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Development of Entropy Change in Philosophy of Science

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Entropy is important in philosophy of science, but some fallacies originate from the misunderstanding entropy increases. The basis of thermodynamics is the statistics and its basic principle of statistical independence. We proposed possible entropy decrease due to fluctuation magnified and internal interactions in isolated systems, and discuss this possibility of various aspects on science and nature. Further, we derive quantitatively a total formula of entropy change for universal evolution of any natural and social systems, and discuss entropy decrease in economics and social sciences. Entropy change is a testable science. As long as we break through the bondage of the second law of thermodynamics, the rich and complex world is full of examples of entropy decrease. We believe world is not pessimistic always.

Keywords: philosophy of science, entropy, world view, internal interaction, counterexample

Introduction

Entropy and its increase in isolated systems are great contribution in science and philosophy, and applied widely many aspects. It becomes even a new world view (Rifkin & Toward, 1981), but, whose role introduces some disputes, even misunderstanding, etc. It almost becomes a belief. Prigogine proposed the theory of dissipative structure as open systems, which is an important development of thermodynamics.

The basis of thermodynamics is the statistics, in which a basic principle is statistical independence: the state of one subsystem does not affect the probabilities of various states of the other subsystems (Landau, Luke, & May, 1980). We proposed that if various internal complex interactions cannot be neglected, fluctuations and its magnified exist among various subsystems of an isolated system, entropy decrease in the isolated system will be possible (Chang, 1997; 2005), which includes physics which includes phase transformation from disorder uniformity to order state (Chang, 2012; 2019), chemistry (Chang, 2013a), biology (Chang, 2013b), astronomy (Chang, 2013c), etc.

We emphasized preconditions of entropy increase, and discussed the solidification forms spontaneously an order structure, and it may be process of entropy decrease. We proposed that entropy decrease exists necessarily in self-assembly as isolated system and the molecular motor and entropy decreases in biology (Chang, 2020). As long as we break through the bondage of the second law of thermodynamics, the rich and complex world is full of examples of entropy decrease.

Entropy Decrease in Science and Nature

The most particular property of entropy is its universality, which may include various systems from microscopic particles, atoms, molecules to macroscopic celestial body, universe, even in philosophy and social

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sciences. But, its infinite generalized conclusion will derive some fallacies, for example, the negative temperature (Chang, 2012), entropy of black hole (Chang, 2013c), superfluid without entropy (Reichl, 1980) for jet, and various evolutions are always entropy and disorder increase, etc. These are also some counterexample.

Usually entropy increases in an isolated system, and may decrease or increase in an open system. We proposed possible entropy decrease for isolated systems in natural and social sciences due to internal interactions. A universal formula for any isolated system is (Chang, 2005):

$$dS = dS^a + dS^i, \tag{1}$$

where dS^a is an additive part of entropy and is always positive, and dS^i is an interacting part of entropy and can be positive or negative. Eq. (2) is similar to a well known formula:

$$dS = d_i S + d_e S, \tag{2}$$

in the theory of dissipative structure. Two formulae are applicable for internal or external interactions, respectively. Further, we proposed a complete formulation on change of entropy should be the symmetrical structure:

$$Entropy \rightarrow \begin{cases} increase. \\ decrease \rightarrow \begin{cases} \mathrm{dS} = \mathrm{d_i}S + \mathrm{d_e}S. \\ dS = dS^a + dS^i. \end{cases} \end{cases} \tag{3}$$

Here entropy decrease may be the dissipative structure for an open system, or be the internal interactions for an isolated system. Based on above formulae we may derive quantitatively a universal entropy theory on evolution of any natural and social systems (Chang, 2014; 2015a; 2020). The total formula of entropy change is:

$$dS = dS^a + dS^i_+ - dS^i_- + dS_i + dS^+_e - dS^-_e. \tag{4}$$

Entropy increase $dS > 0$ or entropy decrease $dS < 0$ is determined by the input negative entropy flow in open system and the internal attractive interactions in isolated system $dS^-_e + dS^i_-$. The change of entropy should be a testable science. In epistemology it is testability and falsifiability principles. From a basic formula

$$S(t) = -k\sum_r P_r(t)\ln P_r(t) \tag{5}$$

or $S = k\ln\Omega$ in an internal condensed process, we may calculate quantitatively entropy decrease (Chang, 2005).

The auto-control mechanism in an isolated system may produce a degree of order. If it does not need the input energy, at least in a given time interval, the auto-control will act like a type of Maxwell demon (Chang, 1997), which is just a type of internal interactions. The demon may be a permeable membrane.

