

On the building of theoretic system of information science

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Abstract: *The objective world consists of material world and information world, each world has two proorties -- existence and activity, then the objective world has four inherences -- material, energy; information, and intelligence. The material science is the study of material world, which is a great disciplines and now is very considerably rich and complete. Information science is the study of information world, which is also a major disciplines, but the development of its theoretical system just started, in which there are many rules needed to be explored. In this paper, the process of building material scientific system will be reviewed carefully, from which we are able to get some important enlightenments for the development of theoretical system of information science.*

Keywords: Material world Information world Material science Information Science Theoretical system

Acknowledgements: This work is supported by Research Fund of Northwestern Polytechnical University, key project (W018101).

The author put forward a scientific hypothesis, i.e., the whole world can be divided into two: the physical world and information world; they have two basic properties respectively: the existence and activity; the all things in the universe possess four basic attributes: substance, energy, information and intelligence. As a major scientific fields, material science exploring the matter have been very rich and full; while another major scientific fields, information science examining information has just begun. The aim of this paper is to review the process of establishing material science, then get some inspiration for the development of theoretal system of information science.

1. Four elements in the two worlds

In the modern history of science, human understanding of the objective world has gone through the following process:

(1) Modern science developed on the basis of the study of material science ,its basic idea that the objective world is material, matter is not dependent on the awareness of man's consciousness that can reflect objective reality.

(2) The dialectical materialism holds that the material is primary ,and consciousness is secondary, being determines consciousness, the meaning can be counter productive in the material^[1].

(3) Material science believe that the physical world has two big inherences —— existence and activity. The earliest discovery and utilization of human existence is a material (materials), on the basis of machine tools and materials appeared in science. Until recent discoveries and utilization of the material active attribute, (activity) appeared on the basis of energy tools and energy science. Although attributes of information have been discovered and used, but it has been locked

in the spirit world and subjective consciousness, do not belong to the objective world. Nature of information and information process has been ignored for a long time, the intelligence is that human beings can only have the privilege.

(4) Through the practices of studies in recent decades on information tools and intelligence tools, such as computers, it was discovered the brain's thought processes and intelligence activities in the original information can be used to implement processor and Artificial Intelligence Machine. Although any information necessary to represent a material carrier and dissemination of any information processing and intelligence activities, inevitably means of a physical process of movement to achieve. However, the information and its material carrier, information processing and intelligence activities, the physical process and its movement is simultaneously but independently of each other, is a thing of the two different aspects. Obtained from the artificial system using these rules to re-observe the mentally network activity, life events, and even a variety of development and evolution of nature, found that they all meet this rule. Both contain any material information, any process of physical movement are accompanied by an information process. These findings provide new understanding of human and location information, information processing and intelligence, put them from the subjective consciousness of the spiritual world and the liberation of levels, as the objective world, independent of the material world in the world^[2].

(5) The world of information also has the existence (information attribute) and activity (smart attribute), human use of these properties have created a lot of information tools and intelligence tools, and the various disciplines which researching information and intelligence are born.

(6) The understanding premises of we discussing the physical science and information science parallel are: the objective world into two, the physical world and information world, they are interdependent

and inseparable. In each world, the existence and activity are two different basic properties. So the objective world form the four basic elements: matter and energy, information and intelligence, these four elements are also interdependent and inseparable^[3].

2. The theoretical system of material science

2.1. Recalling the history of material science

In the physical world, the process of how humans understanding and using matter and energy, and gradually establish a system for the physical process of scientific theory, which is very important reference meaning to research the existence and activity of information on our world today, and using information and intelligence, gradually establishing the Information Science theoretical system.

From the original to modern, human evolution has millions of years, human history is a history of tools and knowledge. As the continuous development of social productive forces, the human limitations of natural ability constantly exposed to, have to resort to various tools of power to break through the limitations of human knowledge increases the ability of natural and modified natural. Tools are driven technology development, industry and development of the theory, promoted the economic and social transformation. In accordance with the basic characteristics of tools, the history of human society can be divided into three times, has experienced two of the times, and it is a transition to the third^[2].

The first era is the material era, which mainly depend on machine tools and the emergence and on going major development, such as stone tools, pottery, bronze and iron and so on. Machine tool's function is to replace the human body in part to the strength, hardness, cutting capacity and precision, a breakthrough to overcome the human hands, feet, teeth and other organs of the limits of nature, a more effective manner to accomplish a more accurate a variety of tasks. But the tools still rely on the period people, animals, wind and water and other

natural forces to drive, fully rely on intelligence to control human nature.

