Contextual Dynamics

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Abstract

Contextual dynamics is about the dynamics for specifying the interrelated conditions of the contextual elements as an organized unity. Contextual specification can proceed even prior to the completion of specification of each individual element involved. Emergence of the context takes place through punctuation of the movement in the present progressive tense by the occurrence of the event registered in the present perfect tense. An energy quantum after Max Planck is a most prominent prototype of the context of material origin. Appearance of biological organizations and their evolution proceed through the transformation of the contexts of material origin. What is unique to the contextual dynamics is that contextual specification can move on even if specification of each contextual element constantly remains to be fulfilled.

1. INTRODUCTION

Everything in this empirical world occurs in relation to everything else also residing there. If we want to address motions or changes of the constituent material bodies whether physical, chemical or biological, the interrelated conditions in which something of interest occurs will become a subject matter of prime concern. A context is just a brief term referring to the interrelated conditions. This perspective comes to remind us that such dynamics cannot be context-free, compared to the case of classical mechanics (Küppers, 1991).

The original formulation of Newtonian classical mechanics, on the other hand, has been context-free. The first law of mechanics on inertia, the second law on force and the third law on action and reaction, all of them have been stated as the rules that linguistically describe changes in a string without reference to elements outside of the string. It goes without saying that the context-free formulation of classical mechanics has been tested extremely powerful in addressing motions and changes in the sense that it can work wherever and in whatever contexts. Nonetheless, classical mechanics does not dispense with the notion of context. It simply would not work unless the three laws are further supplemented by the context known as boundary conditions. At this point arises a new agenda of how the boundary conditions could be implemented and identified in classical mechanics. This will be a major concern for the enterprise of contextual dynamics.

One decisive factor focused on the contrast between contextual and context-free dynamics is causation. Causation is more than just a matter of philosophical dispute. In particular, mechanistic causation specifying how each individual could be related to itself and all of the others at the preceding stage remains unproblematic. Each individual in movement acts upon other individuals and vice versa. However, we also have much stronger form of mechanistic causality amounting to asserting that the movement of each individual is uniquely determined in coordination with all of the others from moment to moment. This observation suggests to us to examine how mechanistic causality could function in reality. The present problem cannot be marginalized simply by declaring it as a minor one especially in view of the fact that mechanistic causality in the sense of being acted upon by others is ubiquitous in any material systems we meet in the empirical world. We shall address ourselves to the issue of how causality could function in natural systems with a special focus upon mechanistic causality.

2. CAUSALITY: REVISITED

We usually take mechanistic causality to be of a one-to-one temporal mapping connecting an arbitrary predecessor to its successor expressed uniquely in the present tense. Newtonian equation of motion is a well-known representative case of mechanistic causality of unique specification. The mechanistic equation of motion can certainly specify how each individual constituting the equation develops in time. At the same time, the mechanistic equation of motion is subject to a constraint coming from the context denoted as the initial conditions. It can be of no use unless it is supplemented by the causation from the context. The present interplay between causation toward each individual and causation from the context as a vehicle of modeling natural systems comes to impart to the mechanistic equation of motion a unique property. Extreme sensitivity of the solution to the initial conditions sometimes reveals a pathological dependence of the mechanistic equation on the context. A slightest deviation in the context may bring about an enormous difference in the behaviors that the equation of motion would exhibit. This pathological sensitivity to the context is not something to be expected of natural systems, since in the latter a significant capacity of homeostasis resisting variations originating in the context, that is, the environment, is usually guaranteed. Newtonian equation of motion may not be a suitable model describing the behavior of natural systems because of its pathological sensitivity to the context.

The pathological sensitivity to the context will more significantly be enhanced if Maxwell's equation of electromagnetic field in three-dimensional space is the case, since the context is specified by its boundary conditions in space and time. The context toward Maxwell's equation is materialized in essence in two forms of potential; one is the retarded potential, and one more is the advanced one. Although it may be relatively easier to prepare a boundary condition corresponding to the retarded potential giving rise to an expanding electromagnetic wave because of the relative smallness of the number of degrees of freedom to be controlled, the case for the advanced potential yielding a contracting wave in three dimensional space is practically impossible because of the presence of an immense number of degrees of freedom to be coordinated initially. Difficulty in fabricating the context applied to the electromagnetic field especially in terms of the advanced potential may render the notion of boundary conditions even irrelevant.

