreversible change. Hence, it must lie outside the normal first and second laws. This means also that dS' is not linked with a heat change necessarily; at least, not in the usual way.

Hence, in

$$T(dS - dS') = Td(S - S') = dU - d'W$$

if anything is a function of state, it is $(S - S')$. Obviously neither S nor S' can be functions of state in general. If this reasoning is correct, it follows that S cannot always be a function of state, although it might be on occasion.

Hence, great care must be exercised when making use of this assumption of entropy increase.

5. Tait and Force.

To end his fascinating book *Recent Advances in Physical Science*, Tait⁷ included his lecture on Force which he delivered to the British Association in Glasgow in September 1876. He commented that, at the time, ‘even among the particularly well educated class who write for the higher literary and scientific Journals, there is wide-spread ignorance as to some of the most important elementary principles of Physics’. It was for this reason that he chose for the subject of that lecture ‘Force’, which he regarded as a ‘much abused and misunderstood term’. He proceeded to comment on the ongoing abuse of the word and ended by speculating that there is probably no such *thing* as force; that it is merely a convenient expression for a certain ‘rate’. The remainder of the lecture is devoted to showing the plausibility of this notion and he eventually draws on an expanded form of Newton’s Third Law of Motion, due to Newton himself, which states that:

‘If the action of an agent be measured by the product of its force into its velocity; and if, similarly the reaction of the resistance be measured by the velocities of its several parts into their several forces, whether these arise from friction, cohesion, weight, or acceleration;- action and reaction, in all combinations of machines, will be equal and opposite’.

The actions and reactions mentioned here and claimed to be equal and opposite are no longer simple forces but are the products of forces and corresponding velocities; that is, they are rates of doing work. Tait goes on to note that force appears to be a mere name and that it is the product of a force with the displacement of its point of contact which possesses a genuine objective existence. In other words, if a force F is displaced through a distance ds , it is the product $F.ds$ which has a real physical meaning, not the force F itself. This interesting interpretation has direct relevance to an ongoing problem in thermodynamics – the question of what is entropy?

As mentioned already, in classical thermodynamics, it is customary and not unreasonable for all to feel they have some knowledge, even understanding, of many of the basic quantities that occur. Number of particles and volume have obvious

immediate meanings; internal energy, pressure, heat and temperature are all quantities with which most have an acquaintance; the idea of heat flow and of the concepts 'hot' and 'cold' cause no concerns. All feel fairly comfortable when considering these. However, entropy is another matter. The introduction of this unfamiliar concept into the framework of classical thermodynamics follows one of two routes, both of which rely on either the Kelvin or Clausius forms of the Second Law. Whether one follows the older introduction via a consideration of Carnot cycles or the more modern approach utilising the approach based on Carathéodory's treatment, the end result is fundamentally the same. It is seen that the symbol representing an element of heat added to, or taken from, a system, $d'Q$, is mathematically a so-called inexact differential but the Second Law shows that an integrating factor exists which equals the absolute temperature T . Hence, the quotient $d'Q/T$ is an exact differential and is usually denoted by dS . It is this quantity S which is termed the thermodynamic entropy. The method of derivation confers some properties, such as additivity, on this quantity but, being a mathematical derivation, no physical meaning is attributed. However, by analogy with Tait's notion about force, that it is only when multiplied by a distance, so that

$$F.ds = dW,$$

where dW represents an element of work, that the symbol, F , representing force has any real meaning, one might not unreasonably claim that the thermodynamic entropy, or, more accurately, the entropy difference, has an objective existence and, hence, physical meaning, only when its change is multiplied by the absolute temperature T to give

$$TdS = d'Q,$$

because here $d'Q$ has a definite physical interpretation as an element of heat.

Hence, the suggestion is that classical thermodynamic entropy has no separate physical meaning and may be interpreted physically only via this equation. It should be noted immediately also that, if heat is added to a system, the change in entropy is positive; if heat is taken from a system, the change is negative. It follows that it is incorrect to talk of entropy as being a quantity which can *never* decrease; such a statement, if ever true, may be true only under some quite specific conditions which would need to be stated whenever such a claim re entropy is made. It might be noted again that all these remarks refer to classical thermodynamic entropy and not to statistical mechanical or information theory entropies. When, or indeed if, these are ever equivalent is a separate issue but the above comments on the physical meaning of the classical thermodynamic entropy remain.

It is interesting also to note that these thoughts stress the importance of a heat change in the deduction of the entropy change. It is heat change and temperature which are the two variables here which possess an immediately recognisable physical interpretation. Without the presence of the heat change here, there would simply be no entropy change introduced. This then emphasises one major difference between the entropy of classical thermodynamics and *all other* so-called entropies – in classical thermodynamics, entropy change is irrevocably linked with a change of heat. Therefore, if such a heat change is not exhibited in other entropy expressions – even if they purport to refer to physical situations – these entropy expressions cannot, at least in general, be equivalent to thermodynamic entropy.

