

Mathematical 4th Crisis: to Reality

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Abstract: There are 3 crises in the development of mathematics from its internal, and particularly, the 3th crisis extensively made it to be consistency in logic, which finally led to its more and more abstract, but getting away the reality of things. It should be noted that the original intention of mathematics is servicing other sciences to hold on the reality of things but today's mathematics is no longer adequate for the needs of other sciences such as those of theoretical physics, complex system and network, cytology, biology and economy developments change rapidly as the time enters the 21st century. Whence, a new crisis appears in front of mathematicians, i.e., *how to keep up mathematics with the developments of other sciences?* I call it the 4th crisis of mathematics from the external, i.e., the original intention of mathematics because it is the main topic of human beings.

Key Words: Mathematical crisis, reality, contradiction, TAO TEH KING, mathematical universe hypothesis, Smarandachely denied axiom, Smarandache multispace, mathematical combinatorics, traditional Chinese medicine.

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§1. Introduction

As we known, one or the main function of mathematics in science is it can establish exact mathematical expressions for scientific models on things. Certainly, a theory can not be without the practice, and it can be only from the practice. By this view, the creating source of mathematics can be only from solving problems appeared in practice of human beings, and then move its method and technique upward a mathematica theory for understanding the reality of things in the world.

Usually, a thing is complex, even hybrid with other things sometimes. Then, *what is the reality of a thing?* The reality of a thing is its state of existed, exists, or will exist in the world,

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independent on the understanding of human beings, which implies that the reality holds on by human beings maybe local or gradual, not the reality of a thing. Hence, to hold on the reality of things is the main objective of science in the history of human development.

But, *a mathematical conclusion really reflects the reality of a thing?* The answer is not certain because the practice of human beings shows the mathematical conclusion do not correspond to the reality of a thing sometimes, for instance the *Ames Room*. Usually, the understanding of a thing is by observation of human beings, which is dependent on the observable model, data collection by scientific instruments with data processing by mathematics. Such an observation brings about a unilateral, or an incomplete knowledge on a thing. In this case, the mathematical conclusion reflects partial datum, not all the collection, and in fact, all collection data (by different observers with different model) with data processed is not a mathematical system, even with contradictions in usual unless a data set, which implies that there are no mathematical subfields applicable.

We all know that it appeared 3 crises in mathematical development. In each time, mathematics itself was enriched, improved and completed. However, along with the solving process of the 3th mathematical crisis, the trend of mathematical developing in 19th and 20th centuries shows that a mathematical system is more concise, and its conclusion is more extended, then farther to the reality of things because it abandons more and more characters of things. Besides, more and more researchers only pay attention on questions or problems in himself branch along with the mathematical branch divided, and few peoples consider his research whether is or not valuable for developing the whole mathematics, for understanding the nature and beneficial to human progress, which finally results in mathematics father to the practice of human beings, weaker for hold on the true face of things in the world.

As the time enters the 21st century, science developments change rapidly, and meanwhile, a few global questions constantly emerge, such as those of local war, food safety, epidemic spreading network, environmental protection, multilateral trade dispute, more and more questions accompanied with the overdevelopment and applying the internet, ..., etc. Clearly, today's mathematics is no longer adequate for the needs of other sciences. It is far falling behind the development of society. A new crisis appears in front of mathematicians, i.e., *how to keep up mathematics with the developments of other sciences for hold on the reality of things?* I think this is a big and more important problem in the development of mathematics in the 21th century, and call it the *mathematical 4th crisis* because holding on the reality of things is the central objective of human beings.

The main purpose of the review is analyzing this crisis and points out the way of one how to out this crisis by establishing new mathematical theory, also provides an envelope theory, i.e., *mathematical combinatorics* as the candidate for the way.

