Resolution of the SLT-Order Paradox

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The Second Law of Thermodynamics (SLT) states that the entropy or disorder of an isolated system can only increase. And yet, we see numerous systems all around us that that clearly have decreasing entropy and increasing order: the SLT-Order Paradox. Systems philosophers have proposed numerous solutions to the paradox without success. From Schrödinger's "negentropy" to Prigogine's "fluctuations," "distance from equilibrium," "nonlinearity," or "self-organizing," there always has been residual bias in favor of the system over the environment. At one extreme, the SLT was said to predict the eventual "heat death" of the finite, expanding universe. As with all paradoxes, however, the solution simply involves a change in beginning assumptions. The paradox dissolves if one considers the universe to be infinite. Then, the SLT is a law of divergence; its complement is a law of convergence. Matter leaving one portion of the infinite, 3-dimensional universe invariably converges upon matter in another portion of that universe. Destruction in one place leads to construction in another place. The resulting *complementarity* shows the SLT to be a restatement of Newton's First Law of Motion in which the word "unless" is replaced by the word "until," in tune with Infinite Universe Theory. The imagined "ideal isolation" required by the SLT has an equally imaginary "ideal nonisolation" required by its complement. All real systems come into being at the behest of relative nonisolation and dissipate at the behest of relative isolation. Complementarity is essential for univironmental determinism, the universal mechanism of evolution stating that what happens to a portion of the universe is determined by the infinite matter in motion within and without.

Introduction

The Second Law of Thermodynamics (SLT) states that *the entropy or apparent disorder of an ideally isolated system can only increase*. In the strictest sense, the SLT says everything about increasing disorder, but nothing about increasing order. Yet as philosopher-physicist L. L. Whyte noted: "The fact which we cannot, it seems, deny is that over vast regions of space and immense periods of time the tendency toward disorder has not been powerful enough to arrest the formation of the great inorganic hierarchy and the myriad organic ones [1]."

Indeed, one only needs to look around to see that for every system in which order is decreasing, there is another in which order is increasing. The SLT, however, predicts only destruction, while nature exhibits construction as well—the SLT-Order Paradox. The Second Law of Thermodynamics obviously tells only half of the story.

The other half of the story is still to be explained by a principle that complements the SLT. Many investigators have recognized that the SLT by itself is inadequate for resolving the SLT-Order Paradox and for explaining the source of order. They obviously have not been completely satisfied with the conventional resolution of the paradox, which is generally stated like this: "whenever a semblance of order is created anywhere on Earth or in the universe, it is done at the expense of causing an even greater disorder in the surrounding environment [2]."

Of course, this implies that a finite, isolated universe would run down like a clock. In the conventional view, the universe is descending deeper and deeper into chaos as the order in the surroundings of every system is exhausted. This prospect causes philosophical unease among scientists because it implies an initial *creation* as well as an eventual "heat death" of the universe. We require some principle that would both complement the SLT and avoid this predicted violation of *conservation*, the First Law of Thermodynamics, the assumption that matter and the motion of matter neither can be created nor destroyed. There are no scientifically verified exceptions to either the First or the Second Law of Thermodynamics. And yet, there is still no adequate explanation for the apparent production of order from disorder.

Clearly, to resolve the SLT-Order Paradox we must have a radical departure from the present theoretical approach to the problem rather than a change in experimental technique or calculation. If the ending predicted by the current interpretation of the SLT is unacceptable, then there must be something wrong with its initial assumptions.

At this point it may be helpful to explain briefly what we mean when we speak of an "isolated system," "controlling an experiment," or "closing the doors" on a portion of the universe. In conventional scientific terminology, the closest thing to "a portion of the universe" is called a *system*, any object or group of objects that the investigator wishes to consider and to delineate in some way. Ideally, systems can be of three types: isolated, closed, or open. *Isolated* systems exchange neither matter nor motion with the environment. *Closed* systems exchange motion but not matter. *Open* systems exchange both matter and motion. These definitions are idealizations developed from the study of relatively isolated and relatively closed systems. In reality, all systems are open systems; truly isolated or truly closed systems cannot exist.

Although competent scientists no longer believe that any real system could be ideally isolated, few of them seem prepared for the next step: the concept of ideal nonisolation. *Complementarity* [3] assumes that, in an infinite universe, all real systems exist between the extremes of ideal isolation and ideal nonisolation. Whereas a high degree of isolation implies minimum contact between the system and its environment, a high degree of nonisolation implies maximum contact between the system and its environment.