The second era is energy era, mainly power tools and continuous emergence of big development. Power tools in machine tools based on the increased power device, such as the steam engine, internal combustion engines, electric motors, power machine and nuclear machine, which function is in part to replace their energy to drive mechanical devices to complete various tasks in order to break through for people, animals, wind and water and other natural energy resources limitations, but the tool system is still relying on human intelligence to control.

The third era is the information era, the main tools of information and intelligence tools and continuous emergence of major development. Smart Tools on the basis of power tools increased trust and wisdom devices, such as information processors, computers and artificial intelligence machine, its function is to partially replace the people to directly control mechanical devices and power devices in order to break through people's natural intelligence limitations. Intellectual tools can accept the person's instructions, according to the state and changes in the external environment, in accordance with predetermined policies and procedures, coordination of all parts within the tool system activities, joint completion the tasks, and some even of a learning. Comparing to people the independence of intellectual tools are improved, which can be completed independently or semi-autonomous laws of many low-level strong work, the human can concentrate to a higher level of regularity less creative work.

2.2. The basic scientific problems and the core theory in the material era

As the matter has location, size and quality characteristics, there are a lot of material which have color of solid and liquid state of physical existence, so material is the first elements which is used by people. Before the industrial revolution, human material mainly used in a variety of natural or artificial materials of various machine tools, can be referred to as material times, over millions of years. During this period of human history,

often marked by the main material used to divide: If one million years ago, primitive people to stone as a tool, called the Old Stone Age; 10 thousand years ago, humans made of exquisite stone processing tools, which entered the Neolithic Age; appeared in the late firing of pottery, known as the pottery of the times; 5000 BC, humans mastered Smelting technology has begun to enter Bronze Age; 1200 BC, humans began to use cast iron, which entered the Iron Age, the late emergence of the steel-making technology to the industrial revolution and laid an important material foundation.

Throughout the material time, humans mainly use the material elements of the objective world, and the major scientific questions are: Why are there so many types of nature of different substances; Why do different substances have different properties; Do many substances consist of a small number of basic elements; Can a substance into another substance ect. It is shows that the New Age of basic scientific problem can be attributed to macro-material composition and chemical changes. In the process of discussing these basic scientific problems, developing a common foundation disciplines - chemistry, it generally responded to the composition of substances and chemical composition of chemical elements, chemical structure and chemical properties, and material between chemical changes of other issues. Later in the chemical form the basis of the scientific system of the material, so chemistry is the material of the times and the core base materials science theory. Then came the polymer materials and organic materials, and its basic theory is still the core polymer and organic chemistry.

2.3. The basic scientific problems and the core theory in the energy era

In the whole energy of the times, the main man understanding and using of people is the energy, but at first people didn't deeply understand the concepts, such as, force, power and energy-depth. We can guess at that time, man use leverage and a variety of storage devices to provide high-power energy, but all failed. Because they only amplified "power", not to enlarge "function and

energy."In general the energy of the times the main scientific questions of concern are: Why is object movement; factors affecting the movement of objects which, what are they relations; object motion performance of the internal nature and what is external; energy storage, release and conversion law and so on. The basic scientific problem of energy times can be reduced to objects of motion and energy conversion rules. Explore the basic scientific problems in the process, develop a common foundation disciplines - physics, it is

the first by a British scientist Newton was established in 1687, called classical physics, the core part of classical mechanics, and later developed thermodynamics, electrodynamics and nuclear physics. General physics to answer the substance of the mass, force, motion and energy and their mutual conversion between the law and so on, it is the energy of the times and the core foundation of energy science and theory (see Table 1).

Table 1, the basic material science of the core scientific issues and the basic theory

Time name	Material times	Energy time
Tool level	Machine tools	Power tools
Basic properties	Materials	Energy
The basic scientific problem	Material composition and chemical changes	Object motion and energy conversion
Core basic theory	Chemical	Physics
Economic type	Natural economy	Industrial economy

Further study of modern physics shows that matter and energy are inseparable unity. The structure of the material imply the energy, and change the structure of matter is bound to change with the energy: the energy or the need to absorb a certain amount, or release a certain amount of energy, matter and energy can be interchangeable each other.