In contrast, the wavefunction of the Schrödinger's equation of motion in quantum mechanics makes the notion of the context amenable to physical processes taking place there. Coexistence of the wavefunctions propagating in opposite directions in fact generates a standing wavefunction corresponding to the occurrence of an eigen-wavefunction that remains non-propagative. Empirical stability of a quantum state denoted as the standing wavefunction certainly manifests a likelihood of physical conditions giving rise to such a context allowing the wavefunctions to propagate in opposite directions equally. The existence of a standing wavefunction is due to the interference between two types of wavefunction; one is propagating in the forward direction in time and the other in the backward. The context being responsible for the genesis of a standing wavefunction actually admits two types of causation; one is forward in time and the other is backward. As a matter of fact, the stability of a quantum state against its context is due to juxtaposition of both the forward and the backward causations. The present stabilization of dynamics eliminating pathological sensitivity to the context is actually confirmed by conceiving an arbitrary dynamics carrying causations both in the forward and backward directions in time (Dubois, 1996). Causation in the backward is in essence seen as causation from the context since it can be regarded as a reflection of the preceding forward causation at a certain boundary forming the context. Reflected forward causation thus carries with itself the capacity of changing the boundary conditions or the context to be experienced by each individual.

Occurrence of backward causation in time provides a new perspective towards the principle of causation. When it is contrasted to absolute freedom, causality is usually taken antithetical to absolute freedom. However, this contrast is not mutually exclusive. If everything were claimed to follow causality in one way or another, the question would arise as to what could be the cause of causality. Impossibility in answering this question properly would come to vindicate absolute freedom for the sake of the cause of causality. On the other hand, if it were claimed that there is room for absolute freedom to survive, one would necessarily come up with the presence of a stage prior to the action of exercising such an absolute freedom. But, the concatenation between the irrelevant prior stage and the activity of exercising absolute freedom subsequently would come to destroy the whole notion of causality. If causality were to be vindicated by all means, there would be no room for absolute freedom. The present Kantian antinomy between causality and absolute freedom can be resolved only by supposing that the dichotomy of causality and absolute freedom is a false one. Causation can carry with itself some form of freedom or indefiniteness (Matsuno, 1989). This recognition of indefiniteness being compatible with the operation of causation suggests to us a possibility of accommodating the backward causation in time to the forward one properly.

Causation propagating in the backward in time is however metaphorical at best, since every dynamic is actualized in the process of transferring the present progressive tense to the present perfect one. Causation from the context toward each individual inside is always of a retarded character. Individualization associated with causation toward each specified individual would be mechanistic when both the causes originating in the preceding context and the complete specification of the individual were secured by whatever means and remain intact. In contrast, if complete specification of each elementary individual is unavailable for whatever reasons, there could arise such a possibility that some individuals may adjust their contents by themselves so as to fit into the context then available. Individualization and contextualization remain inseparable when complete specification of each individual residing within the context is not feasible (Rosen, 2004). In fact, each individual being subject to causation from the preceding context in turn comes to constitute the subsequent context. Such a contextualization is to come with causation towards the context. Biology is full of causation to and from the context.

Bacterium *E. coli,* for instance, moves towards an attractant such as glucose if available. The presence or absence of attractants sets the context under which an *E. coli* behaves individually. The causation for moving to an attractant comes from the context. In this setting, a stressful situation to the *E. coli* would come up when the attractant it feeds on is depleted. The bacterium starts tumbling its body until it finds the direction along which the concentration of attractants increases. What is intriguing at this point is how each of the bacterium and its context could contribute to the tumbling movement. The context surrounding the bacterium provides an impetus for initiating the tumbling movement. That is causation towards an individual from the context. Needless to say, such an individualization of causation could be taken to be mechanistic in specifying how the bacterium makes its movement if it is thought to act simply responsively. At the same time, the individualization could not synchronize with its contextualization until the bacterium would finally find itself directed towards where attractants are located. The causation coming from the context does not necessarily suit to the context available on the spot. It is only when the bacterium senses the direction along which the concentration of attractants increases that both individualization and contextualization are synchronized. The absence of synchronization between individualization and contextualization leaves the bacterium some room of activity on its own without being specified and controlled totally from the outside.