We have traditionally emphasized one end of this continuum: the system, isolation, increasing disorder, and the SLT. We need to emphasize the other end too: the environment, nonisolation, increasing order, and the complement of the SLT. The resolution of the SLT-Order Paradox awaits a balanced consideration of both the system and its environment. If this analysis is correct, then traditional, system-oriented attempts at resolution are bound to fail, as a few notable examples will demonstrate.

System-Oriented Rationalizations of the Paradox

Each system-oriented attempt to resolve the paradox fails to the degree that it favors the system over the environment. Note in each of the examples, that whether the proposal involves unabashed vitalism, the "geometry of spacetime", outright contradiction, or sophisticated neovitalism, the key to the production of order, the environment, is slighted.

Vitalism

In addition to his work on wave equations in quantum mechanics, Erwin Schrödinger is known for his popularization of the concept of "negative entropy" or negentropy as a resolution of the SLT-Order Paradox [4]. In itself, the idea of an ordering process that functions as the dialectical opposite of the disordering process is excellent. The term *negentropy* is likewise excellent, but we must object to the biased way that Schrödinger described the negentropic process.

Negentropy was seen as a "fight" in which organisms, by themselves, overcame the havoc of the phenomena described by the SLT. The argument essentially followed the philosophical tradition of vitalism: neither matter nor the motion of matter was considered the initiator of the negentropic struggle. The mysterious source of order was internally derived, and was peculiar to living beings. Not only did Schrödinger overemphasize the system itself as a source of order, but he left the SLT-Order Paradox unresolved, at least wherever life was not evident.

Geometry of Spacetime

A slightly improved attempt to resolve the apparent contradiction between the SLT and the tendency toward increases in order was made by L. L. Whyte [5]. Unlike Schrödinger, Whyte was careful to include the inorganic as well as the organic realm in his suggestion. Like Schrödinger, Whyte recognized the need for *complementarity* when he wrote of the "two great, and *apparently* opposed, general tendencies." Unlike Schrödinger, Whyte did not overtly confine his search for the source of increasing order to the system itself. Instead, he tried to avoid consideration of system-environment interactions through an approach that was more in tune with modern physics.

Whyte's suggestion is puzzling. The first of the opposed tendencies involved matter and was "TOWARD DYNAMICAL DISORDER called *Entropic*." The second involved geometry and was "TOWARD SPATIAL ORDER called Morphic." Just how matter and geometry can be seen as independent features of the universe was not explained. As far as I can tell, the "Morphic" tendency seems to have much in common with "curved space" in the general theory of relativity. It explains the tendency toward order in one of the ways Einstein explained gravitation. The "geometry of space" purportedly supplies the orderly, passive fabric upon which the SLT operates, somewhat like the "celestial sphere" of pre-Copernican times. Whyte's answer to the SLT-Order Paradox requires the inscrutable interaction of matter with the supposed 4-dimensional geometry of "spacetime" rather than the interaction of matter with matter.

Contradiction

Spyros Makridakis, a management scientist specializing in General Systems Theory, took his shot at the paradox by rightly claiming that the exact opposite of the SLT was as natural as the SLT itself [6]. But then he proceeded to get it backwards. According to Makridakis, his "Second Law of Systems" resolved the SLT-Order Paradox on its own: "things tend to become more orderly if they are left to themselves." The phrase: "left to themselves" normally means that there is no outside interference. Of course, any system not subject to any outside interference whatsoever is an ideally isolated system. Rather than being a complement to the SLT, this suggestion was merely a contradiction of it. The opposition between the SLT and its complement cannot be derived by viewing systems in their isolation, but in their nonisolation. With respect to the SLT, Makridakis carried systems philosophy to its logical conclusion. The only thing that would save the Second Law of Systems would be to change it to read: "things become more orderly if they are *not* left to themselves."

Sophisticated Neovitalism

Perhaps the most celebrated approach to the SLT-Order Paradox within the discipline of thermodynamics was developed by Nobelist Ilya Prigogine [7]. While Schrödinger, and again, Makridakis, unabashedly treated systems in the customary way (as isolated entities providing their own source of order), Prigogine took some of the early steps toward viewing the environment rather than the system as a source of order.

Prigogine's challenge to classical thermodynamics suitably stressed that complex structures can exist only through continuous interaction with their surroundings. Without this interaction, structures tend to "dissipate," that is, they lose matter or motion as per the SLT. Following Onsager, Prigogine developed the principle of minimum entropy production. His most important conclusion: there had to be a relationship between the production of order and the prevention of disorder.