2.4. Summary of theoretical system of material science

Material science is science to study the existence and activity of the material world, It is a large category, including astronomy, space science, earth science, oceanography and biology, basic sciences, as well as materials science, geological sciences, energy science, medicine, agriculture, forestry, animal husbandry and fisheries and other applied sciences. The entire material physics and chemistry are the core foundation of scientific theory. The forefront of material science research topics are the origin and evolution of the universe, the nature and basic structure of the material, the nature and origin of life, etc.^[4]

The basic research of material science includes material structure, material change, force and field, the object of the exercise, such as energy conversion law. The basic research

of material science is to continue to restore the material to more micro-level interaction between the elements and the hope that physical phenomena will no longer be attributed to a number of sub-elementary particles and fundamental forces. The current understanding is ^[5]:

(1) The four fundamental forces in the material world. Law of motion of material between the material and determine the four basic forces, they are the gravitational, weak nuclear force, electromagnetic force and the strong nuclear force. Gravitational force is between all objects with mass appeal, which is the weakest force in four kinds of natural forces, the role of distance and time infinite, but the strength is inversely proportional to the square of the distance. Gravity in the microscopic world, almost does not work, but play a decisive role in the movement of celestial objects. Weak nuclear force is the only natural forces at work in between elementary particles, the strength of the third, the role of distance is very small, the role of time is only $10^{-6} \sim 10^{-8}$ seconds. Electromagnetic force are charged particles and electromagnetic interaction between charged particles and electromagnetic field passing through the interaction between the

forces. It is the strength of the second, its scope, timing and intensity variation with the same gravity. Strong nuclear force is acting on the natural forces between hadrons, and its intensity, (that's 10^{12} times the weak nuclear force), the role of the shortest distance (about $10^{-15} \sim 10^{-10}$ m).

(2) There are five levels of the material world. Human beings understand from their macro-world, and one hand extends to the universe, and the other hand extends to the microscopic world. There are indications that there may exist a larger view of the world and

a smaller expansion of the vague concept of the world, there are 5 different levels.



Name	Minimum scale	Typical scale	The largest scale	Representation theory
Vaguescopic world		3×10^{-27} meters		to be found
Microscopic world	3×10^{-7} m	3×10^{-17} m	3×10^{-27} m	Quantum mechanics
Macroscopic world	3×10^{12} m	3×10^2 m	3×10^{-7} m	Newtonian mechanics
Macrocosm world	3×10^{31} m	3×10^{21} m	3×10^{12} m	Relativity
Inflation-outlook world	3×10^{31} m			to be found

Macrocosm is known as the largest known physical world, which contains all of space that mankind can observe, is playing a leading role in the field of gravity, and it is subject to special and general relativity. Macroscopic world is the surface to the solar system from around the world, is playing a leading role in gravitational fields, subject to Newtonian mechanics. Macro-effects of electromagnetic fields obey Maxwell's equations. The microscopic world is divided into several layers, the top level consists of the elements and atoms, atomic nuclei and the extranuclear electron has the form. Atom is very small, about 10^{-8} cm in diameter, the nucleus is about 10^{-13} cm, Electronic is even smaller, about 10^{-21} cm. Here are the nucleus of protons and neutrons, protons and neutrons than the smaller, more fundamental particles are mesons, neutrinos, anti-particles, and the composition of protons, neutrons quarks and so on, up to many hundreds of. The microscopic world of particles can be divided into hadrons, leptons and dissemination of sub-categories: hadron refers to the role of the strong nuclear force participation of those particles, including protons, neutrons, π mesons and so on. Also from the quark hadron composed of quarks are up, down, strange, charm, bottom, top six categories, each category there are three kinds, a total of 18 species. Lepton has nothing to do with the role

of strong nuclear force, weak nuclear force participation only, the electromagnetic force and gravitational interactions, such as electronics, neutrino, μ e, τ e and so on. Microscopic world of quantum mechanics play a leading role in the field of micro-electromagnetic effect subject to quantum electrodynamics.

According to quantum field theory point of view, is the field particle excited state, corresponding to specific types of basic strength of the gauge field, so material is further unified field of physical particles, such as gauge boson field quantum field.

The transmission of the forces of nature is done by the propagator, passing strong nuclear force is called gluons, the electromagnetic force is transmitted photons, the weak nuclear force is spread among bosons W^+ , W^- and Z^0 , dissemination of gravity is the graviton.

(3) Existence of dark matter in the material known to man, there are now we know it exists, but do not know what it is, its composition and the known material is also completely different. Calculated based on existing observational data, the total energy of the universe is dark energy 73%. Dark matter and dark energy research may revolutionize our current view of the world.