§2. Be Understood or Not

For reality of things, an elementary but fundamental question should be answered first. That is, *can one really holds on the reality of things?* For this question, there are two but quite opposite answers. One is the reality of things can not completely understanding, i.e., one can

only holds on the approximate reality of things. Another is one can finally understanding the reality of all things, i.e., *Theory of Everything*. We respectively discuss them following.

Not Understood. There is a well-known philosophical book: *TAO TEH KING* written by an ideologist *Lao Zi* in ancient China. In this book, it discussed extensively on the relation of *TAO*, a more general object than the reality with name and things, and shown in its first but central chapter ([8]):

The Tao that experienced is not the eternal Tao;
 The Name named is not the eternal Name;
 The unnamable is the eternally real and naming is the origin of all particular things;
 Freely desire, you realize the mystery but caught in desire, you see only the manifestations;
 The mystery and manifestations arise from the same source called darkness;
 The darkness within darkness, the gateway to all understanding.

For explaining the relation of Tao with knowing ability of human beings respectively in his Chapter 42:

Tao gives birth to One, One gives birth to Two, Two gives birth to Three and Three gives birth to all things;

All things have their backs to the female and stand facing the male. When male and female combine, all things achieve harmony.

and also in Chapter 25:

Human beings follow the earth, Earth follows the universe,
 The universe follows the Tao and the Tao follows only itself.

By the view of Lao Zi, the reality of things is not understood because the Tao that experienced is not the eternal Tao, the Name named is not the eternal Name, and human beings is born after Three along with Three gives birth to all things, particularly, the reality. I agree Lao Zi's notion, i.e., it is difficult to know the reality of all things, and all mathematical reality is only approximate reality, not the reality. For Tao, One and Two before Three, we can only analyze their various possibility by science, can not really hold on their true faces.

Be Understood. The notion is the supporting and main trending in scientific community today, i.e., the reality of all things can be understood by human beings and one can finally holds on and become the dominate of the world. Particularly, the physical world is nothing else but a mathematical structure ([12], [13]) by Tegmark Max, a famous Swedish-American physicist and cosmologist in MIT now.

Here, I would like to analyze 2 hypotheses, i.e., the Big Bang and mathematical universe hypothesis on the physical world.

1. Big Bang Hypothesis. The Big Bang model states that the earliest state of the Universe was an extremely hot and dense one, and that the Universe subsequently expanded and cooled, which is based on general relativity following:

Applying his principle of general relativity, i.e. *all the laws of physics take the same form in any reference system* and the equivalence principle, i.e., *there are no difference for physical effects of the inertial force and the gravitation in a field small enough*, Einstein got the equation of gravitational field

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \lambda g_{\mu\nu} = -8\pi GT_{\mu\nu},$$

where $R_{\mu\nu} = R_{\nu\mu} = R_{\mu i \nu}^{\alpha}$,

$$R_{\mu i \nu}^{\alpha} = \frac{\partial \Gamma_{\mu i}^{\alpha}}{\partial x^{\nu}} - \frac{\partial \Gamma_{\mu \nu}^{\alpha}}{\partial x^i} + \Gamma_{\mu i}^{\alpha} \Gamma_{\alpha \nu}^i - \Gamma_{\mu \nu}^{\alpha} \Gamma_{\alpha i}^i,$$

$$\Gamma_{mn}^g = \frac{1}{2} g^{pq} \left(\frac{\partial g_{mp}}{\partial u^n} + \frac{\partial g_{np}}{\partial u^m} - \frac{\partial g_{mn}}{\partial u^p} \right)$$

and $R = g^{\nu\mu} R_{\nu\mu}$.