Individualization of causation is in fact an instance of making distinctions in which the activity of making distinctions is taken for granted. The origin of such an activity rests upon the absence of synchronization between individualization and contextualization of causes since the causation is taken to come from the context. If the preceding individualization fails to fit into the available context for whatever reasons, the context would suffer variations accordingly and then the subsequent causation from the context would be varied. This sort of variations is certainly in accord with the principle of causation setting a stipulation connecting the context to each individual constituent. Mechanistic causation is arguably an extreme case guaranteeing a unique relationship of causation between the context and every individual constituent that has been specified completely in advance. Such a determinate relationship could become most visible when the condition of ceteris paribus in one form or another is imposed (Matsuno, 1993). Nonetheless, the principle of causation abandons completely synchronized determination of the relationship between the whole context and its every individual constituent. Still, insofar as the principle is respected, the integrity of the context would have to be observed. The principle of causation requires the agency of contextualization more than anything else. If the preceding individualization fails to fit into the then existing context, a subsequent contextualization would necessarily follow, with a consequence of updating the context serving as the agency of supplying further causes of individualization. This sequence can continue indefinitely.

The principle of causation necessarily comes to incorporate into itself the capacity of searching, modifying and accommodating to the context. The activity of accommodating to the context in the form of contextualization is unquestionably self-reflexive and final in maintaining the capacity of behaving for the sake of the context. Despite the final mode of activity, however, the principle makes both mechanistic and final modes of activity mutually commensurable. Unless mechanistic causality employs a form of ceteris paribus enforcing a unique determination of the relationship between the context and its individual constituent, every caused movement holds the capacity of accommodating itself to the context. Otherwise, the principle of causation would fail to hold. Contextualization of each individual comes from the principle of causation. The tumbling movement of a bacterium E. *coli* is certainly a case exhibiting an activity of contextualization on the part of the individual.

The coexistence of both individualization and contextualization is thus seen as a necessary outcome from the indefiniteness latent in the principle of causation (Salthe, 1993, Taborsky, 1997). Contextualization proceeding in the forward direction in time is in fact equivalent to preparing an updated context that would come to act upon each individual subsequently. This type of retardation of causation materializes in the form of contextualization. Unless individualization of mechanistic causation is stipulated to be completely determinate with regard to every participant, there always remains room for contextualization. What is more, it is rather erroneous to assert that there is no room of indefiniteness in the name of the principle of causation, since the dichotomy of causation and absolute freedom is a false one. The present interplay between individualization and contextualization will provide a new perspective towards the principle of causation. One related issue would be a matter of final causality.

Following Aristotle's initiative, mechanistic causality has long taken to be antithetical to final causality. The swing of the pendulum between the two has overly been deflected towards mechanistic causality since the upheaval of Galilean-Newtonian physics. This overwhelming domination of mechanistic causality is, at least historically, quite understandable if one takes it for granted that both causation and caused movement can be explicated crisply in a perspicuous manner. The present descriptive stipulation in turn forces us to accept a definite set of descriptive categories. The presence of definitive categories, when combined with the principle of causation, could come to assert that causation from the context, whatever it may be, can be definitely identifiable and accordingly there would be no room for it to be varied in an unprecedented manner. Complete categorical specification of the context would then eliminate any possibility for the individualization of causation to influence the existing context. There could be no need to having recourse to contextualization. Everything could be taken to follow mechanistic causation. Nonetheless, the presence of definitive descriptive categories remains as a methodological artifact at best. Although such categories would enable us to describe a definitive object out there and its mechanistic dynamics, there is no guarantee for that such would be the case in reality. A more modest attitude towards the problem of causation is to have certain reservation with our apparent over-confidence on descriptive categories of definitive character.