Material science from the above general description of the theoretical system, we can get some interesting insight:

- In the physical world we must first set a physical existence of space, which shows material existence and activity of the stage. Physical space by the three-dimensional space and one dimension of time away from the composition of a four-dimensional space, material and space in each dimension is infinite. The nature of physical space and speed of movement of the object, in the case of low velocity material space is linear, close to the speed of light in the room when the material shows non-linear.

- The existence of material substance is first expressed as occupying a space in the physical possession of material bound to a range of position (volume). Basis in the space-occupying it has a certain inertia (mass), physical structure, diversity (different metals, non-metallic, inorganic, organic, molecular and atomic and various elementary particles), there is the diversity of forms (solid, liquid, gas and plasma states and various games). It is the diversity of physical structure and shape, causing the material type and nature of the diversity.

- The dynamic nature of the decision in the matter of material space, the four fundamental forces (gravity, weak nuclear force, electromagnetic force and strong nuclear forces), while the fundamental forces exist only in the corresponding field (gravitational field, the weak force field, electromagnetic field and strong field) and are only a certain distance of certain substances have an effect, the formation of a specific form of physical exercise and physical structure.

- The existence and activity of material can not be separated, not only the objects related to changes in the movement and energy, but also the structure of the material also contains energy, they must be accompanied by physical changes in the structure of energy changes.

- Scientific research throughout the material, basically from the qualitative observation of natural phenomena and the passive accumulation of information began to experience, when the accumulated data are very rich, the bound into the theory of

quantitative research phase. In the theoretical research phase, with the establishment of quantitative relationship between various factors model, the parameters can be known to calculate the unknown results. Qualitative and quantitative observation of accumulation of theoretical modeling is to establish the essential physical and scientific theoretical system are two important stages^[6].

- The material world is a huge, opening, evolving system, which can study and use from different levels, different sides and different time stages. Therefore, material science is a huge theoretical system is always in a constantly expanding and deepening continuously open theoretical system.

- Unity and diversity of the objective world are a dialectical contradiction, is currently studying the unity of the four fundamental forces, matter and energy in the future may move toward unification, the material world and the world of information may also be moving toward reunification. However, these reunification must first clear all of the full difference.

3. Some basic problems of information science

3.1. Information Science is a major scientific fields

There are many works and discussions on information science, their common feature is used the "information science" orientation in a specific science, as astronomy and biology as the status.

We believe that, if the information world is a parallel world with the physical world, they have the same richness. So we should not be the "information science" conceived as a concrete science, can and should be a "material science" compared to the big science categories. Of course, people had on the understanding of material science and theoretical system is from a specific astronomy, physics, chemistry and materials science step by step, gradually expanded and in-depth. But now we have a system of established scientific theory of material success, can build an information system of scientific theories more conscious way to go, some faster.

We refer to the experience of the science of matter can be envisaged, information science is to study the existence and the world of information science initiative, it is a large scientific categories, which include similar information theory, cybernetics and systems theory that the basic science, similar to computer science and automation applications such as science, also similar to the logic core of this basic theory. Information science basic research content should include information space, information structure, information changes, information field and intelligence information on body movement, the conversion rule so smart.

On the studies of information scientific theories system, which is stay in the qualitative experience of passive observation and data accumulation phase, and the various departments of informatics are busy sorting the information in all areas of the performance of specific forms and characteristics, qualitatively describe them. However, quantitative theoretical study is an essential prerequisite to establish information system of scientific theories. In the quantitative theory studies of information world, together with logic and mathematics will play an irreplaceable role ^[7].

3.2. New scientific theory expediting by informational and intelligent tools

Human history shows that the emergence of machine tools and heavy use of birth of the birth of chemistry and materials science. The emergence of energy tools and extensive use of birth of the birth of physics and energy science. Strong traction in the application requirements, the final shape of the huge material and scientific theoretical system. Now, information tools and intelligence tools (referred to as the letter of intelligence tool) has emerged and large-scale use, it is bound to birth a new group of the birth of scientific theories, and finally form a large information system of scientific theory.

1946, the United States came the first computer ENIAC, marking mankind has entered the information age. The main features of the information age and extensive use of the letter appears wise tool. Machine tools require human drive and control; Power unit with power tools, self-drive, just the necessary human

intelligence control; letter with intellectual tools is their motivation and information processing device, to a certain extent, out of human control and autonomous operation. The emergence of the letter intellectual tools and continuous development means that in the past that large human intelligence as information processing only "driving force" of the situation has changed, mankind has moved from simple and complicated in that part of mental liberation, can wisdom to those more focused on creative work, and to those who alone or with the natural intelligence can not be accomplished and dangerous work.