Combining the Einstein's equation of gravitational field with the cosmological principle, i.e., *there are no difference at different points and different orientations at a point of a universe on the metric $10^4 l.y.$* , Friedmann got a standard model of universe. The metrics of the standard universe are

$$ds^2 = -c^2 dt^2 + a^2(t) \left[\frac{dr^2}{1 - Kr^2} + r^2 (d\theta^2 + \sin^2 \theta d\varphi^2) \right]$$

and

$$g_{tt} = 1, \quad g_{rr} = -\frac{R^2(t)}{1 - Kr^2}, \quad g_{\phi\phi} = -r^2 R^2(t) \sin^2 \theta.$$

The standard model of cosmos finally enables the birth of Big Bang model for the cosmos in thirties of the 20th century, and finally, the NASA's explorer mission WMAP (Wilkinson Microwave Anisotropy Probe) determined the radius of the universe was *13.7 b.l.y* on Big Bang hypothesis.

Mathematical Universe Hypothesis. The mathematical universe hypothesis proposed by Max Tegmark, is a speculative *Theory of Everything*, which claims that *our external physical reality is a mathematical structure* ([12], [13]), i.e., the physical universe is not merely described by mathematics, but is mathematics (specifically, a mathematical structure), which implies the mathematical existence equals to that the physical existence, and all structures that exist mathematically exist physically as well. And observers, including humans ourself, are *self-aware substructures (SASs)*, and in any mathematical structure complex enough to contain such a substructure, it will subjectively perceive itself as existing in a physically real' world.

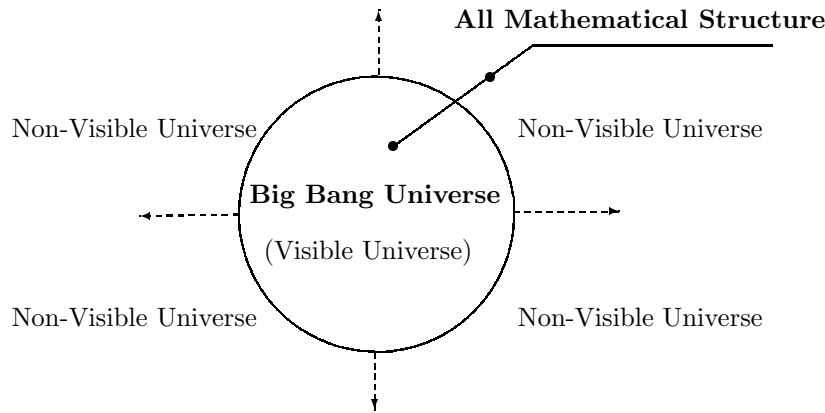


Fig.1

According to Lao Zi's birth ruler, the WMAP is essentially determined the radius of visible universe by human beings is *13.7b.l.y*, but we can not claim the radius of universe is *13.7b.l.y* just by the Big Bang hypothesis. Otherwise, we are in an awkward situation and can not answer what is the outer of the sphere of radius *13.7b.l.y* unless its radius is finite. The advantage of Max Tegmark's hypothesis is it avoids the finite or not of the universe but claims its physical reality is a mathematical structure. These 2 hypotheses are simply shown in Fig.1.

Therefore, the Big Bang hypothesis is only a notion locally on the universe. But why various experimental of human beings verifies it maybe right just because our human beings are after Three, i.e., after the Big Bang by Lao Zi, and the Friedmann's standard model of universe is a special solution of Einstein's gravitational equations, which is essentially to explain the general by special cases. However, we have many solutions on Einstein's gravitational equations, even with constant $\lambda = 0$ ([2]). Certainly, the Max Tegmark's hypothesis is on the whole universe but it also contains lethal deficiency following:

(1) If the Big Bang hypothesis is right, i.e., we can only hold on the reality of the visible universe, how can we verify the external universe, i.e., non-visible universe is mathematics or not;

(2) *Is our mathematical theory can already be used for understanding the reality of all things in the world?* The answer is not certain because mathematics is homogenous without contradictions, i.e. a compatible one in logic but contradictions exist everywhere in the world by philosophy. Thus, the reality known by mathematics on things can be only a subset of the reality set ([4], [5]), i.e., the mathematical structure is not equal to the physical reality.

All of these show that even if the Big Bang and Max Tegmark's hypotheses are both right, we also need to establish a new mathematical theory so that the mathematical structure is equal to the physical reality, i.e., a mathematical crisis is confronted with mathematicians.

