Actual and Eternal Entities in Whitehead, Fa Tsang, and Physics
by Laura E. Weed

The College of St. Rose
432 Western Ave.
Albany, NY USA
weedl@mail.strose.edu

Introduction

There has been a large amount of secondary literature written over the last century that compares the striking similarities between Alfred North Whitehead's process philosophy and Hua Yen Buddhism. Many authors, for instance, have noted the relational nature of Whitehead's actual entities and compared his relational conception of actual entities to *pratitya-samutpada* in the Mahayana tradition.[1] Also, Whitehead's inclusion of feelings in the basic dynamics of the ontological world has been compared to the Buddhist stress on *Dukka.* [2] Likewise, positive comparisons have been made between the three levels of knowledge in T'ien Tai and Hua Yen Buddhism and Whitehead's levels of knowledge through causal efficacy, presentational immediacy, and the mixed mode of symbolic reference.[3]

Other authors have pointed out significant differences between the Whiteheadian and Buddhist perspectives, as well. For example, Charles Hartshorne[4] and Steve Odin[5] have both argued that causation is asymmetrical in Whitehead's world view, but symmetrical in Buddhism. Also, Masao Abe has pointed out that Whitehead's di-polar conception of God renders God's primordial nature radically transcendent of the world in a way that nothing is radically transcendent of reality in Buddhism. Also, God serves as a limit on

what actual occasions can do or be for Whitehead, in ways that nothing limits or directs *dharmas* in Buddhism.[6]

What I hope to contribute to this already impressive discussion in this paper is an updating of some of the issues already discussed, from the point of view of contemporary philosophy of science. Both Whitehead and Buddhism conceived of reality as a field of interrelations among actual entities or *dharmas*. Over the course of the twentieth century, physics has undergone a number of revolutions concerning the nature of the physical 'field.' Tian Yu Cao has described the perturbations of ontological commitment between particles and fields that physicists have traveled through in the last century in his argument for a position in philosophy of science that is in some respects very Whiteheadian and in other respects very Buddhist. I will use Cao's analysis of "ontological synthesis"[7] to argue that although there are important differences between the Whiteheadian and Buddhist ways of understanding basic reality, both supply valuable insights with respect to understanding the nature of things. I will argue for this position through an analysis of Whitehead's conception of eternal ideas, and processes operating in the world, as they apply to physics, and to causation, and as Maso Abe claims they apply to Buddhist meditation.

Whitehead's Eternal Ideas: Propositions, Necessary Truths, and the Primordial Nature of God

One of the chief differences between Whitehead's actual entities and Fa Tsang's *dharmas* that the literature comparing them has pointed out is that Whitehead's entities are affected in important ways by 'eternal ideas' in the forms of propositions, necessary truths, or

truths of logic and mathematics, within the primordial nature of God. But all three of these forms of abstract or eternal ideas are emergent from the actual entities for Whitehead. He frequently stresses the priority of occasions, events, and subjects over conceptions, ideas or abstractions. For example, he claims;

> The final facts are, all alike, actual entities; and these actual entities are drops of experience, complex and interdependent.[8]

Whitehead explains the priority of actual entities through his 'ontological principle':

> ...[E]very condition to which the process of becoming conforms in any particular instance has its reason either in the character of some actual entity in the actual world of that concrescence, or in the character of the subject which is in process of concrescence. This category of explanation is termed the 'onto-logical principle.' It could also be termed the principle of efficient and final causation. This ontological principle means that actual entities are the only *reasons;* so that to search for a *reason* is to search for one or more actual entities. It follows that any condition to be satisfied by one actual entity in its process expresses a fact either about the 'real internal constitutions' of some other actual entities, or about the 'subjective aim' conditioning that process.[9]

When Whitehead does explain the status of eternal ideas, or objects, he explains them as 'forms of definiteness' that exist only as potentials apart from the actual entities in which they are realized. Of eternal objects he says;

> ...[A}n eternal object can be described only in terms of its potentiality for 'ingression' into the becoming of actual entities; and ... its analysis only discloses other eternal objects. It is a pure potential.... contributing to the definiteness of that actual entity.[10]

Likewise, when Whitehead discusses propositions, he calls them an 'impure type'[11] of entity, that is a 'nexus' between actual entities and eternal objects. He makes the existence and meaningfulness of propositions directly dependent on there being some concrete actual entity that can be a subject who, consciously or not, can entertain the proposition.