Again, in classical thermodynamics the introduction of the change in the quantity commonly referred to as entropy always follows from an amount of heat being added to, or indeed subtracted from, a system. Considering the reasoning involved, it would seem reasonable to suppose this a one-way process; that is, it is not possible in classical thermodynamics for a change in heat in a system to be produced by a change in the quantity referred to as entropy. Of course, this immediately raises questions concerning Landauer's suggestion⁸ that erasure of information is a dissipative process and that a small quantity of heat must be produced when a classical bit of information is deleted. However, in view of what has gone before, one may wonder if Landauer was truly concerned with the entropy of classical thermodynamics when he formulated his suggestion.

In addition to what has been written earlier, the First Law of Thermodynamics may be considered in the form

$$dU = d'W + d'Q.$$

In this form, it is clear that the First Law shows that any energy change is, in general, composed of contributions of work and heat or, alternatively, as work and a quantity of energy not available for transformation into work. It is this second term which, as seen earlier, is shown to be equivalent to the product of absolute temperature and entropy change by the Second Law. Hence, it is easy to see how entropy can be viewed as the unavailable energy per degree. This interpretation does seem to come closer to assigning a genuine physical meaning to the function termed 'entropy' in classical thermodynamics. It might be noted that this is quite consistent with the notion of an adiabatic change in which there is no heat change. Crucially, though, this is an interpretation purely within the realm of classical thermodynamics; it is a quite definite quantity, not an average one, and certainly not one admitting fluctuations in its value. Hence, it might be stressed again that the entropies of statistical mechanics/statistical thermodynamics and of information theory are not being discussed here.

In connection with this latter point, it is worth noting the comments of Baierlein in appendix D of his book *Atoms and Information Theory*⁹ in which he makes it abundantly clear that. Although there is a close correspondence between quantities in classical thermodynamics and statistical mechanics/statistical thermodynamics, they are not identical. As he also points out, it is simply the case that 'for practical calculations, they are numerically equivalent'. In other words, numerical equivalence does not necessarily mean actual equivalence. Possibly it should be stressed again that the comments here concerning a physical meaning of the entropy relate specifically to classical thermodynamics. Finally on this particular point, it might be noted that Baierlein also makes some pertinent comments concerning the relation between the entropies of classical thermodynamics and information theory. Again he stresses numerical, but not conceptual, equivalence but he also goes on to note that 'the failure to preserve a *distinction* is often a stumbling block on the path to an appreciation of both.' However, on this issue it is possibly worth considering some thoughts of Lazar Mayants¹⁰. A function which often crops up in thermodynamics is the Helmholtz Free Energy which is defined by

$$F = U - TS$$

from which may be derived the incremental form

$$dF = dU - TdS - SdT.$$

Eliminating dU between this equation and that representing the combined First and Second Law

$$TdS = dU + pdV$$

if $d'W$ is taken to be an amount of purely mechanical work given by $-pdV$, leads to

$$dF = -pdV - SdT,$$

from which it is seen that

$$S = -\left(\frac{\partial F}{\partial T}\right)_V.$$

It then follows that

$$\frac{U}{T^2} = \frac{F}{T^2} + \frac{S}{T} = \frac{F}{T^2} - \frac{1}{T} \left(\frac{\partial F}{\partial T}\right)_V = -\frac{\partial}{\partial T} \left(\frac{F}{T}\right)_V \quad (*)$$

This is one of the neat steps introduced by Mayants¹⁰ in his discussion of the point to be highlighted here. Up to this point, all the formulae and manipulations have been well-known; it is the introduction of this relationship which makes what follows feasible. If attention now turns to the area of statistical mechanics and is restricted to the canonical ensemble, the equilibrium value of the probability p that the system of the ensemble has energy ε is given by

$$p = Z^{-1} \exp(-\beta\varepsilon)$$

where

$$Z = \sum \exp(-\beta\varepsilon)$$

is the partition function.

It follows that the average or internal energy is given by

$$U = \sum \frac{1}{Z} \varepsilon e^{-\beta\varepsilon}$$

and it readily follows that

$$U = kT^2 \left(\frac{\partial \ln Z}{\partial T}\right)_V$$

Comparing with the equation (*) above, it is seen that

$$F = -kT \ln Z$$

Then

$$S = -\left(\frac{\partial F}{\partial T}\right)_V = k \ln Z + kT \left(\frac{\partial \ln Z}{\partial T}\right)_V = k \ln Z + \frac{U}{T}$$

Again, from the expression for the probability that the system of the ensemble has energy ε , it follows that

$$\ln p = -\frac{\varepsilon}{kT} - \ln Z$$

Therefore, the mathematical expectation of $\ln p$ is easily seen to be

$$\overline{\ln p} = -\frac{U}{kT} - \ln Z$$

Hence, it follows that

$$S = k \ln W$$

where

$$\ln W = -\overline{\ln p}$$

These two final equations give a probabilistic interpretation of the entropy normally associated with classical thermodynamics and hence with that entropy whose change is irrevocably associated with a change in heat at some specified value of the absolute temperature.