§3. Mathematical Crisis in 21th Century

3.1 Brief Review 3 Crises of Mathematics in History

As we known, there are 3 crises in the development of mathematics following, each of them motivates mathematics itself constantly enriched, improved and completed..

First Crisis. The early Pythagorean mathematics was based on the so-called *commensurability principle*, i.e., Pythagorean's assertion: "*everything is a number*". According to this principle two geometric values Q and V have common measure, divisible by it, i.e., their ratio can be expressed as the ratio of the relative prime numbers m and n . However, Hippasu, a member of Pythagorean's found the length of the diagonal of a unit square is $\sqrt{2}$, which can not be as a ratio of two relative prime numbers, i.e., it is an irrational number. This discovery became a *turning point* in mathematics development, which ruined the former system of Pythagoreans, extended the rational to real numbers and finally resulted in new mathematical theories.

Second Crisis. Even at present, calculus is a subject with the most widely applying

to other science for hold on reality of things. However, its foundations refers to the rigorous development of the subject in its early time. The cause was the unrigorous use of infinitesimal quantities in that time, which resulted in the second crisis of mathematics, i.e., the foundation of calculus. Certainly, there are many mathematicians work hard for going out this crisis, formed new mathematical theories. For example, the limitation of Weierstrass eventually became common of calculus base, instead of infinitesimal quantities as the rigorous approach, and established real analysis which included full definitions, theorems with rigorous proof of calculus.

Third Crisis. The third crisis of mathematics came from the foundation of mathematics, i.e., set theory by Russell paradox following:

Let R be the set of all sets that are not members of themselves. If R is not a member of itself, then its definition dictates that it must contain itself, and if it contains itself, then it contradicts its own definition as the set of all sets that are not members of themselves, i.e.,

$$R = \{x | x \notin x\}, \text{ then } R \in R \Leftrightarrow R \notin R.$$

Russell paradox finally resulted in the establishing of axiomatic set theory, i.e., Russell's type theory and the Zermelo set theory in 1908.

3.2 Mathematical Crisis in 21th Century

The mathematical crisis, or the 4th crisis in 21th century does not come from its internal but in the external needs or in its original intension. As we discussed, the axiomatic and abstract on mathematics in the 19th and 20th centuries finally results in mathematics away from practice. This trend also found by physicists in 20th century. Einstein once complain mathematics: *as far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.* Besides, more and more problems appeared in the practice can not find an applicable mathematics and don't know how to hold on their characters. In fact, there are more examples supporting this claim with social development in 21th century.

Elementary Particle. We have known matters consist of two classes particles, i.e., bosons with integer spin n , fermions with fractional spin $n/2$, $n \equiv 1(\text{mod}2)$, and by a widely held view, the elementary particles consists of quarks, leptons with interaction quanta including photons and other particles of mediated interactions ([6], [7]), which constitute hadrons, i.e., mesons, baryons and their antiparticles.

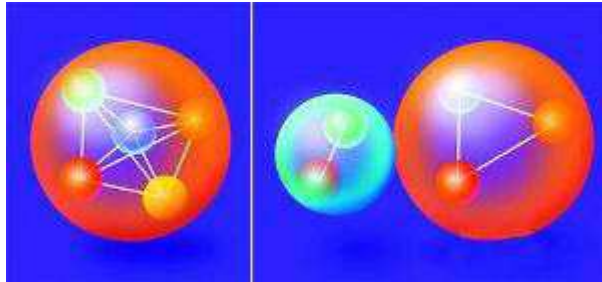


Fig.2

Although quark model is a formal classifying scheme for hadrons, i.e., the quarks and antiquarks of Sakata, or Gell-Mann and Ne'eman, it appeared subconscious in the multiverse interpretation of H.Everett on the superposition of particle. It should be noted that the multiverse interpretation or quark is proposed by physicist for explaining behavior of particles without an applicable mathematics. However, it completely changed the usual notion that a particle is an geometrical point or a subset of space, and opened a new way for understanding the reality of a hadron in notion, i.e., we are not need to insist again that a hadron is a geometrical point or a subset of space such as those of assumptions in determinable science. For example, a baryon is predominantly formed by three quarks, and a meson is mainly composed of a quark and an antiquark in quark models, such as those shown in the right of Fig.2, where a particle consists of 5 quarks can be also found on the left.