3. MAKING DESCRIPTIVE CATEGORIES PLASTIC

Once we set ourselves free from the strict stipulation of definitive categories and admit that they are still incomplete, a totally different perspective toward the issue of causation will come up. In particular, it is quite natural to observe that the activity of making distinctions is far more ubiquitous in our empirical world compared to that of making categorization in terms of definitive categories. Making categorization is only a special case of making distinctions. When it is combined with the principle of causation, the capacity of making distinctions will certainly operate in the process of individualization of causation. What is more, there is no pre-determined guarantee that the distinction made for the individualization may also satisfy the condition for perfectly matched contextualization. Making distinctions is an activity encompassing both individualization and contextualization of causation. When we refer to the contextualization of causation as an instance of final causality, a key to this observation is our reservation such that our descriptive categories are still changing in time and cannot remain definitive.

Of course, we have witnessed a strong argument for asking that there must be a definite set of descriptive categories in order to complete our recognition of the outside world. Despite this strong assertion, however, there is a sharp difference between simply asking categorized perception of the outside world and justifying it. Final causality lives up with contextualization of causation insofar as the capacity of making distinctions is taken to be primary.

Contextual dynamics addressing the context of interrelated conditions among the participating elements is unique in exhibiting the capacity of contextual selection. No contextual element can belong to two mutually incommensurable contexts at the same time, since the context is about an organization of the interrelated conditions as a coherent unity. Otherwise, the contextual unity would be jeopardized. Classical mechanics thus assumes the intervention of the external agency for its contextualization, to which all of the capacity of exercising the contextual selection and specification is relegated. Classical mechanics has in fact been complete in deciphering the mechanistic makeup of whatever material bodies in motion, while it still remains incomplete in uncovering the nature of the contextual agency. Then, thermodynamics comes to the fore.

Thermodynamics has historically been attempted as an endeavor towards an incomplete contextualization supplemented by an incomplete mechanistic underpinning. Something called heat was first introduced without recourse to explicating its mechanistic or atomic makeup. Despite this obvious drawback, however, thermodynamics has been concrete enough to introduce some quantitative figures addressing what the context of material bodies of interest would be all about, such as the amount of heat energy flowing through between two different bodies at different temperatures in contact. Take, for instance, temperature conceived in thermodynamics. Once the temperature of a material body, whatever it may be, is identified by whatever means, no contextual element of that body can participate in the contexts at different temperatures. This is just another way of saying that temperature is an intensive quantity about a context as a whole. Above all, an empirical law known as the first law of thermodynamics on energy transformation has anticipated the upcoming of contextual dynamics as admitting that the energy carried by the context can be preserved as a quantity even if the context is being transformed from within. In thermodynamics, as a matter of fact, a portion of heat energy can be transformed into mechanical energy without losing any amount of the energy involved.

The first law of thermodynamics on energy conservation through its transformation is concrete enough to specify the quantity of the energy to be transformed despite the fact that the mechanistic deciphering of the transformation mechanism remains yet to be seen. Then, a serious question arises with regard to what should be responsible for specifying the quantity inherent to the context. Asking the external agency for the concrete specification is of course one solution as has been practiced in classical mechanics. However, classical mechanics begs the further sturdy question of who in the world could that external agency be. In contrast, thermodynamics has anticipated that capacity of concrete specification arising from within. Since the capacity of concrete specification rests upon the act of measurement, thermodynamics comes to terms with measurement internal to thermodynamic bodies. Internal measurement is concrete and specific enough to point to and to be pointed out by whatever material bodies internally.

