YinYang Bipolar Relativity

– A Unifying Theory of Nature, Agents, and Life Science

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Abstract **— YinYang bipolar relativity and a real world bipolar string theory are introduced as a unification of nature, agents, and life science. Nine axioms and 16 conjectures are posted for microscopic and macroscopic agent interaction, regulation, coordination, and exploratory scientific discovery in physical and social sciences. It is concluded that bipolar relativity constitutes an equilibrium-based axiomatization of physics – a partial but most general solution to Hilbert's Problem 6.**

Keywords *– Bipolar Relativity; Bipolar Causality; Bipolar Strings; Axiomatization of Physics; Agent Interaction; Life Science*

I. INTRODUCTION

Agents and agent interactions are essential in physics, socioeconomics, and life science. Unified mathematical abstraction and axiomatization of agent interaction in microscopic and macroscopic worlds are needed for scientific discoveries and for the coordination and global regulation of both non-autonomous and autonomous agents.

Since agent interactions are governed by physical and social dynamics, the difficulty of axiomatizing agent interactions can be traced back to the axiomatization of physics [3]. Among Hilbert's 23 mathematical problems, Problem 6 - ***"Axiomatize all of physics"*** - has remained unsolved for more than a century. While the problem is widely considered **"unsolvable"**, it can be argued that the principle of truth-based mathematical abstraction itself is a major barrier preventing a possible solution because without bipolarity truth-based systems including quantum logic and string theory [15] are "too logical" for the "illogical" but nevertheless natural aspects of agents [31] such as emotion, disorder, generosity, greed, and chaos. Thus, with truth-based systems, we have the paradox: ***"Logical Axiomatization for Illogical Physics" (LAFIP or LAFIB)*** [30].

The concept of equilibrium is ubiquitous, general, and central in both physical and social sciences as manifested by Newton's laws in thermodynamics, Nash equilibrium in macroeconomics [5], and the spontaneous broken symmetry model in physics [9]. As natural reality, agents and agent interactions can be modeled with equilibria or non-equilibria. Since a multidimensional equilibrium can be decomposed into multiple bipolar equilibria or non-equilibibra (Fig. 1), bipolar equilibrium can be considered a generic form and bipolarity as an integral and inherent part of equilibrium is inseparable from equilibrium-based holistic truth. While bivalent truth is concerned with truth and falsity, equilibrium-based truth is concerned with equilibrium and non-equilibrium. In addition to (-q,+q) and (-f,+f) in modern physics textbooks, the bipolar fusion of self-negation and self-assertion abilities denoted (self-negation, self-assertion) of an adaptive agent, (competition, cooperation) in socio-economics, (repression, activation) abilities of a genetic regulator gene [10] such as YinYang1 (YY1) [7] and the YinYang bipolar subatomic particle discovered at the Fermi National Accelerator Laboratory [6] that can change polarity trillions times a second show typical bipolar equilibrium/non-equilibrium properties. Furthermore, it is becoming scientifically evident that brain bioelectromagnetic field is crucial for neurodynamics and different mental states [1] where bipolarity is unavoidable.

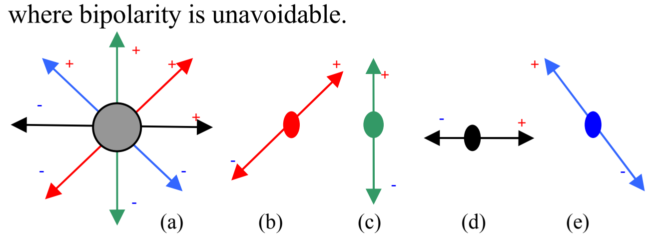

Figure 1. (a) A multidimensional equilibrium; (b)-(e) Bipolar equilibria

Based on [30,31], this paper presents an equilibrium-based bipolar relativity theory with nine axioms and 16 conjectures. It is shown that bipolar relativity is a unifying theory of natural and social sciences and constitutes a partial solution to Hilbert's problem 6. (Note: Refs. [30,31] do not cover the unifying aspects and stopped short of claiming the partial solution.) Section II introduces a bipolar axiomatization; Section III presents agents and bipolar relativity; Section IV presents a bipolar string theory; Section V is a prospect on equilibrium-based holistic science; Section VI draws a few conclusions.

II. BIPOLAR AXIOMATIZATION

A. Bipolar Elements and Sets

From a unipolar perspective, the two opposing poles of an equilibrium can be considered negative and positive elements [25]. ***Positive elements***, such as positive electric charges, action forces, positive ions, cooperative relations, activation, positive causalities, self-assertion, or positive numbers (including 0 as the bottom), etc, can form a ***positive set***. ***Negative elements***, such as negative electric charges, reaction forces, negative ions, competitive relations, repression, negative causalities, self-negation, or negative numbers (including 0 as the bottom), etc, can form a ***negative set***. We call positive and negative elements and sets ***unipolar elements and sets***, respectively.

Bipolar Reification. Since the two poles of a bipolar equilibrium coexist in a fusion or binding with opposite polarities, we say that ***they are not isomorphic to each other*** [30]. This distinction enables (-,+) bipolar semantics/syntax be elicited and distinguished from (+,+) such that bipolar equilibrium can be defined as bipolar holistic truth (see endnote).

Bipolar Sets. A ***bipolar set*** [25] is a collection of bipolar equilibria or non-equilibria each of which as ***self-evident bipolar element*** has two poles which are unipolar elements with different polarities in a bipolar fusion or binding.

We refer to the above definition as ***the principle of equilibrium-based bipolar mathematical abstraction***. With this principle, negative and positive poles as unipolar elements are partial concepts derived from bipolar elements.

