Why the Second Law of Thermodynamics is Invalid

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The Second Law of Thermodynamics (SLT) states that

> " … the entropy of an isolated system never decreases, because isolated systems spontaneously evolve towards thermodynamic equilibrium—the state of maximum entropy. [..]
> The second law is an empirically validated postulate of thermodynamics, but it can be understood and explained using the underlying quantum statistical mechanics, together with the assumption of low-entropy initial conditions in the distant past (possibly at the beginning of the universe).
> [..] Because equilibrium corresponds to a vastly greater number of microscopic configurations than any non-equilibrium state, it has the maximum entropy, and the second law follows because random chance alone practically guarantees that the system will evolve towards equilibrium.
> The second law is thought to be the source of the direction of time. It is an expression of the fact that over time, differences in temperature, pressure, and chemical potential decrease in an isolated non-gravitational physical system, leading eventually to a state of thermodynamic equilibrium. [..] initial conditions early in the universe were those of low entropy. [..] gravitational systems tend towards non-even distribution of mass and energy."[1]

While a mixture of gasses certainly doesn't unmix spontaneously, a broken egg unbreak, to examine whether the SLT holds for the universe, we need to establish whether its initial state indeed is a state of minimum entropy.
Though a low entropy may correspond to a system far out of equilibrium, a system only can be out of equilibrium if there is an equilibrium state, if there are physical laws operational by means of which the inequilibrium can, *must* convert into an equilibrium state.
If an inequilibrium only is created as soon as the laws kick in which determine the nature of the initial and subsequent states, at the time it actually starts to transform into another state so one state doesn't *causally* precede the other, then can the entropy of the universe change at all?
Moreover, if an inequilibrium only can emerge when the laws of nature become operative, then shouldn't they prevent the creation of the inequilibrium in the first place, an event like the big bang to happen at all?

If the initial state comprises all laws of nature, instructions how to get from one state to the next, laws which specify the nature of all consecutive states so contains *all* information about the entire future evolution of the universe, then this information must've been put into it from the outside (by the Tooth Fairy? –or is there a school for aspirant universes?) –in which case it isn't closed and the SLT doesn't apply anyway.
If the entropy of the universe is like the sum of the kinetic and potential energy of an object in a gravitational field –which doesn't depend on whether it has already fallen or not– and the initial state contains *all* information and a high information content corresponds to a low entropy, then you'd say that the entropy of the universe cannot depend on *when* we look at it.
If, on the other hand, the universe *is* perfectly closed, if nothing can enter or leave it so any inequilibrium must be the product of an evolution so cannot causally precede the equilibrium, then it cannot start out with a minimum entropy –in which case the SLT is invalid.

Put another way, though a broken egg doesn't unbreak, its evolution, its creation in fact comes down to unbreaking the egg: if in a closed universe particles and laws of physics similarly are the product of an evolution so there's no initial low entropy, then the SLT just doesn't hold.

Though random events tend to destroy information and increase the entropy of a system, the assumption of randomness, of spontaneousness –whether the behavior of the involved particles is erratic or not– hinges on whether their properties depend on their behavior.
Though particle properties are *defined* to be independent from their behavior, there only is room for randomness if they indeed are interaction-independent.
If so, then all possible distributions of particles over space would be physically, energetically equivalent, so their actual distribution wouldn't matter for the information they carry in the form of properties nor for the entropy of the universe.
However, their distribution only wouldn't matter if they'd have no mass, if there's no gravity.
So if particles do have mass and contract due to gravity, then that must mean that their mass is *not* an interaction-independent quantity –in which case there's no room for randomness.
If ultimately "all mass is interaction"[2] so particles, particle properties are both cause *and* effect of their interactions, the product of an evolution, then there's no initial minimum entropy, no primordial information to get blurred by randomness.
Though their behavior may seem random if the underlying mechanism is unknown, it's unlikely that nature doesn't know what it does, that there is no mechanism: though it may not know randomness, it *does* know uncertainty[3] –an indefiniteness we mistake for randomness.
If the inequilibrium state indeed cannot *causally* precede the equilibrium state, if the observed time sequence of events doesn't necessarily mean that the first is the cause of the next, then there is something wrong with our idea of time.