He explains the relationship among eternal entities, actual entities and propositions in the following passage.

> A proposition, in abstraction from any particular actual entity which may be realizing it in feeling, is a manner of germaneness of a certain set of eternal objects to a certain set of actual entities. Every proposition presupposes those actual entities which are its logical subjects. It also presupposes certain definite actual entities, or a certain type of actual entities, within a wide systematic nexus. In an extreme case, the nexus may comprise any actual entity whatsoever.[12]

Whitehead rejects a Kantian form of rationalism for what he elsewhere calls a "fallacy of misplaced concreteness." He characterizes the temporal world, as discussed in Kant's *Critique of Pure Reason*, as "... dead, phantasmal, phenomenal...[13]" because the actual entities of noumenal reality are secondary to concepts of pure apperception in Kant's order of priority. Whitehead also faults Aristotle for misleading most subsequent philosophers by casting knowledge in a propositional subject-predicate form, which, he claims, has driven philosophical inquiry to much too high a level of abstraction.[14]

So, it seems that Whitehead only allows real existence to eternal objects, as 'abstractions' in the Primordial Nature of God. And even there, the reality of the eternal objects is tied to their 'relevance' to temporal realization in the world. He describes the necessity of 'togetherness' between eternal objects and the real world in the following passage.

> The ontological principle can be expressed as: All real togetherness is togetherness in the formal constitution of an actuality. So if there be a relevance of what in the temporal world is unrealized, the relevance must express a fact of togetherness in the formal constitution of a non-temporal actuality. ... Such a primordial superject of creativity achieves, in its unity of satisfaction, the complete conceptual valuation of all eternal objects.[15]

So, God, in his primordial nature, is a reservoir of modal logic. Whitehead doesn't seem to make the contemporary distinction between metaphysical possibility as a form of possibility that is restricted by the nature of reality and epistemological possibility as a form of possibility restricted only by what is logically possible and not by what can physically exist in the real world[16]. But his program of reduction of propositions to nexus between eternal objects and real entities would seem to be unsympathetic to the possibility of physically unrealizable eternal entities. Topology, for instance, is an area of mathematics that deals with physiologically impossible, (but clearly epistemologically possible) abstract entities. Whitehead seems to repudiate such purely epistemological modal speculation when he discusses the value of statistics.

> There is no difficulty in imagining a world -- i.e., a cosmic epoch in which arithmetic would be an interesting fanciful topic for dreamers, but useless for practical people engrossed in the business of life. In fact, we seem to have been barely rescued from such a state of things. For, amid the actual occasions located in the wilds of so-called 'empty space,' and well removed from the enduring objects which go to form the enduring material bodies, it is quite probable that the contemplation of arithmetic would not direct attention to any very important relations of things.[17]

The position expressed in this paragraph, that mathematics might be an idle game, and would be idle if it did not represent actual relations among actual entities, is not at all typical of the attitude of most mathematicians and physicists. While some philosophers of mathematics think that mathematical possibility is epistemologically limited by the intuitions of mathematicians,[18] others are Platonic realists about the conceptual objects apprehended in mathematical reasoning, believing that only purely formal or logical restraints limit the possibilities of mathematical analysis and possible relations to physical reality are irrelevant.[19] Gottlob Frege, like Plato, believed that the realm of the Forms, or the 'Third Realm', transcending both things and minds, is the place of residence

of the 'eternal things' that are most real, which were Forms for Plato and propositions for Frege[20]. In view of the positions of these philosophers, Whitehead's restriction of the domain of legitimate mathematical reasoning to metaphysically possible descriptions of actual entities seems very minimalist and restrained.