Even the total entropy for whole system is positive and increase, but, so long as different entropy states for any systems exist, entropy must decrease in transformation process or point from a higher entropy state of economy, society, culture, and life to a lower entropy state (Rifkin & Toward, 1981), in Figure 1 from A to B (Chang, 2015a; 2015b; 2020). It contacts usually with the phase transformation. If this system is isolated, it will correct and develop the second law of thermodynamics. These examples may be the spontaneous magnetization,

and from chaos to order, from war to peace, etc.

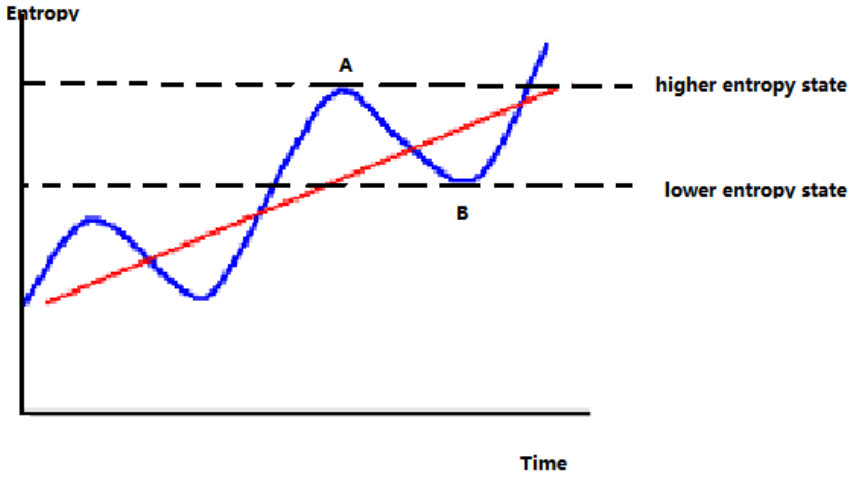

Figure 1. Transformation processes between states with higher entropy and lower entropy.

So far, these are surprised: Nuclear fission and nuclear fusion all are entropy increases. In chemistry the exothermic reaction and the endothermic reaction all are entropy increases. Biological creation and biological die all are entropy increases. All change, even these various complete opposite changes all are entropy increases.

In a biological self-organizing process, some isolated systems may spontaneously proceed toward the orderly states. Brain, consciousness, neuroscience, the permeable membrane, the molecular motor, etc., are all some internal interactions. They even possible take a key role for decrease entropy in isolated system. Dormancy of living body is an order state, whose entropy passes through adjustment and decrease to smaller. For the typical instance, the hibernation of animal, and the dormancy of Madagascar's lemur and of various hexapods all show obviously the entropy decrease in isolated system. Qigong and various practices are often related to these order states with entropy decrease (Chang, 2013b).

The auto-control mechanism in an isolated system may produce a degree of order. If it does not need the input energy, at least in a given time interval, the auto-control will act like a type of Maxwell demon, which is just a type of internal interactions. Ordering is the formation of structure through the self-organization from a disordered state. The emergence and self-organization of biology and human all depend mainly on self-interaction, because only sunlight cannot produce spontaneously biology on Earth; at least, they cannot evolve some higher living body.

In an evolutional process with long time, life forms a nonlinear complex and complete system with multi-levels: gene, cell, tissue, organ, system, individual, population, community, ecosystem, bio-sphere. For various levels in isolated systems usual entropy increase, but entropy possibly decreases under some conditions with internal interactions, which has possibly different levels in biological systems, for example, membrane, enzyme, and molecular motor, etc. Smolin (2013) proposed that high entropy and high complexity cannot coexist.

The biologic membranes may choose a direction self-motion. Samal and Geckeler (2001) studied an unexpected solute aggregation for DNA, etc., in water on dilution, which violates the second law of thermodynamics. The cell membrane is a barrier with selectivity, on which the ion channel exists. For cell it

inputs continuously the metabolized matter, and removes the metabolized outcome. A permeable membrane is namely the Maxwell demon, which may derive entropy decrease. The endothermic reactions and opposite exergonic reaction in biology should correspond to entropy increase and opposite entropy decrease (Chang, 1997; 2005).

Anomalous Cognition (AC) is defined as a form of information transfer in which all known sensorial stimuli are absent. Lantz et al. (1994) have reported testing sender condition and target types in AC experiments. There is a difference between static and dynamic target material. Entropy is defined as a measure of uncertainty or lack of information about a system. The data from both of these studies were analyzed with regard to the gradient of Shannon's entropy of the targets. May, Spottiswoode, and James (1994) were able to compute the entropy and its mathematical gradient for each target in these experiments. AC was more pronounced when targets underwent massive changes in energy or entropy in a very short period of time. In addition, dynamic targets produced better results in the Ganzfeld than did static targets, a result that is suggestive of changes of entropy.