A bipolar element can be in singleton or bipolar form such as $e = (e^-,e^+)$ or (e^+,e^-). We say $e = (e^-,e^+)$ is in ***full equilibrium*** if $e^+ = -e^-$ where the negation operator $(-)$ changes the polarity of a pole. When $|e^-| \neq e^+$ we call the binding or fusion $e = (e^-,e^+)$ *a* ***non-equilibrium***. We call a negative-positive ordered pair (n,p) an (-,+) equilibrium/non-equilibrium (Note: Left-right is relative; (-,+) bipolarity is not relative but a universal concept). Thus, a bipolar set can be denoted as $\{e\}=\{(e^-,e^+)\}$. A ***bipolar poset*** $(B_p,\geq\geq)$ is a (-,+) bipolar set where $\geq\geq$ is a bipolar partial order relation and, $\forall(x,y),(u,v)\in B_p$, we have the ***bipolar partial ordering*** [25]:

$$(x,y)\geq\geq(u,v), \text{ iff } |x|\geq|u| \text{ and } y\geq v. \quad (1)$$

(The use of absolute value |x| is for explicit bipolarity only.)

B. Zeroth-Order YinYang Bipolar Dynamic Logic (BDL)

Fig. 2(a) shows a binary interpretation of YinYang given by Leibniz who invented the first binary numeral system in the 17th century and attributed his invention to YinYang trigrams [12] [13]. Fig. 2(b) shows a bipolar interpretation of YinYang based on bipolar sets. $B_1=\{-1,0\}\times\{0,1\}$ in Fig. 2(b) forms a symmetrical bipolar lattice [30]. The (-,+) bipolar interpretation follows the Daoist cosmology "everything has two poles." Although 4-valued structures resemble each others' forms, all resemble YinYang-4-Images (Fig. 2(a)).

In B_1, (0,0), (0,1), (-1,0), and (-1,1) stand, respectively, for bipolar false (non-existence or eternal equilibrium), negative pole false and positive pole true (e.g. mania), negative pole true and positive pole false (e.g. depression); and bipolar true or equilibrium. $\forall(x,y),(u,v)\in B_1$, we have Eq. (1)-(12) that form a bipolar dynamic logic (BDL) [30][31].

Complement: $\neg(x,y)\equiv(-1,1)-(x,y)\equiv(\neg x,\neg y)\equiv(-1-x,1-y)$. (2)

Logical Negation (Implication):

$$(x,y)\Rightarrow(u,v)\equiv(x\rightarrow u,y\rightarrow v)\equiv(\neg x\vee u, \neg y\vee v). \quad (3)$$

Arithmetic Negation: $-(x,y)\equiv(-y,-x)$. (4)

In addition to (1)-(4) we have eight dynamic operators:

Bipolar least upper bound (blub):

$$blub((x,y),(u,v))\equiv(x,y)\oplus(u,v)\equiv(-(|x|\vee|u|),y\vee v); \quad (5)$$

Bipolar greatest lower bound (bglb):

$$bglb((x,y),(u,v))\equiv(x,y)\ \&\ (u,v)\equiv(-(|x|\wedge|u|),y\wedge v); \quad (6)$$

Negation of blub:

$$blub^-((x,y),(u,v))\equiv(x,y)\oplus^-(u,v)\equiv(-(y\vee v),(|x|\vee|u|)); \quad (7)$$

Negation of bglb:

$$bglb^-((x,y),(u,v))\equiv(x,y)\&^-(u,v)\equiv(-(y\wedge v),|x|\wedge|u|); \quad (8)$$

Cross-pole greatest lower bound (cglb):

$$cglb((x,y),(u,v))\equiv(x,y)\otimes(u,v) \equiv(-(|x|\wedge|v|\vee|y|\wedge|u|),(|x|\wedge|u|\vee|y|\wedge|v|)); \quad (9)$$

Cross-pole least upper bound (cglb):

$$club((x,y),(u,v))\equiv(x,y)\varnothing(u,v)\equiv(-1,1)-(\neg(x,y)\otimes\neg(u,v)); \quad (10)$$

Negation of cglb:

$$cglb^-((x,y),(u,v))\equiv(x,y)\otimes^-(u,v)\equiv-((x,y)\otimes(u,v)); \quad (11)$$

Negation of club:

$$club^-((x,y),(u,v))\equiv(x,y)\varnothing^-(u,v)\equiv-((x,y)\varnothing(u,v)). \quad (12)$$

Operators $\oplus$ and $\oplus^-$ are ***"balancers"***; & and $\&^-$ are energy ***"minimizers";*** $\varnothing$ and $\otimes$ are intuitive ***"oscillators"***; $\varnothing^-$ and $\otimes^-$ are counter-intuitive "oscillators". A bipolar operator is said ***linearly bipolar equivalent*** to its unipolar counterpart if it doesn't account for cross-pole interaction and its operation on each pole is equivalent to its unipolar counterpart. $\oplus$ and & are linearly bipolar equivalent to $\vee$ and $\wedge$, respectively; $\otimes$ and $\varnothing$ are non-linear (Fig. 3).

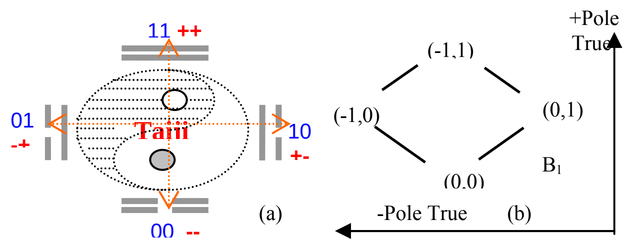

Figure 2. (a) YinYang-4-Images (adapted from [4]); (b) Hasse diagram of B_1 ((adapted from [25])

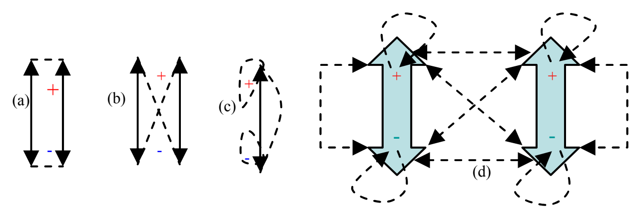

Figure 3. Bipolar Elements: (a) Linear; (b) Cross-pole; (c) Oscillatory; (d) Bipolar Interactive [30]