Biological Population. The biological populations are dependent each other by food web, i.e., a natural interconnection of food chains and a graphical representation of what-eats-what in an ecological community on the earth. For example, a food chain starts from producer organisms (such as grass or trees which use radiation from the sun to make their food) and end at apex predator species (like grizzly bears or killer whales), detritivores (like earthworms or woodlice), or decomposer species (such as fungi or bacteria). Usually, a model of a biological system is converted into a system of equations. The solution of the equations, by either analytical or numerical means, describes how the biological system behaves either over time or at equilibrium. In fact, a food web is an interaction system in physics which can be mathematically characterized by the strength of what action on what. For a biological 2-system, let x, y be the two species with the action strength $F'(x \rightarrow y)$, $F(y \rightarrow x)$ of x to y and y to x on their growth rate, ([1]). Such a biological 2-system can be quantitatively characterized by differential equations

$$\begin{cases} \dot{x} = F(y \rightarrow x) \\ \dot{y} = F'(x \rightarrow y) \end{cases}$$

on the populations of species x and y . However, this method can be only applied to the small number (≤ 3) of populations in this web. If the number m of populations ≥ 4 , such as those shown birds in Fig.3,



Fig.3

[illegible]

Regional Economy. Today, the regional trade regulation enables each one of his member develops extensively on other members. Achieving mutual benefit, and finally striving for trade balance is the purpose of the regional trade organization. This situation appears both in the global or area economy because there are few countries or areas still in self-sufficient today. The trade surplus and deficit usually result in the trade disputing in members, processes the multilateral negotiations, and then reaches a new regulation for members in the international trade. Usually, one can obtains statistical data published by customs or statistical services in a country or an area, but there are no a mathematical subfield for characterizing the global or local changing in economy.

Why I say it to be the 4th crisis of mathematics? The reason is that mathematics is gradually ignored and replaced by computer simulation in society development. It already become a subject of indulge in self-admiration by mathematician ourselves. If we do not turn it around, it will be abandoned sooner or later by the society finally.

§4. Out of the Crisis

Let us discuss the two things flowing.

1. Smarandache Multispace. Today, we have known a kind of geometry breaking through the non-contradiction in classical mathematics, i.e., *Smarandache geometry* (1969) by introducing a new type axiom for space. An axiom is said to be *Smarandachely denied* if the axiom behaves in at least two different ways within the same space, i.e., validated and invalided, or only invalided but in multiple distinct ways. A Smarandache geometry [10] is a geometry which has at least one Smarandachely denied axiom (1969). If \mathcal{A} is a Smarandache denied axiom on space \mathcal{T} , then all points in \mathcal{T} with \mathcal{A} validated or invalided consist of points sets $T^{H(\mathcal{A})}$ and $T^{N(\mathcal{A})}$, and if it is in multiple distinct ways invalided, without loss of generality, let s be its multiplicity. Then all points of \mathcal{T} are classified into $T_1^{\mathcal{A}}, T_2^{\mathcal{A}}, \dots, T_s^{\mathcal{A}}$. Hence, we get a partition on points of space \mathcal{T} as follow:

$$\mathcal{T} = T^{H(\mathcal{A})} \cup T^{N(\mathcal{A})}, \quad \text{or} \quad \mathcal{T} = T_1^{\mathcal{A}} \cup T_2^{\mathcal{A}} \cup \dots \cup T_s^{\mathcal{A}}.$$

This shows that \mathcal{T} should be a Smarandache multispace.