A living being as a whole represents an extremely orderly state of being and must be an open system for long-time. A living being's death represents a transformation to a state of total disorder, while sickness is a state of local disorder and a state of recovering from sickness is marked by a return to the higher order of health. The order parameters are thus health targets. But, for a short-time Qigong and some states attained during religious practices, for example, Buddhist and Taoist meditation, may be considered isolated systems that are characterized by entropy decreases.

In Buddhist practice, everyone is expected to face everyday in a happy mood with thanks to Nature. A harmonious unification of these two activities of the human mind (body) and spirit can only consist completely of a normal sound activity. Qigong requires that one must be calm and good-natured, which is a more orderly state for a person. Clinical practices show that the practice of Qigong causes a reduction in human metabolism. This reduction seems to the possibility that human ideas and similar thought form also entropy decrease, and achieves an ordering within a living system that could cure sickness and increase internal immune system strength. In the Chinese traditional practices the Inducing Into Tranquilization and Qigong, and the "Chan-Ding" in Buddhism are all an ordering state. In these cases the metabolism is entropy decrease in isolated system. These practice methods all are to benefit the control of consciousness. Probably, some ways are propitious to the cure of cancer.

The self-organized order of any organism in isolated system is inevitably a process of entropy decrease, it may hold at least in a certain time. Various biological systems possess very rich and colorful internal interactions; we proposed entropy decrease as an index of therapeutics in biophysics, and believe that the biothermodynamics will make great contribution to the test of development on the thermodynamics of entropy decrease in isolated system. Biology will be a wide region for research of entropy decrease in various isolated systems.

Entropy Decrease in Economy and Society

Entropy decrease exists more in economics and social sciences (Chang, 2013e; 2014; 2015b). We searched three-dimensional philosophy and its four principles: the structure principle, the stability principle, the complexity principle and the nonlinearity principle. In the society and the politics the structures of key elements restricted each other produce stability more easily, so three-dimensional philosophy is a philosophy on society

stability and on world peace (Chang, 2013f).

The laws of energy and entropy are two important quantities necessarily considered in the development of economy and society. But, entropy is often misunderstood in some cases. In social science entropy is applied mainly in ecological economics (Common & Stagl, 2005). Georgescu-Roegen (1971; 1976) researched the entropy law and the economic process, and studied that the entropy law in the economic process imposes an absolute resource scarcity which cannot be overcome with technological change, exploration, or substitution (Georgescu-Roegen, 1986). Daly (1974) discussed the controlled throughput by physical method at the point of lower entropy in the economics of the steady state. Ayres (1978) edited book: *Resources, Environment and Economics: Applications of the Balance Principle*. Swaney (1985) searched economics, ecology, and entropy. Hall, Cleveland, and Kaufmann (1986) researched the ecology of the economic process: energy and resource quality. Faber, Manstetten, and Proops (1996) discussed concepts and methods of ecological economics.

Ayres (1998) discussed eco-thermodynamics: economics and the second law, and pointed out: The laws of physics, especially the first and second laws of thermodynamics, have significant implications for economic theory, in which the economic implications of the entropy law are that the supposed constraints on economic growth imposed by the fact that economic processes utilize “low-entropy” raw materials and discard “high-entropy” wastes. This fact has strong implications for economic growth theory.

Based on the mathematical economics (Fuente, 2000), we think that the nonlinear evolution is a universal rule for economic growth, and propose the nonlinear theory of economic growth and its three laws: economic takeoff-growth-stagnancy law, social conservation and economic decay law, economic growth mode transition and new developed period law (Chang, 2013e). Further development of social economy must exploit new merchandise and market, and adjust output configuration, and reform technique, and train personnel, so that boost up the immanence ability of social development and the international competitiveness. At the same time, the social framework and various personnel must readjust combination, and the management level raises up to follow the social development and new talented persons, new equipments, new outputs, new techniques, and new capital introduced. Such the society should reform continuously to achieve a higher seedtime. This is namely to search new economic growth point for microeconomics. It is also a process of entropy decrease.

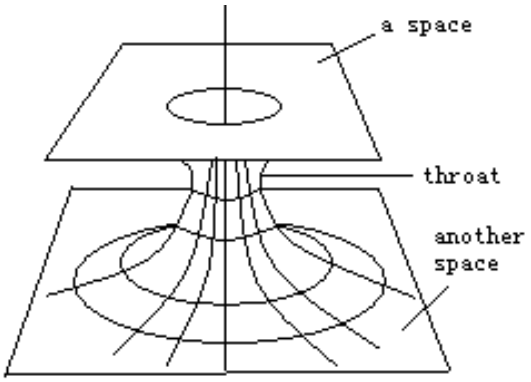

Figure 2. The wormhole model in social economics from a space into another topological space.