Causality, Gravity and the Arrow of Time[4]

According to relativity theory, a clock inside a gravitational field is observed to run slower as the field strength at the clock is stronger compared to that at the observer, so as seen from outside the field, time passes slower inside of it.[5]
As a consequence, 'random' events, quantum fluctuations[6] which lead to an increase of the field strength, of the mass of its source, tend to be preserved, favored above events decreasing it, so in imposing a direction on events, gravity can be said to power time itself, driving the changes we experience as the passing of time.
If in a closed universe particles have to create themselves, each other so their properties are both the effect and cause of their interactions, of forces between them –and mass cannot causally precede gravity nor the other way around– then mass similarly has the tendency to increase, to keep creating itself –which is just the trick a universe needs if it is to create itself.
The misleading thing about gravity, then, is that, in powering the changes we experience as the passing of time, we have a sequence between events we misinterpret as proof that one is the cause of the other, as if mass can precede gravity, cause particles to contract.
If mass cannot precede gravity, then we can as well say that gravity between the particles –the mass they have according to each other– only increases *if and when* they contact –which, given the stickiness of mass, the self-enhancing tendency of gravity, they are bound to do.

Indeed, Newton's action = reaction law, stating that a force *at all times* equals the counter force it evokes so they *always* are in equilibrium so one force cannot precede the other, suggests that the observed sequence of events doesn't necessarily mean that the first is the cause of the next.

Historically, particles were thought to contract because they were created, given mass by God, so their mass was assumed to be only the cause of their contraction, to precede gravity.
In the slightly more enlightened present time, however, elementary particles are thought to acquire mass by interacting with the so-called Higgs field or the associated Higgs particle.[7]
However, to be able to interact with the Higgs field, a particle must already exist, have some (unknown) property which enables it to actually interact with the field and pick up the species-specific quantity of mass it is supposed to have: how can it know what particle it is to become?
Furthermore, the theory doesn't explain the origin of the mass of the Higgs particle nor predict the masses of the particles it is supposed to provide with mass: does the Higgs particle owe its mass to interactions with a pre-Higgs field or particle, which, in turn, owes its mass to … ?
If we can as well say that the Higgs particle owes its mass to interactions with the particles it is supposed to provide with mass, then the Higgs mechanism doesn't really explain anything.

Anyhow, if we cannot isolate a system from gravity so no system (except the universe itself) is perfectly closed, then the SLT doesn't apply: though one might say that gasses mix even if when isolated from gravity, if in that case time would stand still inside of it, they wouldn't mix: if they *would* be perfectly isolated, then they would no longer be part of the universe of the observer.

Its from Bits?

Perhaps inspired[8] by the weirdness of quantum mechanics, things like Schrödinger's cat[9] and the double-slit experiment[10], enigma's which remain incomprehensible as long as we allow ourselves to be mesmerized by causality, John Wheeler[11] proposed that

> "… every 'it' –every particle, every field of force, even the space-time continuum itself– derives its function, its meaning, its very existence entirely –even if in some contexts indirectly– from the apparatus-elicited answers to yes-or-no questions, binary choices, bits.
> 'It from bit' symbolizes the idea that every item of the physical world has at bottom –a very deep bottom, in most instances– an immaterial source and explanation; that which we call reality arises in the last analysis from the posing of yes–no questions and the registering of equipment-evoked responses; in short, that all things physical are information-theoretic in origin and that this is a *participatory universe*."[12]

Evidently, Wheeler, not wanting to let go of causality as a guiding principle in understanding nature, tries to make sense of quantum mechanics by reversing cause and effect.
Instead of following tradition and consider particles, 'its', only to be the source, the cause of events, of forces and interactions, that is, of the exchange of information, of 'bits', he intimates that instead it are the 'bits' which cause the 'its', the particles to exist.
Clearly, if particles, 'its', "in the last analysis" create one another, if they express and preserve each other's properties, the information they represent by interacting, by exchanging 'bits', then information is no more fundamental than, nor can it casually precede its material carriers.