Generally, let $(\Sigma_1; \mathcal{R}_1), (\Sigma_2; \mathcal{R}_2), \dots, (\Sigma_m; \mathcal{R}_m)$ be m mathematical spaces, different two by two. A *Smarandache multispace* $\tilde{\Sigma}$ is a union $\bigcup_{i=1}^m \Sigma_i$ with rules $\tilde{\mathcal{R}} = \bigcup_{i=1}^m \mathcal{R}_i$ on $\tilde{\Sigma}$, i.e., the rule \mathcal{R}_i on Σ_i for integers $1 \leq i \leq m$ ([3],[9]-[10]). Thus, the reality of things, whatever its accurate or approximate should be characterized or found out on Smarandache multispaces. Whence, the Smarandache multispace solved better the contradiction in classical mathematics. However, an abstract Smarandache multispace is nothing else but an algebraic or set problem ([11]), which worked out finely the equal rights, but

- (1) To be also new conceptions accumulation;
- (2) Not solve the universal connection of things;
- (3) Can not extensively applies achievements in today's mathematics, \dots , etc..

Thus, for understanding the reality of things, a new envelope theory should be established on Smarandache multispace, i.e., *mathematical combinatorics*.

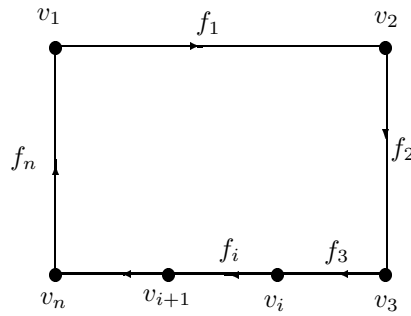


Fig.4

2. Mathematical Combinatorics. *What is mathematical combinatorics?* The mathematical combinatorics is such a mathematics over topological graphs \vec{G} , i.e., establish an envelope mathematics on the elements of universal connection of things, which worked out finely both the equal rights and universal connection of things. And *how to combine classical mathematics with topological graphs \vec{G} ?* I found a typical set of labeled graphs \vec{G}^L , called

continuity flows can be viewed as mathematical elements, i.e., labeling their edges by elements in a Banach space \mathcal{B} with two end-operators on \mathcal{B} and holding on the continuity equation on each vertex in \vec{G} . For example, such a continuity flow over \vec{C}_n is shown in Fig.4, where, $A_{v_i v_{i+1}}^+ = 1$, $A_{v_i v_{i-1}}^+ = 2$ and

$$f_i = \frac{f_1 + (2^{i-1} - 1) F(t, \bar{x})}{2^{i-1}}$$

for integers $1 \leq i \leq n$. Then, such a set of labeled graphs \vec{G}^L inherits the character of today's mathematics, i.e., if $\vec{G}_1, \vec{G}_2, \dots, \vec{G}_n$ are oriented topological graphs and \mathcal{B} a Banach space, then all such labeled graphs \vec{G}^L with linear end-operators is also a Banach space, and furthermore, if \mathcal{B} is a Hilbert space, all such labeled graphs \vec{G}^L with linear end-operators is a Hilbert space too.

Now, there are 2 kinds of problems on continuity flows \vec{G}^L :

- (1) Globally, given a graph family $\{\vec{G}_1, \vec{G}_2, \dots, \vec{G}_n\}, n \geq 1$ and a Banach space \mathcal{B} , whether there exists continuity flows over graphs $\vec{G}_1^L, \vec{G}_2^L, \dots, \vec{G}_n^L$ to be elements form a mathematical space;
- (2) Locally, for a continuity flow \vec{G}^L , if some vertices are no longer conserved by outside interference, how to make it conserved again such that it is still a continuity flow.