Conversely, using the similar formulas of the preference relation and the utility function, we proposed the confidence relations and the corresponding influence functions that represent various interacting strengths of different families, cliques and systems of organization. This produces a multiply connected topological economics. It is often a process with entropy increase. From this some capital will pass through a throat into

another topological space (Figure 2), or from a region to another region in the same space. This wormhole model may describe a loss of capital (including waste, and corruption). Further, we discussed the binary periods of the political economy by the complex function and the elliptic functions. By the nonlinear equations of hydrodynamics we derived the formulations of the binary and multiple centers in various social systems (Chang, 2013e). From backward society to modern society, the standardization and legalization of economics and market management are all social progress from disorder to order with entropy decrease. We proposed that a developed direction of society is unification of simplicity and complexity. The application of mathematics and physics will be an important direction of modern social science at 21st century.

In a word, the social open is a necessary condition for economic further development, but it must add corresponding social reform as a sufficient condition of economic development. It may combine the theorem of transformation from energy to quality on social development (Chang, 2013d). Rivera-Batiz discussed the relation among democracy, governance, and economic growth (Rivera-Batiz, 2002). Generally, dictatorship system is an inevitable decline with entropy increase, and as the age of the dictator increases, the closeness increases. Conversely, social progress requires constant political reform that changes ideas and structures in the original system along with entropy decrease.

Based on general social physics and the sameness for men or any elements in the social systems, we searched the social thermodynamics (Chang, 2013e), and discussed some social sustainable developed patterns: be the nonlinear limit and cycle pattern of three elements, the synergetic pattern on society-economy-environment developed together, the promotion-restraint pattern on Five-Element. Their basis is lower entropy, even entropy decrease (Chang, 2015b). From this we discussed various stable social structures of different levels. The basis of the modern stable and harmonious society is equality. Natural laws are unfeeling, but world is not pessimistic always.

Rifkin and Toward (1981) pointed out that inflation and unemployment are all entropy increases. But it is well known that they cannot increase forever. We proposed the four theorems of the knowledge economic theory: the innovation theorem by talented persons; from zero to things theorem, which is a process of information translated into substance and wealth; the increment theorem by cooperation; the continuous cycle theorem (Chang, 2013f). Any cycle and hypercycle cannot always be entropy increase.

Entropy as a measure of disorder is very important in sociology. Cooley (1964) discussed human nature and the social order. Society should keep a lower entropy state, and has slow rate of entropy increase, so it can be sustainable development. New tendency—simple living (Elgin, 1993; Luhrs, 1997) may decrease desires, and decrease entropy. Based on the synergetics, we proposed the social synergetics and the four basic theorems, in which theorem of perfect correlation on humanity is namely an internal interaction, and theorem of transformation from quantity to quality on social development, which corresponds to GDP replaced by GDH (Gross Domestic Happiness). A certain population can be used as an isolated system. If they communicate only, their information will be reduced; but, if they discuss, argue, and interaction each other, many new ideas may be generated, and information will increase. Therefore, the democratic and equal society is more conducive to the development of science and the social progress. We should advocate a low-entropy world view, and enter a low-entropy era (Rifkin & Toward, 1981).

Life and society should obey the principle of least action, which corresponds to slow rate of entropy increase. Human always hope to build an order society, for example, rule of law, Chinese etiquette, harmonious

society, and so on. These are all at some states with lower entropy. In Figure 1 from A to B it corresponds to the social changes, which shows the wave development from a tendency to another tendency. A developed direction of society is the combination from macroscopic to microscopic order, from an actual capable handling to an ideal pursuance.

Conclusion

Empedocles (B.C. 493-433) in ancient Greek assumed that the two basic forces: Love is attraction and hation is repulsion. They are entropy decreases or entropy increases, and form order or disorder society, respectively. The philosophy of harmony is a worldview, outlook on life and methodology with a harmonious point of view. This is a classical example of unifying goodness and beauty. Plato believed everything in the world will change from disorder to order. It is result of internal interaction with entropy decrease. The philosophy of harmony is namely the philosophy of entropy decrease.

Generally, the entropy increase law possesses relativity and approximation, because it must be an isolated system, but which is always dependent of some conditions. Complete exact isolated system does not exist in essence, since the gravitational interaction cannot be screened completely. Change of entropy must consider relations, structures, time, and evolution, etc., which should be related to the new structuralism (Sturrock, 1979; Harland, 1988) and the functionalism.

In a word, entropy increase and entropy decrease should possess symmetry, and be beautiful. Only then can the complexity of natural evolution be produced. If the world is always entropy increase, any product and structures will be impossible. It is not only pessimistic, but also lacks basic beauty and complexity. The change of entropy is a testable science. At least some extensions of the second law of thermodynamics are not universal.

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