Yet Masao Abe argues that even Whitehead's minimalist concession in the direction of eternal objects is too much transcendentalism. Abe faults Whitehead for his Primordial conception of God, arguing that actual occasions do not need the di-polar 'appetition' towards an unrealized future and limit on possibilities to be realized imposed by Whitehead's eternal objects. Abe criticizes Whitehead,

> ...[One,] though actual occasions (as superjects) are *completely* immanent in God, God is *not necessarily completely* immanent in the world, and two, that God transcends the world by virtue of *his perfection*, but the world, though transcending God, is *lacking his perfection.*
> ... This transcendence of God signifies, in Whitehead, that God is the principle of limitation which, by transcending every temporal occasion, gives an initial aim to an actual occasion to determine its limit. Without God as the principle of limitation, there could be no finite and ordered actualities nor values and one would have an "indiscriminate modal pluralism". [21]

Abe's rejection of Whitehead's limitations on an "indiscriminate modal pluralism" seems to indicate, in this context, that Abe would accept an indiscriminate modal pluralism as a correct and appropriate description of the way the world is according to the Buddhist doctrine of dependent co-origination. Abe stresses the dialectical way that interdependence arises in Buddhism, in contrast to Whitehead's limits and eternal potentials. The dialectic of transcending all di-polarities and even transcendence and immanence, themselves, is to be used to realize that ultimately the ordinary world *just is*

Nirvana, and there is nothing more real than the interdependence of the *dharmas*, not even in the sense of pure potentials.[22]

Still, for Abe, there is a clear point to going through the dialectical process of comparing Form and Emptiness, Emptiness and Form. Abe suggests that Buddhists could use Whitehead's principle of limitation to prevent "recurrent misunderstandings of the ideas of Emptiness and Suchness, the meanings of which tend to be misinterpreted negatively".[23] So, although Abe rejects Whitehead's account of the propositional nexus that is generated by the interaction of eternal ideas and actual entities, he thinks the mental process of examining actual entities and contrasting their conventional form and content described by Whitehead has heuristic value.

I would like to conclude this exposition of eternal ideas and their relationship to actual entities or *dharmas*, with a summary of the points I have tried to exhibit in the last few pages. To summarize:

1. Whitehead has a very minimalist conception of 'eternal ideas,' that is limited to what is metaphysically possible, that is, to only those possibilities that could be physically realized in actual entities in the actual world.

2. Although Masao Abe objects to even Whitehead's minimalist eternal ideas as possibilities, Abe also expresses a need in Buddhism to specify the value of the dialectical analysis of the relationship between concepts and suchness that ultimately will be used, in Buddhism, to get past all conceptions and di-polarities.

In the next section of this paper, I will apply Whitehead's minimalist conception of eternal ideas and the Hua-yen conception of the dialectic of the reasoning process to physics.

Minimalist Eternal Objects, and Dialectic in Physics

Tian Yu Cao traces the history of scientific revolutions in the twentieth century to argue that both the linear 'convergent realism' of Ernest Nagel[24] and the 'incommensurability thesis' of Thomas Kuhn[25] are untenable extremes in philosophy of science. Cao argues that it does not follow from the fact that major philosophical shifts in the ontology of physicists take place in the understanding of the evidence provided by their research that there is no continuity or accumulation of knowledge in physics. He argues that, despite wide swings in ontological commitment there has been direction, development and progress in theoretical physics in the twentieth century. I will highlight some of Cao's observations in this section to show how Cao thinks this works[26]. Along the way, it should be apparent that both neoplatonism and atomism, while recurring as themes, are becoming incorporated into a dialectically developing picture of interrelationships among points of reality that might be alternatively conceived of as Buddhist nothingness or Whiteheadian superjects. Also, I will point out roles played by Whiteheadian conceptions of reality as minimalist eternal entities contributing to the superject causation of actual entities, and roles played by a Hua-Yen type of dialectic between form and suchness, as I follow Cao's analysis.