If we understand something only if we can explain it as the effect of some cause and understand this cause only if we can explain it as the effect of a preceding cause and the chain of cause-and-effect either goes on *ad infinitum*[*] or ends/starts with some primordial cause or event which, as it cannot be explained as the result from a preceding event, cannot be understood by definition, then causality ultimately cannot explain anything.
As a causal reasoning cannot but start from some hypothetical primordial cause or event which cannot be explained nor be proved but only be *believed* to have happened, causality is not a scientific, but a metaphysical concept.
If in a self-contained universe particles create, cause each other, then they explain each other in a *circular* way: here we can take any element of an explanation, any link of the chain of reasoning without proof, use it to explain the next link and so on, to follow the circle back to the assumption we started with –which this time is explained by the foregoing reasoning.[†]

If the distance and relative motion of particles affect the properties they 'observe' each other to have, the 'bits' they exchange, then a particle at all times is completely informed about the nature, position and motion of all other particles within its interaction horizon, its universe.
A particle then is like a hologram fragment which contains all info of the entire hologram: like the information of a hologram fragment is vaguer as it is smaller, the information a particle carries, represents is smaller, less definite as its properties are less defined, that is, as its energy –and hence its interaction horizon, its universe– is smaller, less defined.
As the observer is part of the particle's universe so is himself depicted in the hologram fragment he inspects, he cannot but affect what he observes, so if an experimenter can affect whether the answer he asks a system with some device is yes or no, then answers aren't as unequivocal, as absolute as Wheeler wants to believe is possible.

Though I have the utmost respect for a renown physicist as John Wheeler, as current physics, obsessed as it is with causality, is unable to explain *why* quantum mechanics works, we might try a different approach and replace causality with reason as a tool to understand our world.[‡]

If any information particles contain is expressed and preserved in its exchange so there exists no information outside its communication, no redundant, 'net' information in the universe, then the SLT doesn't apply to the universe itself.

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[*] so there's no "bottom", no primal "immaterial"–disembodied?– source of information, no primal cause
[†] If at the most fundamental (quantum) level we ultimately cannot distinguish cause from effect, then the reasoning should work as well in the reverse direction.
[‡] How that world may look like, see www.quantumgravity.nl –a study which shows *why* quantum mechanics works –and why string theory, for example, never will.

References

[1] http://en.wikipedia.org/wiki/Second_law_of_thermodynamics ref. date 22-5-2013
[2] Richard Feynman, quoted in "Genius : The Life and Science of Richard Feynman" (1992) by James Gleick in "Principles"
[3] http://en.wikipedia.org/wiki/Uncertainty_principle ref. date 22-5-2013
[4] http://en.wikipedia.org/wiki/Arrow_of_time ref. date 22-5-2013
[5] http://en.wikipedia.org/wiki/Gravitational_time_dilation ref. date 22-5-32013
[6] http://en.wikipedia.org/wiki/Quantum_fluctuation ref. date 22-5-2013.
For details of the self-creation of mass, see www.quantumgravity.nl
[7] http://en.wikipedia.org/wiki/Higgs_particle ref. date 22-5-2013
[8] http://suif.stanford.edu/~jeffop/WWW/wheeler.txt ref. date 22-5-2013
[9] http://en.wikipedia.org/wiki/Schr%C3%B6dinger%27s_cat ref. date 22-5-2013
[10] http://en.wikipedia.org/wiki/Double-slit_experiment ref. date 22-5-2013
[11] http://en.wikipedia.org/wiki/John_Archibald_Wheeler ref. date 22-5-2013
[12] For the quote see: http://en.wikipedia.org/wiki/John_Archibald_Wheeler ref. date 22-5-2013
For the complete article "Information, Physics, Quantum: The Search for Links", see http://jawarchive.files.wordpress.com/2012/03/informationquantumphysics.pdf p 309
(from Proc. 3rd Int. Symp. Foundations of Quantum Mechanics. Tokyo 1989 pp. 354-368)