It would seem to follow, therefore, that there is still much to be done to finalise the link or links between the various entropies appearing in the various branches of physics – classical thermodynamics, statistical thermodynamics and information theory. One point concerning the above argument due to Mayants which may be relevant to this and should definitely be considered is that, in statistical thermodynamics, many results from classical thermodynamics are routinely considered to continue to hold. This may, or may not, be so but, using them in this way could conceivably almost force equivalence of the different entropies to appear valid when reality could be something totally different. This is certainly an area in need of further open minded investigation.

6. Links with notions advanced by Bearden.

Many of the notions referred to here are to be found discussed in *Free Energy Generation* written jointly by T. Bearden and J. Bedini (2011, Energetic Productions, Inc.)^{11a}, specifically in notes concerned with negative entropy, or negentropy, which appear on pages 221-222. Their discussion centres on what they see as the ‘overly restrictive second law of thermodynamics’, by which they mean the statement concerning the notion that entropy can never decrease. They go on to discuss negative entropy, or negentropy, noting that, in their work, such a quantity is a reality. Their mistake is to regard the so-called law of increase of entropy as a valid statement of the Second Law of Thermodynamics. They cite the experimental work of the Australian team of Evans and Searles¹² in support of this. However, in the cited experimental work, a process has been considered in which entropy is claimed to have decreased; there is no mention of cycles which are so crucial in classical thermodynamics. If classical thermodynamics is under consideration in this, there is no problem because and change in entropy would be given by

$$dS = d'Q/T$$

and, in this expression $d'Q$ could be positive, zero or negative depending on whether heat is added to the system, there is no heat change, or heat is taken from the system. If the system considered is felt to be controlled by irreversible

thermodynamics then a totally different argument is involved as is seen above but any increase in the overall entropy would not negate the validity of the Second Law and it must always be remembered what de Groot stated, as quoted above, regarding the assumptions made in this theoretical field. Again, it might be noted in passing that if classical thermodynamics is not under consideration but rather information theory then the notion of negentropy is quite basic as is evidenced by reference to the work of Brillouin¹³. The simple truth is that the Second Law of Thermodynamics is not overly restricted in the sense intimated by Bedini and Bearden; it is just that one must appeal to the correct formulation of that law and not be distracted by claims which must obviously be untrue. It must always be remembered that heat may be added to, or subtracted from, a system and in the first case that implies a positive change in entropy, in the second it implies a negative change.

However, it must be stressed that there appears to be an evident effect of considerable importance demonstrated in the Bedini/Bearden work [reference 11a, pp. 1-77]. Here apparent energetic extraction is seen from “the vacuum” which must not be a vacuum in the traditional sense and appears to be functioning as an energy density. The effect has, in principle, been replicated by many others, including a young student completing a school science project. [ibid. pp. 210-216]. The pollution free and potentially limitless energy production effects demonstrated appear real and are worth immediate investigation. It is proposed that once these ideas and others¹⁴ become the focus of the scientific community, the underlying physical mechanics revealed could hold much of the science that will enrich the future of man while leaving thermodynamic theory intact and logically consistent, much as has been described here.

Over-unity energy gain mechanism and thermodynamic implications

It must be remembered that an actual physical mechanism must explain the evidence gained within physical science. The Relativity model proposed by Einstein, inclusive of both the General and Special theories, has deep limitations and paradoxical aspects which plainly demonstrate themselves under scientific scrutiny, particularly pertaining to celestial mechanics [15, see: *Practical and theoretical assessment of relativistic theory*]. It has been deduced from analysis of the available evidence that curved space-time is a mathematical model and not a causal descriptor. Indeed, space-time as such is a purely mathematical construct as distinct from something genuinely physical. Also, it must be remembered at the outset that the statement of the second law of thermodynamics in terms of continual entropy increase is not actually a statement of that law but merely a flawed inference and hence may be discarded as physical evidence demonstrates situations of entropy decrease with no implied contradiction [15 and above]. Then it should be noted that the link between entropy and ‘order’ is a somewhat tenuous one. It is one based on noting such physical processes as the boiling of a liquid and noting that the liquid becomes more and more agitated as it is heated. This is, not unreasonably, taken to mean that the liquid is becoming more and more disordered. This interpretation is understandable but it does not necessarily indicate any link between entropy and ‘order’ and any such supposed link is seen to be one manufactured to some extent at least¹⁶. It is a notion which has more possible relevance in statistical thermodynamics or even information theory but has no place in classical thermodynamics. With these basic points in mind, thoughts on the actual mechanisms involved in those demonstrated over-unity power gains in the science of Bearden and Bedini, as exemplified within the Motionless Electromagnetic Generator (MEG) device and the Bedini circuit may now be considered.