20TH Century Physics, Minimalist Eternal Entities and Dialectic

At the outset of the twentieth century physics was dominated by two mechanical conceptions of the basic stuff of reality. Boyle advocated a molecular and atomistic theory, while a version of Neoplatonism, traceable to Kepler, stressed mathematical formal structures as the reason why things are what they are.[27] Both Whitehead and Fa

Tsang would reject atomism as too substantialistic and inadequately sensitive to the interdependence of things and neoplatonism as too indebted to abstract ideas. Both Boyle's and Kepler's views were seriously contested by Einstein's theory of relativity, according to which the concepts of space that were required for the atomistic and neoplatonic views were undermined. Einstein developed the idea that reality is a field, but retained the notion that atomistic objects exist in it. Cao quotes Einstein as describing the field in these terms in 1952.

> I wish to show that space-time is not ...something to which one can ascribe a separate existence. Physical objects are not in space, but these objects are spatially extended. In this way, the concept 'empty space' loses its meaning.[28]

Thus, the physicist who launched the Quantum Field Theory program in contemporary physics conceived of his project as postulating a field of interrelations among particles. But after Schrodinger's experiments and Dirac's work on the vacuum, the field became even more prominent in the thinking of physicists. Cao says;

> When QFT [quantum field theory] was first invented, the quantum fields had clear and immediate physical interpretations, in terms of the emission and absorption (creation and annihilation) of physical particles. After Dirac introduced his idea of the vacuum, however (1930a) the operator fields became abstract dynamical variables, with the aid of which one constructs the physical states. They themselves do not have any elementary physical interpretation.[29]

So, at this point in the twentieth century, the neo-platonic, or even pythagorean idea that reality is mathematical structures of eternal ideas, was undermining the particle conception of reality. Cao explains the dilemma in the following words, reminiscent of Fa Tsang, and of Abe's relational conception of suchness and form.

> On the one hand, according to Special Relativity, the vacuum must be a Lorentz invariant state of zero energy, zero momentum, zero angular momentum, zero charge, zero whatever, that is, a state of nothingness. Considering that energy and momentum have been thought to be the essential

> properties of substance in modern physics and modern metaphysics, the vacuum can definitely not be regarded as a substance.[30]

The result of these observations was an Abe-like dialectic;

> The distinction between matter and force-field vanishes from the scene, and is to be replaced by a universal particle-field duality effecting equally each of the constituent entities.[31]

Interactions among elements in QFT were also highly problematic. Attempts at quantizing portions of the field became hindered by the fact that unmanageable infinities would result from calculations conducted on the isolated quanta. So, since most western theorists were wedded to some form of atomism, 'renormalization' procedures were developed to limit the quanta to manageable numbers. Through 'renormalization' procedures, physicists came to describe 'virtual quanta processes' of infinite momentum as an explicit fiction. Cao describes the renormalization procedures as attempts to maintain western atomism, within QFT. Unrenormalized, QFT implies that the particles described in the interactions are not the most basic, but are composed of yet smaller ones, reminiscent of Whitehead's actual entities as societies. Cao points out that,

> On the one hand, the structureless character of particles, as we know them at any level is not absolute, but contingent and context dependent, justified only by relatively low energy experimental probing. ...On the other hand, with the revealing of the structure of particles at one level there emerges..... (seemingly) structureless objects at the next level.[32]

A more pitched debate over whether the particles, the neo-platonic mathematical structures, or the field was most basic was to develop during the 1960's. G.F. Chew and colleagues argued that QFT should be abandoned and replaced with S-matrix theory, in which processes rather than entities are the basic ontology. In S-matrix theory, all units of reality are seen as composites, again in a Whiteheadian sense, whose parameters can be described by dynamical equations.