C. Equilibrium Relations

A bipolar dynamic relation R in X is a (non-linear) bipolar ***equilibrium relation*** [23] if it is (1) bipolar symmetric; (2) positive pole reflexive; and (3) $\oplus$-$\otimes$ transitive (or cross-pole bipolar interactive). It is proved that, given a bipolar relation $R\equiv[r_{ij}]\equiv[(r_{ij}^-, r_{ij}^+)]\equiv([r_{ij}^-],[r_{ij}^+])\equiv(R^-,R^+)$ in a non-empty set X, the following six conditions are ***necessary and sufficient*** for R to be a bipolar equilibrium relation [23][25]: 1) R^+ is an equivalence relation; 2) $|R^-|\cup R^+$ is an equivalence relation; 3) If $(R^+\cap|R^-|)$ isn't null it must be a local equivalence; 4) If $(|R^-|\cup R^+)-(R^+\cap|R^-|)$ isn't null it must be a local equivalence; 5) If $(|R^-|\cup R^+) - |R^-|$ is not null it must be a local equivalence; 6) $R^+ - (R^+\cap|R^-|) \equiv (|R^-|\cup R^+) - |R^-|$. Thus, an equilibrium Relation can be a non-linear bipolar fusion of many equivalence relations that leads to the conjecture of bipolar S5 modality (see Conjecture11, section III).

D. First-Order Syntax and Semantics

A formal BDL doesn't exclude classical logic syntax [30][31]. It extends 1^{st}-order logic with the addition of non-linear bipolar fusion, interaction, oscillation, and inference. A **bipolar tautology** is a bipolar well-formed formula (bwf) whose form makes it always bipolar true (-1,1) regardless of the truth values of its undesignated variables. Both **operator** and **variable instantiations** can be involved in bipolar inference. We use *"IF ($bwf_1 * bwf_2$); THEN ($bwf_3 * bwf_4$)"* to indicate that if bipolar interaction $*$ occurs in the premise between bwf_1 and bwf_2, the same interaction $*$ also occurs in the consequent between bwf_3 and bwf_4. *For notational simplicity, we assume in this work that all bipolar implication in the form $A \Rightarrow B$ is designated bipolar true; any other bwf is not designated.* The variables in a designated bwf are *free but* must collectively satisfy the designation.

E. The Laws of Equilibrium

It has been proved that the laws of excluded middle (LEMs), non-contradiction, and the bipolar DeMorgan's laws in Fig. 4 hold on B_1. The operators &, $\oplus$, $\&^-$, $\oplus^-$, $\otimes$, $\varnothing$, $\otimes^-$, and $\varnothing^-$ are commutative and bipolar monotonic w.r.t. the bipolar partial order ($\geq\geq$) relation (Eq. 1).

Excluded Middle	$(x,y)\oplus\neg(x,y)\equiv(-1,1)$; $(x,y)\oplus^-\neg(x,y)\equiv(-1,1)$;
Non-Contradiction	$\neg((x,y)\&\neg(x,y))\equiv\neg((x,y)\&^-\neg(x,y))\equiv(-1,1)$;
Linear Bipolar DeMorgan's Laws	$\neg((a,b)\&(c,d))\equiv\neg(a,b)\oplus\neg(c,d)$; $\neg((a,b)\oplus(c,d))\equiv\neg(a,b)\&\neg(c,d)$; $\neg((a,b)\&^-(c,d))\equiv\neg(a,b)\oplus^-\neg(c,d)$; $\neg((a,b)\oplus^-(c,d))\equiv\neg(a,b)\&^-\neg(c,d)$;
Non-Linear Bipolar DeMorgan's Laws	$\neg((a,b)\otimes(c,d))\equiv\neg(a,b)\varnothing\neg(c,d)$; $\neg((a,b)\varnothing(c,d))\equiv\neg(a,b)\otimes\neg(c,d)$; $\neg((a,b)\otimes^-(c,d))\equiv\neg(a,b)\varnothing^-\neg(c,d)$; $\neg((a,b)\varnothing^-(c,d))\equiv\neg(a,b)\otimes^-\neg(c,d)$

Figure 4. Bipolar laws

Finding 1: (a) Bipolar universal modus ponens (BUMP) (see Fig. 5) is a bipolar tautology; (b) BUMP is an equilibrium-based non-linear bipolar dynamic generalization of classical modus ponens (MP) with both classical logic and quantum logic aspects that are suitable for both inductive and deductive reasoning in an open-world of dynamic equilibria with bipolar interaction, oscillation, and entanglement.

BUMP: $[(\phi^-,\phi^+)\Rightarrow(\varphi^-,\varphi^+)]\ \&\ [(\psi^-,\psi^+)\Rightarrow(\chi^-,\chi^+)]$
$\Rightarrow[(\phi^-,\phi^+)*(\psi^-,\psi^+)\Rightarrow(\varphi^-,\varphi^+)*(\chi^-,\chi^+)]$.

Two-fold universal instantiation:

1) Operator instantiation: $*$ as a universal operator can be bound to &, $\oplus$, $\&^-$, $\oplus^-$, $\otimes$, $\varnothing$, $\otimes^-$, $\varnothing^-$ or any commutative and bipolar monotonic (w.r.t. $\geq\geq$) operator.
2) Bipolar variable instantiation:
$\forall x, (\phi^-,\phi^+)(x)\Rightarrow(\varphi^-,\varphi^+)(x);\ (\phi^-,\phi^+)(A);\ \therefore\ (\varphi^-,\varphi^+)(A)$.
$\forall x_1,x_2, (\phi^-,\phi^+)(x_1)*(\phi^-,\phi^+)(x_2)\Rightarrow(\phi^-,\phi^+)(x_1*x_2)$.