At the same time, the present appraisal of internal measurement comes to face its own problem to be solved. That is about how to address the occurrence of internal measurement linguistically. Referring to the occurrence of something concrete particular in third person description in the present tense is in fact simply inconceivable since the agency of exercising such capacity of concrete specification is local both in space and in time. Third person description in the present tense, on the other hand, takes it for granted that the descriptive object can be situated out there even in space and time of an infinite extension, because the descriptive author can be detached from the object both in space and time and can remain even anonymous. Thus, the linguistic vehicle for addressing the capacity of internal measurement is at most through second person description. Second person description is concrete particular in identifying the object in the second person status, and its activity is in the present progressive instead of in the present tense. Internal measurement necessitates the participation of material processes accessible in second person description in the present progressive tense. This should exactly be the occasion in which the role of quantum dynamics is to properly be appreciated.

4. EMERGENCE OF THE CONTEXT OF MATERIAL ORIGIN

An empirical basis of quantum dynamics resides in the activity in the present progressive tense demarcated clearly by the occurrence of its completion referred to in the present perfect tense. When a black body emits and absorbs light waves, Max Planck observed that light emission in progress is always punctuated by its completion. The discontinuous distinction between light emission in progress and its completion is legitimately materialistic in its origin. A photon as a propagating wave is in the present progressive, while a photon as a particle serves as the container of the propagating wave whose progressive movement inside has been perfected at the contour of the container. What is unique to internal measurement on the part of an energy quantum in general and a photon in particular is the natural transference from the present progressive to the present perfect tense at the contour of the quantum. An energy quantum after Planck is a material embodiment of both movement in progress and movement perfected. The distinction between the inside and the outside of a quantum is to be accomplished through internal measurement proceeding there. Internal measurement viewed from the perspective of quantum dynamics is agential in the act of transferring the present progressive tense into the present perfect one and serves as the material agency bridging the present progressive and the present perfect tenses. Quantum dynamics thus empirically provides a material support for addressing thermodynamics in second person description in the present progressive tense, the latter of which is necessarily punctuated by the present perfect tense from time to time from within. That is agential from within, instead of from without.

To be sure, mechanistic causation is invincible insofar as the externalist stance guaranteeing the certitude and integrity of the descriptive object out there in the third person status is sanctioned. The causation toward each individual is definite and proceeds in a completely consistent manner with the rest constituting the whole object. Complete definiteness of mechanistic causation dispenses with even the notion of context and contextualization since the definiteness has already been guaranteed for every individual constituting the whole context of whatever kind. Mechanistic causation for individualization is already implicit with complete contextualization. On the other hand, causation for contextualization goes beyond simply being mechanistic when the completeness of individualization is jeopardized for whatever reasons. Final causation will enter for contextualization when there remains some indefiniteness in materializing each individual cause. The lack of complete individualization of causes will arise when each individual cause comes to influence and communicate with others. Final cause for the context then available is an inevitable participant in causation when there arises a conflict between the communication for causation and the caused movement. Unless the caused movement simultaneously turns out causation to others, the communication of causation not synchronized with the caused movement becomes real. The communication of causation is mechanistic in leaving the caused movement behind, but final at the same time in acting toward conformity with the context. Communicating causation is mechanistic in its individualization, while being final in its contextualization.

The distinction between contextual and mechanistic dynamics will become obvious when one distinguishes between the second and the third person descriptions to be employed. Dynamics addressable in third person description has to be mechanistic, since third person description admits the agential capacity of neither the speaker or writer of the utterance in which it occurs nor the one to which that utterance is addressed. The agential capacity influencing the content of the utterance in third person description is always sought outside the utterance. In contrast, dynamics addressed in second person description can be contextual since second person description refers to and appreciates the agency of a thing addressed in the utterance in which it occurs. The thing addressed in second person description can maintain room of influencing and modifying further the context of the utterance that has already been perfected by the speaker or writer. What is more, this distinction between contextual and mechanistic dynamics is not merely a matter of linguistic artifact. The origin of the object addressable in second person description is even quantum dynamical empirically. Contextual dynamics requires both quantum dynamics and thermodynamics on a par, instead of being intended to derive one from the other.