Meanwhile, apart from S-matrix theory, an attempt was being made by other physicists to axiomatize Field Theory, through purely mathematical means, to prove its consistency. This explicitly neo-platonic attempt to do physics through exclusively eternal ideas ultimately failed, although Cao thinks it may have played an important role in the later development of double dispersion relations. Likewise, the subsequent 'current algebra program' "deliberately ignored the dynamic details, thus simplifying the complicated situation."[33] Cao mentions that the current algebra program , also may have made some contribution to the eventual development of the Yang-Mills type of theory. But these failures of purely mathematical attempts to understand physics during this period also lead Cao to comment,

> ..formal manipulation without any resort to the dynamics that underlies the algebraic relations is unreliable. [34]

Here, Cao seems to be endorsing the minimalist conception of the value of mathematics, as articulated by Whitehead, against the more Platonic or Neoplatonic conceptions that are and have been prevalent among some physicists and philosophers of mathematics.

However, dramatic discoveries within QFT in the late 1960's tended to overwhelm Chew's opposition to it. The quark-parton model of particles was developed, the scaling law was discovered in deep inelastic scatterings, and more sophisticated quantum chromodynamics were developed, suggesting that QFT could provide a framework for hadronic physics.[35] This led to the development of the gauge-field program and the objections that had previously been voiced against QFT were mostly forgotten.[36]

QFT evolved rather substantially over the next forty years, however, becoming, first, the Gauge Field Program, and then, Effective Field Theory. As physicists discovered many new subatomic particles, it became necessary for them to find a principle according to which they could decide what proposed couplings among the new particles might be most productive to study. Yang and Mills proposed 'gauge invariance' as this principle, on the hypothesis that the subatomic strong nuclear interaction would preserve isospin, on analogy with the preservation of electric charge at the atomic level.[37] The Gauge Field Program sought gauge symmetries among interactions, and lead to many important discoveries, such as spontaneous symmetry breaking, the characteristics of the weak nuclear interaction, and the characteristics of superconductivity.

But, as the successes of the Yang-Mills theory in describing weak and strong nuclear reactions continued to progress, some conflicts with the presumptions of basic QFT also began to emerge. QFT supposed that all interactions among phenomena would be localizable within specific fields, that renormalizability for the theories would be possible and that the unitary quality of the theories could be preserved. But eventually, in gauge theories, the renormalizability and unitariness of the theories came into conflict with one another. And global considerations, that violated the supposed local range of interactions were observed to occur. Cao describes the global/local puzzle in this passage.

> ...[F]irst, the breaking of gauge symmetry by anomalies has a quantum origin because classical dynamics is entirely characterized by the equations of motion. Second, it suggests that the anomalies have connections with the large-distance behavior of gauge potentials. More precisely it suggests that what is broken by the anomalies is the symmetry under certain finite, rather than infinitesimal gauge transformations. [38]

The significance of this context-dependent interaction across atomic and subatomic levels of operation was that the cut-off points adopted for renormalization procedures became important, problematic, and inconsistent with the apparently emerging fact that one theory could describe all interaction within physics.

Ontologically, advanced versions of GFP also blurred the distinction between composite and basic elementary particles, especially with respect to scalar particles, about which Cao comments;

> In the superconducting system, the asymmetric phase, the symmetric phase and the phase transition between them are all real. In the scalar system, however, the Goldstone boson is non-physical, the Higgs boson escapes our observation and the symmetric solution attracts little or no attention from physicists. [39]

Here, it looks almost as if we have Fa-Tsang's dharmas, as empty bubbles of intentionality, on the boson side of the analysis, while Whiteheadian superjects describe the phase transitions.

Effective Field Theories have been a response to the non-renormalizability of prior theories, which have either abandoned the idea of renormalizability and replaced it with a pluralistic theory of physics as consisting of a stack of different accounts of matter, hierarchically arranged according to energy levels, or have imposed patently neo-platonic and arbitrary measures for establishing cut-off points between renormalized theories. Cao reports that during the 1990's there were three rival interpretations of what EFT's have to say about the quantum field program in physics. Gross (1985) and Weinberg (1995) maintain a realist and atomistic point of view, holding that a deeper consistent

particle theory will be developed from the current EFTs in a systematic way. These physicists think that perhaps a string theory will accomplish this task. Wightman (1992 and Jaffe(1995), hold to a neoplatonic interpretation of things, according to which more elaborate mathematical models will eventually provide a consistent version of QFT, and salvage its status as an account of the foundation of physics. Cao argues against these conservative positions that a new picture of the physics of the world is required. He claims that the puzzles revealed in his work represent conceptual difficulties that the methodology and reductionistic structure of QFT are unlikely to be able to resolve.