Within a little known volume by Maxwell, *A Dynamical Theory of the Electromagnetic Field*¹⁷ is found the basis of an actual physical mechanism that could explain the observed over-unity energy gain effects [11a,18,19]. Bearden claims theoretically that a tension within curved space-time is responsible for the gravitational energies harvested in the MEG device^{11a,18}. Bearden also claims on his extensive web site that curved space-time and scalar waves are functionally the same ideas. Within that little known volume by Maxwell¹⁷, caution is urged from the beginning that the new mathematics and hypothetical theory presented are just that, save for two points which are actual demonstrated physical mechanisms of causality; those two mechanism being the aspects of the magnetic field responsible for its energy: (i) the magnetic polarizations and (ii) the electric polarizations. Movement is associated with point one, tension in an elastic medium with point two. Video is available which presents the working mechanism of the MEG.¹⁹ It is believed the energy gained in the MEG extends from a causal magnetic polarization inducing an electric polarization which is harvested to produce over-unity energy gains. Tension in the elastic medium is harvested *voltage*, a scalar wave^{17,20}. Gravitational expressions presented as theoretical tension in “curved space-time” are actually tensions in an elastic medium: electric polarizations, scalar waves within the surrounding energy density once known as aether. It is this energy density which comprises Bearden’s hypothetical “active vacuum.”²⁰

Note that claims of scattering and time reversal associated with these effects showing the second law to be overly restrictive^{11a,11b} are based upon the mistaken notion of entropy increase as an actual statement of the second law itself which is simply false, since the notion of entropy as derived in classical thermodynamics has no such property. Also it is worth noting that Bearden’s claims are based upon the idea of negative entropy as expressed in an ordering of energy. These claims are not physically based but are instead associated with statistical mechanics. It must be noted also note that any proven claims of Bearden’s considering entropy decrease in conjunction with temperature decrease are indeed supported by thermodynamics. Again emphasizing that in all of these cases no contradiction with the second law is present.

Next, the Bedini circuit^{11a} appears to use system self-energies re-injected into the system to gain new energies. The resonance “hammer effect” so often mentioned in Bearden’s and Bedini’s texts appears to be physically real. Motion demonstrated as vibratory resonance and ionic mobility are expressed due to a *tuned* current-spike induced (molecular/atomic//ionic) magnetic polarization leading then in turn to system coherence and emergent electric polarizations. Coherence is theoretically implied as a frequency-specific spike relates the many system parts including electrolytic borne ions and other electro-dynamic components. It may be deduced that the induced electric polarizations (scalar waves) are harvested as voltage, as the causal resonant magnetic polarizations carry the system ions backward.

7. Conclusions.

This article does not set out to give a complete and definite answer to the basic question raised but rather to make people aware of some of the very real, but unstated, problems associated with the quantity, or more probably the quantities, referred to as 'entropy' in modern science. In particular, we have highlighted some of the assumptions that have been made within the development of the subject and which have since been overlooked or possibly regarded as statements of fact rather than the assumptions they truly are. Very real questions have been raised which are worthy of further consideration, if the physical property associated with entropy is ever to be totally understood and, by extension, how different processes change this property. In this respect, problems associated with the notions of 'reversibility' and 'irreversibility' of physical processes have again been raised, as has the query concerning whether or not entropy is always a state function. Definite answers have not been advanced but some conclusions may be drawn. It does seem that, whatever the success of present day notions in some practical situations, the idea that all the entropies discussed so freely are the same is simply not true. The crucial point highlighted in this context is that, in classical thermodynamics, a change in the entropy function is linked irrevocably with a flow of heat but this is not the case in other areas. In addition, it has been shown that the seemingly blanket claim that the "Second Law of Thermodynamics states that the entropy can never decrease" is, at the very least, misleading and, at worst, totally incorrect; it should be remembered always that the Second Law of Thermodynamics originated with a study of heat engines and is associated with cyclic processes. The only truly acceptable statements of this powerful law are those due to Kelvin and Clausius with the possible inclusion of that due to Carathéodory; all others are, at best, deductions from these and often have a limited range of validity.

Possibly the most important conclusion to come out of these considerations and one which should be noted by all researchers utilising thermodynamic arguments and particularly when appealing to the Second Law is that, whatever else it might be, the so-called 'Law of Increase of Entropy' is *not* a statement of the Second Law of Thermodynamics! Within that sure fact the entirety of electromagnetic theory and thermodynamics may then be applied to ease the burdens of mankind.

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