Figure 5. Bipolar Universal Modus Ponens (BUMP)

Finding 2: (a) The set {BA1-5, BR1 (BUMP)} (see Fig. 6) is zeroth-order sound and complete with respect to $\neg$, &, and $\otimes$; (b) the set {BA1-7, BR1(BUMP), BR2} (see Fig. 6) is first-order sound and complete with respect to $\neg$, &, and $\otimes$; (c) the non-linear bipolar dynamic operators $\otimes$, $\varnothing$, $\otimes^-$, and $\varnothing^-$ are recoverable to Boolean operators $\vee$ or $\wedge$ through depolarization. BDL is recoverable to Boolean logic.

Bipolar Linear Axioms:
BA1: $(\phi^-,\phi^+)\Rightarrow((\varphi^-,\varphi^+)\Rightarrow(\phi^-,\phi^+))$;
BA2: $[(\phi^-,\phi^+)\Rightarrow((\varphi^-,\varphi^+)\Rightarrow(\chi^-,\chi^+))]$
$\Rightarrow(((\phi^-,\phi^+)\Rightarrow(\varphi^-,\varphi^+))\Rightarrow((\phi^-,\phi^+)\Rightarrow(\chi^-,\chi^+)))$;
BA3: $(\neg(\phi^-,\phi^+)\Rightarrow(\varphi^-,\varphi^+))\Rightarrow((\neg(\phi^-,\phi^+)\Rightarrow\neg(\varphi^-,\varphi^+))\Rightarrow(\phi^-,\phi^+))$;
BA4: (a) $(\phi^-,\phi^+)\&(\varphi^-,\varphi^+)\Rightarrow(\phi^-,\phi^+)$; (b) $(\phi^-,\phi^+)\&(\varphi^-,\varphi^+)\Rightarrow(\varphi^-,\varphi^+)$;
BA5: $(\phi^-,\phi^+)\Rightarrow((\varphi^-,\varphi^+)\Rightarrow((\phi^-,\phi^+)\&(\varphi^-,\varphi^+)))$;

BR1: *Bipolar Universal Modus Ponens (BUMP)*
IF $((\phi^-,\phi^+)*(\psi^-,\psi^+))\&[((\phi^-,\phi^+)\Rightarrow(\varphi^-,\varphi^+))\&((\psi^-,\psi^+)\Rightarrow(\chi^-,\chi^+))]$,
THEN $((\varphi^-,\varphi^+)*(\chi^-,\chi^+))$;

Bipolar Predicate axioms and Rules of inference
BA6: $\forall x,(\phi^-(x),\phi^+(x))\Rightarrow(\phi^-(t),\phi^+(t))$;
BA7: $\forall x,((\phi^-,\phi^+)\Rightarrow(\varphi^-,\varphi^+))\Rightarrow((\phi^-,\phi^+)\Rightarrow\forall x,(\varphi^-,\varphi^+)$;
BR2-Generalization: $(\phi^-,\phi^+)\Rightarrow\forall x,(\phi^-(x),\phi^+(x))$

Figure 6. Bipolar axioms and inference rules

III. YinYang Bipolar Relativity

The significance of bipolar elements and sets lies in their equilibrium-based semantics for agent-oriented bipolar interactions where an agent could be physical or social, microscopic or macroscopic, autonomous or nonautonomous.

A. Agents

By commonsense any physical existence must be in certain form of bipolar equilibrium or non-equilibrium. Therefore, we say something A **exists** iff $\exists\varphi\ \{\varphi(A)\in B_1\ \&\ \varphi(A)\neq(0,0)\}$. An **agent** is any physical existence. A **primitive agent** is an agent for which there is only a single φ under consideration such that $\{\varphi(A)\in B_1\ \&\ \varphi(A)\neq(0,0)\}$. Any other agent is a ***non-primitive agent***. Thus, any non-primitive agent is in a multidimensional equilibrium.

Since any agent exists in at least one bipolar equilibrium state, **an agent is bipolar** from an equilibrium-based perspective. Thus, we are all bipolar, in bipolar equilibrium or in disorder. While an electron (–Q,0) or positron (0,+Q) or the binding (-Q,+Q) can be considered a **primitive agent**, a person with or without bipolar disorder isn't primitive because there are other bipolar equilibria involved besides (self-negation, self-assertion) such as (reaction, action). Similarly, the universe is not a primitive agent because it is a multidimensional equilibrium or non-equilibrium such as (reaction, action), (antimatter, matter), and other dimensions. Evidently, a multidimensional equilibrium can be decomposed into a number of bipolar equilibria.

We say an agent A is **adaptive** iff A has either self-negation ability or self-assertion ability or both and A can regain at least one type of bipolar equilibrium state. Formally, let φ=(self-negation, self-assertion)$\in B_1$ be a bipolar predicate, A is adaptive iff $\varphi(A)\neq(0,0)$ and A exhibits both bipolar fusion ($\oplus$) and interaction ($\otimes$) functionalities such that:

1) if $\varphi(A)=(-1,0)$, A exhibits self-adaptivity:
$$\varphi(A)\oplus[\varphi(A)\otimes\varphi(A)]=(-1,1); \quad (13)$$
2) if $\varphi(A)=(0,1)$, A exhibits assisted adaptivity with external input (-1,0):
$$\varphi(A)\oplus[\varphi(A)\otimes(-1,0)]=(-1,1); \quad (14)$$

Eq. (13) typically characterizes a depressed person who temporarily lost self-assertion ability but is self-adaptive to mental equilibrium as long as whose bipolar fusion (⊕) and bipolar oscillation (⊗) neurobiological functionalities are intact. Thus, clinical mental depression could be diagnosed as the loss of bipolar fusion (⊕) or bipolar interaction (⊗) *functionalities. This interpretation is also supported by a* Traditional Chinese Medicine principle which states Yin (-) produces Yang (+) but not vice versa.

Eq. (14) typically characterizes a manic person who temporarily lost self-negation ability but is able to recover to mental equilibrium with a medical intervention characterized with (-1,0). The recovery is possible because the patient's bipolar fusion (⊕) and bipolar interaction (⊗) functionalities responded to the medical intervention. Thus, clinical mental mania could also be diagnosed as the loss of bipolar fusion (⊕) or bipolar interaction (⊗) functionalities.