> What is required in dealing with these conceptual problems, it seems, is a drastic change in our conception of fundamental physics, itself, a change from aiming at a fundamental theory (as a foundation for physics) to having effective theories at various energy scales.[40]

Cao defends this proposal for understanding the ontology of contemporary physics pluralistically through an argument that the real observables in any ontology are not things and their essential properties, in an Aristotelian sense. He accepts the Duhem-Quine thesis of the under-determination of theory by evidence, admitting that it would make any ontological claims about things and their properties non-comparable across different theories.[41] But he argues that some structural properties of things are cross-theoretically stable, such as *external symmetries* of the Lorentz symmetry type, and *internal symmetries* such as isospin in quarks. Also, *geometrizability* as a structural property of a space-time manifold and its extension, and *quantizability* as a structural property of portions of a continuous plenum, are cross-theoretically stable types of generalizations.[42]

Structural properties of this type are stable across developments in theories specifically because they are higher-order properties and relations, and not observation statements that pick out specific entities. Cao argues that, in general, science produces accounts of structures of this type, rather than of observations.

> What such a model provides us with, therefore, is not literally true descriptions of the underlying entities themselves, but rather, by analogy, the assertions of the observable structural relations carried on by the hypothetical entity. In fact a stronger case can be argued that an ontological characterization of a system is always and exclusively structural in nature. [43]

Here, Cao is presenting an interesting synthesis of the ideas of actual entities presented by both Fa Tsang and Whitehead. On the one hand, it is the structural or 'eternal' mathematical properties of things that are known by science and account for the relations between and among the things, and indeed, even for the differentiation of the things, as theoretical entities. But Cao is also agreeing with Fa Tsang and Mahayana metaphysics that all of the above says nothing about the ultimate suchness of anything. Rather, what the structural principles provide is criteria for differentiation among portions of an inherently undifferentiated continuum. Further, Cao agrees with Abe that the process of analyzing the natures of things by comparing the eternal qualities and the emptiness of the suchness is a valuable mental exercise, through which progress may be made. However, this process, itself, does not converge on some ultimate knowledge of that suchness as content, but only on more refined conceptions of its parameters.

Conclusions

Cao describes the process of ontological synthesis as a form of appropriation of the past into the present, that works like a Hegelian dialectic, which he describes as a sense of overcoming, while preserving. He points out that the scientific revolutions from QFT to

GFP to EFT each transformed the basic entities of the prior theory into epi-phenomena, but maintained, while transforming, the structural relations of internal and external symmetries, quantization and geometrizability.

To summarize this paper, I think this excursus into physics and philosophy of physics has shown:

1. the importance of insights from both Fa Tsang's account of *dharmas* and the Buddhist dialectic to shake oneself free of the conceptual limits of ordinary thought to see the *dharmas* as they are, as Abe claimed, and

2. the importance of Whitehead's conception of actual entities as exhibitors of generalizations in their relations to other things, and of the world as the totality of such systems of interrelations.

3. Further, both Whitehead and Fa Tsang endorse a conception of reality as a dynamical system of dialectically mutually informing relations among loci in a space-time contunuum. For both, as for Cao, freedom and an absence of substantial identity characterize both the loci and the dialectical processes in the continuum. Determinism does not occur in this analysis of nature, in contrast with atomism and neoplatonism.

Notes

[1] for example, Kenneth K. Inada, in "The Metaphysics of Buddhist Experience and the Whiteheadian Encounter", in *Philosophy East and West*, Vol 25, no. 4, October 1975, 465.