5. THERMODYNAMICS ON CONTEXTUAL SPECIFICATION

What is unique to thermodynamics is that it introduces macroscopic variables such as volume, pressure, temperature and entropy without detailing their atomistic makeup at the outset. These macroscopic variables are about the context in which the underlying microscopic elements, whatever they may be, are eventually situated. The contextual dynamics specifying the values of the macroscopic variables is constantly operative there (Brooks and Wiley, 1988). Even if the fundamental dynamics of microscopic elements is left unspecified, the contextual specification is to proceed. A molecule in the gas is subject to the temperature of the gas while at the same time the molecule is part of the gas substantiating the same temperature. Thus, any contextual element constituting the context comes to materialize and share the same contextual specification. Thermodynamics is unique in emphasizing the priority of contextual specification over elementary specification of each constituent element. Although mechanics is a theoretical enterprise equating elementary specification of an imposed character literally to contextual one in a crisp manner, thermodynamics is quite different in allowing an under-complete elementary specification whether or not it is of an imposed character. The present contextual specification now provides the interplay between the two of the contextual and the elementary dynamics with a possibility of influencing each other in both ways, namely, from the elementary to the contextual and vice versa.

One attempt for relating the elementary to the contextual dynamics is through a statistics of mechanics over an ensemble of elementary specifications. Statistical mechanics is grounded upon the premise that an ensemble of elementary specifications could be a substitute for the interplay between the two specifications, the contextual and the elementary ones. A justification of the ensemble of elementary specifications came from Boltzmann's Stosszahl Ansatz or hypothesis of a molecular chaos stating that molecules in the gas lose their memory of the past collisions with the others except for the latest ones. Those molecules in the gas thus come to have almost no correlation with the others or to move almost randomly with each other. This is equivalent to saying that the context which Boltzmann introduced is the one under which every contextual element moves almost randomly with each other. More specifically, one particular quantitative figure characterizing the Boltzmann's context is called temperature. To be sure, Boltzmann's context is found ubiquitous in physics. Nonetheless, it is no more than a heuristic candidate for fulfilling the role of contextual specification operating in thermodynamics. There certainly is another candidate for meeting the similar requirement of contextual specification. That is quantum mechanics.

6. QUANTUM MECHANICS ON CONTEXTUAL SPECIFICATION

Just for the sake of focusing on the extreme exquisiteness of material coordination and configuration met in biology from the perspective of quantum mechanics, let us suppose that there is a cookbook on how to make life from scratch in a planet in another remote solar system in the universe. If the cookbook is perfect enough not to require its further revision and at the same time inclusive enough to allow for the existence of the beings full of curiosity like us, it would get into trouble. If the perfect edition were in sight by any chance, there would be no room for such a curious being to appear in the first place.

On the other hand, however, if there were no likelihood of expecting the perfect edition, the best cookbook that could ever be imagined would be the one whose editors constantly come and go, while they can come up with a revised edition from time to time. The accepted cookbook would be the one coherent enough as an edited volume, but premature enough to allow for the editorial board members to think about its further revision, while the term of each board member is definitely limited. Moreover, since the editorial board of the cookbook also constitutes part of the content, the self-referential clumsiness and complication would become inevitable in the endeavor of compiling such a cookbook of life.

The overly exaggerated relationship between the occurrence of biological organization and its theoretical description as depicted in the above just points up to a necessity of naturalizing whatever theoretical edifices as much as possible. Naturalization means dispensing with theoretical artifacts to the extent that can be tolerated while making access to empirical reality as closely as possible. One agenda in this regard is the occurrence of what is called the context. The context of material dynamics is constructed in a bottom-up manner, while the boundary condition addressing the context theoretically is imposed in a top-down manner. Naturalization of the context in biology is in the effort of minimizing the top-down influence of imposed character in describing biological organization (Matsuno, 1989).

Atoms and molecules constituting a biological organism are placed within the material context of an extremely specific configuration. Such a specificity of the material context makes biological organization unique compared to nonliving physical organization of atoms and molecules. Needless to say, physics has its own rich history on explicating the nature of whatever material contexts available there. One example of an extreme significance is the material context discovered by Max Planck.