A **logical agent** can be defined as an agent whose behavior is strictly governed by Boolean logic. A **bipolar agent** can be defined as an agent whose behavior is governed by BDL. With these definitions, a logical agent is not adaptive to bipolar equilibrium; an adaptive agent is not strictly logical. This may sound ironic but it is commonsense. For instance, a computer is strictly logical but by no means adaptive to mental equilibrium even being programmed because it does not have a biological mind. On the other hand, a normal person is biologically adaptive to mental equilibrium but can by no means be strictly logical like a computer.

Two bipolar sets X and Y are **physically bipolar interactive** if, $\forall x \in X$ and $\forall y \in Y$, x and y are physically bipolar interactive denoted $x \blacklozenge y$. Two bipolar predicates $\varphi(x) \in B_1$ *and* $\phi(y) \in B_1$ are **logically bipolar interactive** denoted $\varphi(x)*\phi(y)$ iff x and y are either physically bipolar interactive ($x \blacklozenge y$) or logically bipolar interactive ($x*y$). The following hold on bipolar agent interactivity:

1) $\forall x,y,\ [(\varphi^-,\varphi^+)(x)*(\phi^-,\phi^+)(y)] \rightarrow [(x \blacklozenge y) \vee (x*y)]$;
2) $\forall x,y,\ x \blacklozenge y,\ [(\phi^-,\phi^+)(x)*(\phi^-,\phi^+)(y)] \Rightarrow (\phi^-,\phi^+)(x \blacklozenge y)$;
3) $\forall x,y,\ x*y,\ [(\phi^-,\phi^+)(x)*(\phi^-,\phi^+)(y)] \Rightarrow (\phi^-,\phi^+)(x*y)$;
4) $\forall x,y \in B_1,\ (x \blacklozenge y) \equiv (x*y)$.

Bipolar physical interaction can be chemical, biological, organizational, or any type. Physical interaction may lead to **scalability** with composition or decomposition.

B. Bipolar Relativity

BDL so far did not take time and space dimensions into consideration. Since the universal operator ∗ in BUMP is symmetrical and presents in both the premise and the consequent, **bipolar relativity** can be embedded in BUMP and BDL can be naturally extended to a temporal logic with time and space dimensions.

Let $\psi = (\psi^-,\psi^+)$, $\phi = (\phi^-,\phi^+)$, $\chi = (\chi^-,\chi^+)$, and $\varphi = (\varphi^-,\varphi^+)$ be any bipolar predicates; let $a(t_1,p_1), b(t_1,p_2), c(t_2,p_3), d(t_2,p_4)$ be any bipolar agents where a(t,p) stands for "agent a at time t and space p" where t_x and t_y can be the same or different points in time and p_x and p_y can be the same or different points in space, BUMP with time and space dimensions is shown in Eq. (15). Based on Eq. (15), an agent without time and space is assumed at any time t and space p that is more general. An agent at time t and space p is therefore more specific. However, time and/or space can be omitted in some discussion for simplicity without loosing generality.

$$\forall a,b,c,d,\ [\psi(a(t_x,p_1)) \Rightarrow \chi(c(t_y,p_3))] \& [\phi(b(t_x,p_2)) \Rightarrow \varphi(d(t_y,p_4))] \Rightarrow [\psi(a(t_x,p_1))*\phi(b(t_x,p_2)) \Rightarrow \chi(c(t_y,p_3))*\varphi(d(t_y,p_4))]. \quad (15)$$

Based on general relativity, gravity "travels" at the speed of light and the effect of a disturbance to the Sun (S) would take 499 seconds to reach the Earth (E). Let f(S)=f(E)=(-f,f)(S)=(-f,f)(E) be the bilateral gravitational (reaction, action) forces between S and E; let time t be in seconds; let p_1 and p_2 be points for S and E, respectively; let (0,0)(S) be the hypothetical Sun's vanishment; we have

$$[f(S(t,p_1)) \Rightarrow f(E(t+499,p_2)] \Rightarrow [f(S(t,p_1)) \blacklozenge (0,0)) \Rightarrow f(E(t+499,p_2)) \blacklozenge (0,0)]. \quad (16)$$

If f() is normalized to a bipolar predicate, ♦ can be replaced with ∗, and the binding of &, $\&^-$, ⊗, $\otimes^-$, ∅, or $\varnothing^-$ to ∗ in Eq. (16) would lead to the vanishment of the Sun and then the disappearing of the Earth from its orbit after 499 seconds. Thus, bipolar equilibrium/non-equilibrium and general relativity are unified under bipolar relativity.

C. Bipolar Causality

Following the critique on Aristotle's principle of causality by D. Hume [14], L. A. Zadeh has continued the line of criticism and become the strongest critic on the causality principle in modern times [17]. A major argument of Zadeh has been "*Causality is Undefinable*" [17]. From a bivalent static truth-based logical point of view, causality is indeed undefinable. For instance, following classical modus ponens (MP) we have "IF A→B and A, THEN B", where action and causality have no position. From an equilibrium or non-equilibrium-based dynamic point of view, however, BUMP has led to perfectly definable bipolar causality as shown in Eq. (15) and (16). *(Note: The author acknowledges L. A. Zadeh for being the first authority to recognize bipolar fuzzy sets in Scholarpedia [18].)*

With bipolar causality we have the questions: *"If the 'big bang' theory is valid, what caused it to happen? Could it be caused by equilibrium or non-equilibrium?" "Did singularity* [16] *come first or did bipolarity come first?"* Evidently, the consequence of bipolar relativity and bipolar causality is fundamentally far reaching.

D. Axioms and Conjectures

Based on bipolar agents and bipolar relativity, we extend the six conjectures in [30] to nine axioms and 16 conjectures in physical, social, and life sciences.