[2] ibid. 466.

[3] Robert F. Olson, "Whitehead, Madhyamika and the Prajnaparamita," in *Philosophy East and West*, vol. 25 no. 4, October 1975, 458-ff.

[4] Charles Hartshorne, "Whitehead's Differences from Buddhism", in *Philosophy East and West*, vol. 25, no. 4, October 1975, 411.

[5] Steve Odin *Process Metaphysics and Hua Yen Buddhism* (Albany, NY: State University of New York Press) 1982 , Part II, 69-155.

[6] Masao Abe, " Madhayana Buddhism and Whitehead-- A view by a Lay Student of Whitehead's Philosophy", in *Philosophy East and West*, vol. 25, no. 4, October 1975, 418-421.

[7]Tian Yu Cao, *Conceptual Developments of 20th Century Field Theories* (Cambridge, UK: Cambridge University Press) 1997, last chapter.

[8] A.N. Whitehead, *Process and Reality*, corrected ed. ed, D.R. Griffin and D.W. Sherburne (New York, NY: Free Press), 1978, 18.

[9]ibid. 24.

[10] Ibid. 23.

[11] Ibid. 188.

[12]ibid. 188.

[13] ibid. 190.

[14] ibid. 30.

[15] ibid 32.

[16] Saul Kripke makes this distinction in *Naming and Necessity (* Cambridge, MA: Harvard University Press) 1972

[17] Whitehead, op. cit. 199.

[18] Arend Heyting, "Disputation" and L.E.J. Brouwer, " Intuitionism and Formalism" in *Philosophy of Mathematics*, 2nd ed. eds. Paul Benacerraf & Hilary Putnam (Cambridge, UK: Cambridge University Press) 1983

[19] Gottlob Frege, "The Concept of Number" and Paul Bernays "On Platonism in Mathematics" in *Philosophy of Mathematics*, op. cit.

[20] Frege, op. cit.

[21] Masao Abe, "Mahayana Buddhism and Whitehead -- A View by a Lay Student of Whitehead's Philosophy", in *Philosophy East and West*, vol. XXV # 4 October, 1975, 418.

[22] ibid. 419.

[23] ibid. 427.

[24] Ernest Nagel, *The Structure of Science: Problems in the Logic of Scientific Explanation* (New York ,NY: Harcourt, Brace and World) 1961

[25] Thomas Kuhn, *The Structure of Scientific Revolutions*, (Chicago IL: The University of Chicago Press) 1962

[26] Simon Saunders argues in *Critical Notice: Tian Yu Cao's The Conceptual Development of 20th Century Field Theories*, (http://users.ox.ac.UK/~lina0174/cao4uUJ(s).pdf) that Cao underrates the importance of the measurement problem in physics in his book. Saunders argues that Cao has demonstrated a dynamical or structural continuity across 20th century physics that might support a form of structural realism, but that Cao's arguments do not support his claims for ontological continuity. I won't address Saunders' criticisms in this paper, because Fa Tsang and Whitehead both try to demonstrate the connections between ontology and structure that Saunders claims are missing in Cao's work. Whether any of them (Cao, Whitehead or Fa Tsang) succeeds in demonstrating the non-duality they all claim between structures and ontology is a question for another paper. See Jean-Marie Breuvart's paper "The Non-Substantialistic Turn in Whitehead's Philosophy, Its Meaning, Its Limits," in this volume of IJFB.

[27] Tian Yu Cao, *Conceptual Development of 20th Century Field Theories*,(Cambridge, UK: Cambridge University Press) 1997, 24-25.

[28] ibid. 95.

[29] ibid. 170.

[30] ibid. 176.

[31] ibid. 178.

[32] ibid. 206.

[33] ibid. 245.

[34] ibid. 244.

[35] ibid. 261.

[36] ibid. 262.

[37] ibid. 274.

[38] ibid. 307.

[39] ibid. 312.

[40]ibid. 351.

[41] ibid. 357.

[42] ibid. 361.

[43] ibid.360.