Unfortunately, due to the constraints of the paradigm—systems philosophy—under which Prigogine and almost all modern scientists work, this did not lead directly to a singular principle that could be considered fully complementary to the SLT. Prigogine eventually was led to suggest some silly producers of order: fluctuations, distance from equilibrium, and nonlinearity that were not explicitly system-environment interactions. In the end, they had to be considered subsystem interactions.

Despite all his mathematical acrobatics, Prigogine's mechanisms could not be considered net producers of order for the system as a whole in the same way that phenomena described by the SLT produce disorder for the system as a whole. Thus, fluctuations produced as a result of interactions between the system and its environment eventually ended up being attributed to the system itself. Similarly, equilibrium and nonlinearity were said to occur *in* the system rather than *between* the system and its environment. There was always a residual bias in favor of the system over the environment.

Like the others, Prigogine offered reasons for the production of order in opposition to the SLT from a system-oriented point of view. Following tradition, he ultimately focused on the system—the forte of the SLT—to the neglect of the environment. He insisted that the production of order is a "self-organizing" process—a sort of neovitalism that, although not restricted to living systems, ultimately neglects environmental factors as producers of order. In my view, the ideal of nonisolation is equally as important as the ideal of isolation. Because such belief is, by definition, foreign to systems philosophy it cannot produce a complement to the Second Law of Thermodynamics.

Resolution of the Paradox

Systems philosophy was adequate for developing the SLT, a law about ideal isolation. But an environmentally focused viewpoint would be needed to for the development of a complementary principle, a law about ideal nonisolation. The unification of these two one-sided viewpoints must consider both systems and their environments as equally important. *The SLT-Order Paradox can be resolved only through a balanced system-environment approach* [8] *that describes the reality existing between ideal isolation and ideal nonisolation*.

Actually, an early step in this direction had been taken long ago by classical mechanics. According to Newton's First Law of Motion: "Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon." Like those who later developed thermodynamics, Newton first assumed that his system was ideally isolated, with Newtonian bodies traveling through "empty space" or the "stationary ether" under their own inertia. Then, on second thought, he discarded the notion of ideal isolation and completed his First Law of Motion. Classical thermodynamics managed the first thought but not the second.

In devising the SLT, the originators of thermodynamics also assumed the system to be ideally isolated—it was necessary to be temporarily myopic. But if we should now reject this system myopia as Newton attempted to do, we would have a pertinent question to ask: "If matter or the motion of matter has diverged spontaneously from such an 'isolated system' where has it gone?" The obvious answer is that it has moved toward other matter in the universe. If the universe was infinite, there would be no perfectly isolated systems; all matter everywhere would converge on and diverge from matter everywhere else.

If the above statement is true, then Newton's First Law of Motion must be modified to recognize this balance explicitly—the word *unless* must be replaced by the word *until*. This small adjustment completes the train of thought that Newton only began and classical thermodynamics never really started. Indeed, matter in motion is inconceivable without the ideas of departure and arrival. The SLT is a law of divergence. It is like a travel schedule showing only departures. Its complement is a law of convergence. It is like a travel schedule showing only arrivals. Together, the SLT and its complement quite simply describe the motion of matter.

This modification of classical mechanics is consistent with the fundamentals of thermodynamics. For example, in the usual demonstration of the SLT (Fig. 1), chamber A is filled with gas and chamber B is essentially a vacuum. Opening the valve between the two (considered a "negligible" outside influence) allows gas from chamber A to enter chamber B spontaneously and irreversibly. This "spontaneity" is merely a reflection of the inertial motion of the gas molecules that, instead of colliding with the closed valve, now move through it. Entropy (or apparent disorder) increases as the molecules of gas diverge from each other as they emerge from chamber A. The process is irreversible because all the gas molecules will not spontaneously return to chamber A by themselves. They cannot be "self-organizing" despite Prigogine's special pleas. To produce a vacuum at chamber B and reestablish the previously "better-ordered" state, we would have to introduce some extremely significant outside influence clearly forbidden by the assumption that this is an isolated system. The strength of the classical view, not countermanded by Prigogine or anyone else, is its insistence that an ideally isolated system cannot, of itself, produce a net increase in order. *The source of the order producing mechanism must lie outside the system itself*.