Axiom1. Let $\psi = (\psi^-,\psi^+)$ = (self-negation, self-assertion) be a bipolar predicate for the mental equilibrium measures of a patient set P at the neurophysiologic level; let (χ^-,χ^+) be that of the set P at the mood or behavior level; let $\phi = (\phi^-,\phi^+)$ = (negative, positive) be a bipolar predicate for the biochemical capacities of a medicine set M for bipolar disorders; let (φ^-, φ^+) = (un-excite, un-depress) be that for the effects of M at the mental level. $\forall a,b,\ a \in P$ and $b \in M$,

$$[(\psi(a(t_x)) \Rightarrow \chi(a(t_y)))] \& [(\phi(b(t_x)) \Rightarrow \varphi(b(t_y)))] \Rightarrow [(\psi(a(t_x))*\phi(b(t_x))) \Rightarrow (\chi(a(t_y))*\varphi(b(t_y)))].$$

Conjecture1. Axiom1 is a fundamental law for equilibrium-based brain and behavior of bipolar disorder patients, which can be applied in nanobiomedicine for psychiatric mood regulation on an individual and/or a cohort of mental disorder patients.

Axiom2. Let $\psi = (\psi^-,\psi^+)$ = (negative, positive) be a bipolar predicate and a,b,c,d be any four YinYang bipolar subatomic particles that can change polarity trillions of times a second [6]. $\forall$a,b,c,d, we have:

$$[(\psi(a(t_x,p_1))\Rightarrow\psi(c(t_y,p_3)))\&(\psi(b(t_x,p_2))\Rightarrow\psi(d(t_y,p_4)))]$$
$$\Rightarrow[(\psi(a(t_x,p_1))*\psi(b(t_x,p_2)))\Rightarrow(\psi(c(t_y,p_3))*\psi(d(t_y,p_4)))]$$
$$\Rightarrow[\psi(a(t_x,p_1)\blacklozenge b(t_x,p_2))\Rightarrow\psi(c(t_y,p_3)\blacklozenge d(t_y,p_4))].$$

Conjecture 2. Axiom2 can be implemented as bipolar quantum mechanics for quantum computation, communication, and nano-biomedicine based on bipolar entanglement (Finding 1) and depolarization (Finding 2).

Axiom3. Let $\psi=(\psi^-,\psi^+)$=(repression, activation) be a bipolar predicate for the abilities of regulator genetic agents [10] such as YY1 [7]; let $\phi=(\phi^-,\phi^+)$=(repressability, activatability) be a predicate for the bipolar capacities of regulated genetic agents; let (χ^-,χ^+) and (φ^-,φ^+) be any bipolar predicates; let a,b,c,d be any agents. We have the laws in Fig. 7.

Conjecture 3. Axiom 3 is a fundamental law for equilibrium-based gene binding, mutation, and regulation.

Axiom4. Let $\psi = (\psi^-,\psi^+)$ = (negative, positive) be a bipolar predicate and a,b,c,d be any four antimatter and/or matter bindings. $\forall$*a,b,c,d,* we have:

$$[(\psi(a(t_x,p_1))\Rightarrow\psi(c(t_y,p_3)))\ \&\ (\psi(b(t_x,p_2))\Rightarrow\psi(d(t_y,p_4)))]$$
$$\Rightarrow[(\psi(a(t_x,p_1))*\psi(b(t_x,p_2)))\Rightarrow(\psi(c(t_y,p_3))*\psi(d(t_y,p_4)))]$$
$$\Rightarrow[(\psi(a(t_x,p_1)\blacklozenge b(t_x,p_2))\Rightarrow(\psi(c(t_y,p_3)\blacklozenge d(t_y,p_4))].$$

Conjecture4. Axiom 4 is an equilibrium-based fundamental law for scientific discovery in astrophysics.

Axiom5. Similar to Axiom3, let $\psi = (\psi^-,\psi^+)$ = (inhibition, stimulation) be a predicate for the bipolar abilities of an economic intervention; let $\phi = (\phi^-,\phi^+)$ = (inhibitability, stimulatability) be a predicate for the bipolar capacities of economic agents; let (χ^-,χ^+) and (φ^-,φ^+) be any bipolar predicates; let a,b,c,d be any economic agents. We have the laws in Fig. 7.

Conjecture5. *Axiom5 is a fundamental law in equilibrium-based regulation and intervention in macroeconomics.*

Axiom6. Similar to Conjectures 3, let $\psi = (\psi^-,\psi^+)$ = (pollution-decrease, pollution-increase) be a predicate for the bipolar abilities of an environment policy; let $\phi = (\phi^-,\phi^+)$ = (protectability, polutability) be a predicate for the bipolar capacities of an environment; let (χ^-,χ^+) and (φ^-,φ^+) be any bipolar predicates; let a,b,c,d be any environmental agents. We have the laws on global warming in Fig. 7.

$\forall$a,b,c,d,

1) $[\psi(a(t_x,p_1))\Rightarrow\phi(c(t_y,p_3))]\&[\psi(b(t_x,p_2))\Rightarrow\phi(d(t_y,p_4))]$
$\Rightarrow[\psi(a(t_x,p_1))*\psi(b(t_x,p_2))\Rightarrow\phi(c(t_y,p_3))*\phi(d(t_y,p_4))]$
$\Rightarrow[\psi(a(t_x,p_1)\blacklozenge b(t_x,p_2))\Rightarrow\phi(c(t_y,p_3)\blacklozenge d(t_y,p_4))];$

2) $[\psi(a(t_x,p_1))\Rightarrow\psi(c(t_y,p_3))]\&[\phi(b(t_x,p_2))\Rightarrow\phi(d(t_y,p_4))]$
$\Rightarrow[\psi(a(t_x,p_1))*\phi(b(t_x,p_2))\Rightarrow\psi(c(t_y,p_3))*\phi(d(t_y,p_4))]$

Figure 7. Equilibrium and non-equilibrium in genomics

Conjecture6. *Axiom6 is an equilibrium-based fundamental law in environmental protection and regulation."*