First of all, context as a limiting modifier of the contextual elements, if empirically available, must remain robust to a reasonable extent. Otherwise there would be no possibility for denoting it as such in the empirical domain. Empirical confirmation of the occurrence of such a robust context including a set of macroscopic variables in thermodynamics comes from examining the empirical record of the events of interest. The record is about the events already registered in the present perfect tense, while the ones right in the making are in the present progressive tense. The robust record rests upon the transference of events in the present progressive tense to those in the present perfect one. In fact, quantum mechanics grounds itself upon the existence of such a robust record.

When Planck introduced the notion of a quantum for the first time, the relevant empirical fact referred to was that a light-wave emission from and absorption to a black body in thermal equilibrium with its surroundings are punctuated in a discrete manner. The discreteness is associated with the empirical observation that light-wave emission in progress comes to shortly be punctuated by the emission completed, and light-wave absorption in progress similarly comes to be punctuated by the absorption done. There is no indefinite prolongation of light-wave emission and absorption over to an infinite duration in a continuous manner. The punctuated light-wave referred to as a light quantum or a photon carries with itself the context within which continuous light-wave is encapsulated in a coherent manner. In particular, Schrödinger identified that the coherent nature of the encapsulation is due to the occurrence of a standing wave as a coherent superposition of both the retarded and the advanced wave of material origin.

The context discovered by Planck, or Planck's context, is thus the one for those contextual elements moving almost coherently with each other. Planck's context is just a polar opposite to Boltzmann's, in the latter of which the contextual elements are taken to move almost randomly in an incoherent fashion with each other. However, the relationship between Planck's context and Boltzmann's is not mutually exclusive. Planck's context is more fundamental and more inclusive in that any material element of whatever sort is a quantum after Planck. In contrast, Boltzmann's context is subject to Planck's contexts embedded in it. At the same time, Planck's context is also subject to influences coming from the outside, because it always presumes the action of making a sharp distinction between the present progressive and present perfect tense by both itself and others external to the context itself. What is responsible for generating the context is the robust interplay between the inside and the outside. The present interplay can now furnish a Boltzmann's context as a source matrix of the measuring agencies toward each Planck's context residing in its inside with the capacity of modifying the latter context in time internally. Occurrence of a Boltzmann's context is in fact an empirical testimony to the observation that the constituent quanta or Planck's contexts are measuring each other internally, that is to say, involved in internal measurement altogether.

In particular, the contrast between Planck's context and Boltzmann's will become more transparent once the nature of internal measurement involved is focused. Although Boltzmann's context rests upon the stipulation that each quantum loses the memory of the past measurements of the others shortly, Planck's context is about the persistent memory of the measurement internal to each quantum while distinguishing the movement in the present progressive mode from the one in the present perfect. Planck's context is for long memory of internal measurement, while Boltzmann's is for short memory.

7. CONCLUDING REMARKS

Contextual specification in thermodynamics now comes to incorporate into itself the act of internal measurement of quantum mechanical origin. Again, once measurement is directly focused, it will place upon quantum mechanics to be practiced one more constraint. Measurement, whatever sort it may be, is a physical process proceeding in the phase space in general or in the ordinary three-dimensional space in particular. This constraining to the phase space is to generate further repercussions in the practice of quantum mechanics. In particular, in view of the fact that the basic quantity accessible to measurement is the probability density reducible from probability amplitude in the phase space, it would be desirable to directly refer to the probability density in the phase space, that is to say, the Wigner function (Holland, 1993). Measurement of a moving body or an energy quantum in the phase space takes up the issue of identifying the probability measure of finding what, where, in which direction, and how fast. However, a plain fact is that the probability density in the phase space is not always positive definite. The occurrence of negative probability densities is due simply to the fact that the conjugate pair of the phase space coordinates, such as the position of a particle in the ordinary space and its momentum, cannot be identified simultaneously in a definite manner. Nonetheless, negative probability density is hard to swallow in reality especially in measurement. If the interplay between Planck's context and Boltzmann's is legitimate physically as it should be, a way out of the occurrence of negative probability densities will have to be worked out by all means. This will be a major issue on the emergence and evolution of various biological organizations since biology is about contextual dynamics proceeding in the ordinary three-dimensional space as part of the phase space sanctioned in physics.

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