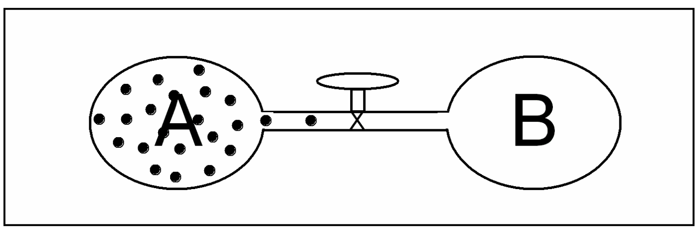

Fig. 1. The classical demonstration of entropy change described by the Second Law of Thermodynamics. An increase in entropy is produced when the gas in chamber A is allowed to pass through the valve into the vacuum of chamber B.

In this demonstration, the usual focus is on the divergence from chamber A, but if we view it from the perspective of chamber B, we see convergence instead. The gas molecules from chamber A rush in upon chamber B just as spontaneously and just as irreversibly as they left chamber A. If disorder has been produced in chamber A, order has been produced in chamber B. In an infinite universe, an increase in entropy in one place results in a simultaneous and equivalent decrease in entropy in another. The convergence of material entities results in an apparent increase in order or organization—the phenomenon that the SLT, by itself, cannot explain.

Conclusion

As I pointed out before, the foremost assumption of mechanics is that the infinite universe consists only of matter in motion.

In mechanical terms, the SLT would be:

All bodies are subject to divergence from other bodies.

Its mechanical complement proposed here becomes:

All bodies are subject to convergence from other bodies.

The SLT-Order Paradox is resolved only by uniting thermodynamics with mechanics. Entropy becomes a statement about divergence, and its opposite, negentropy, becomes a statement about convergence. Subjectively, we can still view increasing disorder as things "fall apart" and increasing order as things "come together." Because the motions of matter are relative, the motion of a particular object may be a divergence for an observer at one point, while it may be a convergence for an observer at another point. Divergence and convergence are the essence of the motion of matter and must be considered objective and necessary features of the infinite universe.

The possibility of nearly ideal isolation derives from the possibility of divergence; the possibility of nearly ideal nonisolation derives from the possibility of convergence. In thermodynamic terms the complement to the SLT becomes: *the entropy or apparent disorder of an ideally nonisolated system can only decrease*. No object can be completely isolated, just as no object can be in an all-encompassing contact with its surroundings. Ideal isolation and ideal nonisolation are opposite ends of the continuum we use to describe the relationships between real objects and their surroundings.

With respect to each other, any two objects are semi-isolated to the degree of their separation and semi-nonisolated to the degree of their union. What we observe as increases in entropy for a particular system are results of the divergence of matter or the motion of matter from that system. What we observe as decreases in entropy for a particular system are results of the convergence of matter or the motion of matter upon that system. Isolation and nonisolation, therefore, are complementary aspects of the motion of matter.

Ironically, the very ideal we required for formulating the SLT: perfect isolation, would prevent its operation. For the entropy of a system to increase, parts of that system must be able to interact with its environment. To the degree that the system cannot transmit motion to the environment, it tends to expand, that is, it invades a portion of the universe formerly classified as "environment." Cosmogonists have applied this necessity for system expansion to the universe itself, but this is a *non sequitur*. The only requirement is for there to be an environment for the parts of a system to move into or to transfer motion to. An infinite universe in which matter and the motion of matter is not everywhere the same is sufficient.

The irreversibility to which the SLT and its complement speak is not a result of a grand, universal predominance of divergence over convergence, but simply a result of the motion of matter within an infinite universe. All systems, being in continual motion relative to each other, have a unique relation to all other systems in the universe at any moment. The motion of a system as a whole relates only to its surroundings. We must view the apparent production, maintenance, and destruction of order, not as a property of the system, but as a relationship between system and environment.

The question arises as to the experimental relevance of this mechanical complement to the SLT. We will continue to study the interactions of subsystems in which entropy (or disorder, from the subjective point of view) is produced and destroyed as subsystems diverge and converge. Nevertheless, because subsystems are always parts of larger systems and these are parts of still larger systems, we must expect eventual convergence from systems unfamiliar to us. The complement to the SLT, convergence, ultimately must be a law of the unknown—a law that predicts that no matter how much we widen the boundaries of a system, there will always be matter in motion outside that system.

The philosophical shift from the system-oriented approach to the system-environment approach resolves the SLT-Order Paradox. The acceptance of *complementarity* for the Second Law of Thermodynamics requires an acceptance of the other assumptions of science with which they are consupponible [9]. *Noncomplementarity,* the indeterministic alternative, can exist only in a finite universe in which the system is considered more important than its environment. The rejection of this "system myopia" will be the culmination of the great work that Copernicus began.

References

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