The first problem has been solved by a series papers of mine (See references of [5] in details), but for the second problems, there are only a few local or partially results. In fact, an independent energy system, including computer, car and human body, cell tissue, biological populations, \dots , etc. adaptive system is nothing else but a continuity flow, and furthermore, conservation flow. Thus, we can use continuity flows to characterize behavior of these systems for reality.

Here, I would like to introduce the twelve meridians theory in traditional Chinese medicine ([14]), which can be viewed as a typical example of continuity flows, particularly, in treating an illness. It is in fact to make the patient balance in Yin and Yang on acupoints of meridians, i.e., conservation, where Yin (Y^-) or Yang (Y^+) can be viewed as negative or positive energy, tendency, \dots , etc. are basic conceptions in traditional Chinese culture, i.e., Y^+ and Y^- are everywhere with that Y^+ in Y^- and Y^- in Y^+ , such as those shown in Fig.5, where the black and white areas respectively represent Y^- and Y^+ .



Fig.5

According to the characteristics of human body, the traditional Chinese medicine proposed

12 meridian theory, i.e., there 12 meridians in human body completely reflects the physical condition. They are respectively *Hand Tai Yang small intestine meridian* (H_1), *Hand Shao Yang Tri-Jiao meridian* (H_2), *Hand Yang Ming large intestine meridian* (H_3), *Hand Tai Yin lungs meridian* (H_4), *Hand Shao Yin heart meridian* (H_5), *Hand Jue Yin pericardium meridian* (H_6), *Foot Yang Ming stomach meridian* (F_1), *Foot Jue Yin liver meridian* (F_2), *Foot Tai Yin spleen meridian* (F_3), *Foot Shao Yin kidney meridian* (F_4), *Foot Shao Yang gallbladder meridian* (F_5), *Foot Tai Yang bladder meridian* (F_6), such as those shown in Fig.6(these red lines in human bodies without acupoint).



Fig.6

The balance of $\{Y^-, Y^+\}$ at points on the 12 meridians is the basic ruler for human body in traditional Chinese medicine. If there exists a point in one of the 12 meridians in which $\{Y^-, Y^+\}$ is imbalance, this person must be ill, and in turn, for a patient there are must be points on the 12 meridians in which $\{Y^-, Y^+\}$ are imbalance. This is the healing theory of traditional Chinese medicine, and by thousands of years of testing, there are no counterexamples appeared in China.

Certainly, the healing theory of traditional Chinese medicine is nothing else but continuity flows. Notice that the 12 meridians are in fact 12 directed pathes $H_1, H_2, H_3, H_4, H_5, H_6, F_1, F_2, F_3, F_4, F_5, F_6$ with vertices of acupoints. Define

$$\vec{G} = \left(\bigcup_{i=1}^6 H_i \right) \cup \left(\bigcup_{i=1}^6 F_i \right)$$

with $L : V(\vec{G}) \rightarrow \{Y^-, Y^+\}$, then, \vec{G}^L should be conserved on its vertices in $\{Y^-, Y^+\}$ for a person, i.e., a continuity flow.

For a patient, i.e., there are points to be imbalance on the 12 meridians, the doctor detects the points on which meridians, at which acupoints and the imbalance is Y^- more than Y^+ , or Y^+ more than Y^- , and then by a natural ruler of the universe in traditional Chinese culture, i.e., *reducing the excess with supply the insufficient*, the doctor regulates these related acupoints by acupuncture or drugs so that the acupoints balance in $\{Y^-, Y^+\}$ again. Clearly, this implies a mathematical process for a continuity flow \vec{G}^L again.

Certainly, there are no specific amount for the action strength $H(x_i \rightarrow x_0)$, where x_0 is the acupoint with $\{Y^-, Y^+\}$ imbalance, x_i is the related acupoints, $1 \leq i \leq s$, which completely depends on the judgement of the doctor, and continuous regulation based on the actual situation of the patient, i.e., a process of response. This also implies that getting a continuity flow \vec{G}^L again maybe by repeatedly regulation of the flows on conditions.

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