Axiom7. Let $\psi = (\psi^-,\psi^+)$ = (competition, cooperation) be a predicate for the relation between two agents, let A_1, A_2, A_3, A_4, A_5, A_6, A_7, and A_8, be any agents. $\forall$ A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, we have:

$$[\psi(A_1,A_2)\Rightarrow\psi(A_3,A_4)]\&[\psi(A_5,A_6)\Rightarrow\psi(A_7,A_8)]$$
$$\Rightarrow\{[\psi(A_1,A_2)*\psi(A_5,A_6)]\Rightarrow[\psi(A_3,A_4)*\psi(A_7,A_8)]\}$$
$$\Rightarrow\{\psi[(A_1,A_2)\blacklozenge(A_5,A_6)]\Rightarrow\psi[(A_3,A_4)\blacklozenge(A_7,A_8)]\}.$$

It is interesting to notice that the physical interaction operator ♦ in this case performs a physical reorganization of the involved agents into new coalition, harmony, or conflict sets (see Section II.c).

Conjecture7. *Axiom7 is a fundamental law for equilibrium-based coordination of multiagent cooperation and competition.*

Axiom8. Let $\psi = (\psi^-,\psi^+)$ = (yin, yang) be a bipolar predicate in traditional Chinese medicine (TCM); let a,b,c,d be any bipolar agents in TCM. $\forall$*a,b,c,d,* we have:

$$[\psi(a(t_x,p_1))\Rightarrow\psi(c(t_y,p_2))]\&[\psi(b(t_x,p_1))\Rightarrow\psi(d(t_y,p_2))]$$
$$\Rightarrow[\psi(a(t_x,p_1))*\psi(b(t_x,p_1))\Rightarrow\psi(c(t_y,p_2))*\psi(d(t_y,p_2))]$$
$$\Rightarrow[\psi(a(t_x,p_1)\blacklozenge b(t_x,p_1))\Rightarrow\psi(c(t_y,p_2)\blacklozenge d(t_y,p_2))].$$

Conjecture8. Axiom8 is an equilibrium-based fundamental law for TCM.

Axiom 9. Let $\psi = (\psi^-,\psi^+)$, $\phi = (\phi^-, \phi^+)$, $\chi = (\chi^-,\chi^+)$, and $\varphi = (\varphi^-,\varphi^+)$ be any bipolar predicates; let a,b,c,d be any bipolar agents in physical and social sciences. $\forall$*a,b,c,d,* we have:

$$[\psi(a(t_x,p_1))\Rightarrow\chi(c(t_y,p_3))]\&[\phi(b(t_x,p_2))\Rightarrow\varphi(d(t_y,p_4))]$$
$$\Rightarrow\{[\psi(a(t_x,p_1))*\phi(b(t_x,p_2))]\Rightarrow[\chi(c(t_y,p_3))*\varphi(d(t_y,p_4))]\}.$$

Conjecture9. All equilibrium-based bipolar fusion, interaction, oscillation, and quantum entanglement in microscopic and macroscopic worlds satisfy Axiom9.

"Can physics be axiomatized?"

Conjecture10. The bipolar aximatization (Fig. 6) is the most primitive (with minimal semantics) and most general (domain independent) equilibrium-based axiomatization of agents and agent interaction in physics, life science and socioeconomics; any other less primitive axiomatization with added semantics (such as space, time, mass, and energy) must necessarily be less general (or more domain-specific).

While classical S5 modality relies on a single static equivalence relation, a bipolar equilibrium relation is a nonlinear bipolar dynamic fusion of multiple equivalence relations (Section II). The non-linearity makes bipolar S5 modality particularly intriguing and challenging.

Conjecture11. Bipolar S5 modality is a logical and physical reality or modern Platonic bipolar reality [29] in an open world of dynamic equilibria or non-equilibria of multiagent systems with or without supersymmetry.

IV. Bipolar Strings

Fundamentally different from string theory or *"theory of everything"* [15], bipolar relativity provides the logical and physical bindings for the "strings" of the universe but retains the open-world non-linear dynamic property of nature tailored for open-ended exploratory scientific discovery. While string theory is far from observable reality, the nonlinear dynamic property of bipolar relativity does not compromise the law of excluded middle (Fig. 4) - a unique basis for a scalable and observable bipolar string theory.

Since (-1,0) ⊗ (-1,0) = $(-1,0)^2$ = (0,1) and (-1,1)⊗(-1,1) = $(-1,1)^2$ = (-1,1), $(-1,0)^n$ defines an oscillatory non-equilibrium and $(-1,1)^n$ defines a non-linear dynamic equilibrium (Fig. 3). Such properties provide a unifying logical representation for particle-wave duality. For instances, $\phi(P)(f)=(-1,0)^n(3\times 10^{12})$ can denote that "particle P changes polarity three trillion times per second"; $\phi(P)(f)=(-1,1)^n(3\times 10^{12})$ can denote that "The two poles of P interact three trillion times per second."

As strings can be one-dimensional oscillating lines or points [15], a ***bipolar string*** can be defined as an elementary bipolar agent e and characterized as $\phi(e)(f)(m)$ where $\phi(e)\in B_1$, f is frequency of bipolar interaction or oscillation, and m is mass. If e is massless we have m = 0. The two poles of e as ***negative*** and ***positive strings*** are non-exclusive, reciprocal, entangled, and inseparable. Thus, bipolar strings cannot be dichotomy and is a non-linear dynamic unification of singularity, bipolarity, and particle-wave duality.

Conjecture12. Bipolar strings are the ***makings of bipolar relativity*** and ***bindings of nature.***

Conjecture13. Gravitational and electromagnetic fields are formed with bipolar strings.

Conjecture14. Bipolar strings are ***scalable***; observable real world bipolar dynamic equilibria (e.g., (-f, f) and (-q, q)) are ***large scale bipolar strings***.

Conjecture15. Singularity, general relativity, electromagnetism, quantum mechanics, bioinformatics, and socioeconomics are different ***phenomena of bipolar relativity***.

Conjecture16. Microscopic and macroscopic agent interactions in physics, socioeconomics, and life science are directly or indirectly caused and regulated by bipolar relativity.

V. Equilibrium-Based Holistic Science

While the word "YinYang" has appeared in many scientific articles in prestigious journals including *Science*, *Nature*, and *Cell*, some researchers still tend to shun "YinYang" due to misunderstanding. Actually YinYang is unavoidable because: (1) The YinYang1 (YY1) regulator protein [7] is ubiquitous in biological systems; (2) YinYang is about equilibrium and without equilibrium there would be no universe; (2) The legendary German mathematician Leibniz [13] invented binary numeral system [12] in the 17th century and attributed his invention to YinYang trigrams (Fig. 2(a)) as recorded in *Yi Jing* (or *I Ching)* [4], now binary numeral system is a basis for all digital technologies. By his invention and attribution not only did Leibniz exhibit unprecedented creativity of a great mathematician but also exemplar academic integrity. To most Chinese and western YinYang scholars, however, it is well-known that the binary interpretation by Leibniz is only one of two or more major interpretations [29][34]. According to the Daoist cosmology YinYang stands for *"everything has two sides or two poles."* We have to ask the honest question *"What would be the consequence if YinYang is interpreted as the two opposite poles of nature such as (-f, +f), (-q, +q), and (antimatter, matter)?"*

The answer is an ***equilibrium-based holistic science*** complementary to western science. As *"passion for symmetry"* can *"permeate the Standard Model of elementary particle physics"* and can unify *"the smallest building blocks of all matter and three of nature's four forces in one single theory"* [9], it is not only reasonable but also inevitable to explore YinYang bipolar holistic science for unifying physics, socioeconomics, and life science including TCM.

Many wonder whether TCM is science. Since without equilibrium at the system, genetic, and molecular levels any mental or physical disorder would be "big bang" from nowhere, TCM can be considered part of equilibrium-based holistic natural medicine. With the holistic science, YinYang equilibrium and harmony can remain a central theme in TCM that does not have to fit completely into western medicine and lose its philosophical identity.

While many efforts lay ahead, early development of the theory has been applied by many researchers in cognitive mapping, decision analysis, and neurobiological modeling [2][20][21-23][27-28]. Later development has led to bipolar mathematics and information technology for modern bioinformatics and TCM [30-33].

VI. Conclusions

YinYang bipolar relativity and a real world bipolar string theory have been introduced. The significance of this work lies in its ***equilibrium-based open-world open-ended unification*** of nature, life science, and socioeconomics as well as general relativity, electromagnetism, quantum mechanics, causality, and agent interaction.

Nine axioms and 16 conjectures have been posted. Conjectures 1-9 are "speculative" only in physical terms not in mathematical terms because they are based on the nine axioms which are bipolar tautologies derived from BUMP. Conjectures 10-16 as domain-independent propositions span both charted and uncharted territories of nature and science. The axioms and conjectures provide guidelines for exploratory scientific discoveries on agent interaction, coordination, and global regulation in microscopic and macroscopic, autonomous and non-autonomous, social and physical worlds [2][8][11][19-33].

Evidently, to remain an equilibrium-based logical space the bipolar lattice $B_1=\{-1,0\}\times\{0,1\}$ can no longer be further reduced. In contrast, to remain a truth-based logical space the bivalent lattice {0,1} can no longer be further reduced. Therefore, bivalent logic can be deemed the minimal but most general truth-based system; BDL can be considered the minimal but most general equilibrium-based logic. Without bipolarity, however, the truth values 0 and 1 are incapable of carrying any direct physical syntax and semantics. A truth-based model, therefore, cannot avoid the LAFIP or LAFIB paradox [30] that could be the reason why there is so far no truth-based axiomatization for physics.

Hilbert stated [3]: *"If geometry is to serve as a model for the treatment of physical axioms, we shall try first by a small number of axioms to include as large a class as possible of physical phenomena, and then by adjoining new axioms to arrive gradually at the more special theories. … The mathematician will have also to take account not only of those theories coming near to reality, but also, as in geometry, of all logically possible theories. He must be always alert to obtain a complete survey of all conclusions derivable from*

the system of axioms assumed." It is interesting to make the following observations:

1) YinYang coordinate is a generic dimensional model in Hilbert space (Fig. 1-3) and bipolar relativity is a continuation of Hilbert's geometric approach to his Problem 6.
2) The axiomatization (Fig. 6) is based on the syntactic approach to proof theory in Hilbert style. With *"a small number of axioms"* it does *"include as large a class as possible of physical phenomena."*
3) Bipolar relativity does *"take account not only of those theories coming near to reality, but also, as in geometry, of all logically possible theories"* such as general relativity, string theory, quantum physics, global economy, global warming, genomics, and computational neuroscience that were undeveloped yet at Hilbert's era.

With these observations it can be concluded that YinYang bipolar relativity constitutes an axiomatization of physics – an equilibrium-based partial but most general solution to Hilbert's Problem 6.

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Endnote: *It is common knowledge in computer/cognitive science that without semantics there would be no need for syntax and without syntactic representation there would be no semantic processing. Thus, without (-,+) bipolar syntax and semantics it would be virtually impossible to reason on (-,+) bipolarity. In logic and mathematics, however, it is often said that "-1 is isomorphic to +1, the 2nd quadrant is isomorphic to the 1st, and using (-,+) bipolarity as part of a new logic is unscientific." Ironically, no physicist would say "electron is isomorphic to positron"; no physician or economist would say "depression is isomorphic to mania"; no logician and mathematician would be willing to ask their children to learn math without the negative sign; no philosopher would say "Yin is isomorphic to Yang"; no electrical engineer would use "+,+" to label the two poles of a battery. Someone has to wonder whether the above so-called "isomorphism" is "a scientific principle" that enhances the strictness of science or "a kind of entrenched noble hypocrisy" that hinders the development of new mathematical foundations for scientific computation and discovery.*