Now that we have entered a different era of the past information, then there must be different from the past era of fundamental scientific questions and unique core of basic theory. We believe that the information age, became the basic scientific questions should go to the structure and movement of information laws, including the traditional information processing and intelligent information processing. The core foundation of the information age is a logical theory. Of course, the existing logic can not take up this task, it requires further strengthened to improve. The future of logics at least need to include a variety of information to describe the theory of form and information structure, standardizing all kinds of information processing and information theory of the conversion process, handling all kinds of uncertain information to identify and reasoning theory, we call this theoretical system for the pan-logic ^[8-10]. We also note that in the past few decades, the main task of the information device is a simple deterministic system, the issue of traditional information processing, while the next few decades the main direction of development of complex systems is the issue of non-deterministic intelligent information processing. Therefore, the information age has obviously two different periods, information and intelligence during the period of the development of their different focus. Information during the main task is to use information to establish the existence of information collection, dissemination, storage, processing and application of deterministic aspects of infrastructure and technology. The main task during the intelligent information technology, based on the dynamic nature of

the use of information in the material produce, social life and in all spheres of comprehensive use Smart Tools Automatic processing all not fully identified. Such as the use of outer space

and deep sea exploration machine, knowledge discovery, intelligent decision-making, intelligent control and intelligent services, etc. (see Table 2).

table 2, the information age, the core foundation of basic scientific issues and theories

Time name	Information period	Intelligent period
Tool level	Information tools	Smart tools
The main attributes used	The existence of information	Information initiative
The basic scientific problem	The changes and structure of information	Information campaigns and intelligent conversion
Core basic theory	Mathematical logic	Mathematical dialectic logic
Economic type	Information economy	Knowledge economy

3.3. The basic problems for further study deeply

(1) Information space is possibility space, which is arena for existence and activity of information, and the information field and intelligence are also in it. The Information space is infinite dimensional space

(2) The existence of information in its first performance in the possibility of occupying space in that information, there is the possibility of the space into a reality in some.

(3) The measure of information not only about the possibility but also many other factors ^[11].

(4) Information has internal structure, which is infinitely divisible. How to describe the internal structure and decomposition of information? Mathematical Logic in the descriptions of the role of the structure.

(5) Information measure has a relative meaning, its size has relation to the location of reference point.

(6) What is the nature of the information field, the force between the information (intelligence) What is it with the information and information

on the internal structure of the movement body What is the relationship?

(7) Intelligence is to describe the amount of information initiative, which is the body of information in intelligence-driven, displacement occurs in the information field have done Zhi Gong. Dialectical logic in the mathematical description of the role of intelligence, According to the information needs of science and quantitative mathematical establishment and development of dialectical logic.

(8) We should strictly distinction intelligence, intelligent (intellectual) and intellectual power of these three different concepts, the clear relationship among them. Information field, distance, information body, body mass of information, intelligence is a body of information occurs in the information field, the displacement of the force, Intelligence to make information displacement work done, Intellectual power is generated within the system's intelligence on time ^[12].

References

- [1] Yilian Peng, Qinrong Ma. *Logic Dictionary*[M] (in Chinese). Shanghai: Shanghai Lexicographical Publishing House, 2004. 431, 481
- [2] Huacan He, Yingcang Ma. *Information, intelligence and logical volume* [M] (in Chinese). Xi'an: Northwestern Polytechnical University Press, 2008. 1-54
- [3] Zongrong Li, Xingzheng Jin. *Introduction to Information Theory*[M] (in Chinese). Beijing: China Education and Culture Publishing House, 2006
- [4] Hongjia Ma, Xian Chen. *Essentials of Physical Sciences*[M] (in Chinese). Beijing: Higher Education Press, 2003
- [5] Xuesen Qian. *Basic scientific research should accept the guidance of Marxist philosophy*, China Youth Net 2009-11-17, <http://www.youth.cn>

- [6] Dayou Wu, Wulun Jin, Xin Hu And translation. *History and philosophy of physics*, Encyclopedia of China Publishing House, 1997
- [7] Yuanyuan Wang. *Modern computer science logic*[M] Beijing: Science Press, 2001. 1,6
- [8] Huacan He, Hua Wang, Yonghuai Liu etc. *Universal Logics Principle*, Science Press, 2001
- [9] Huacan He, Lirong Ai, Hua Wang. *Dialectical logic of mathematics trend*[J] Hechi College No.1, 2007,1.
- [10] Huacan He, Zhitao He, Yingcang Ma, Lirong Ai. *Philosophical Significance of Universal Logic---On Second Revolution of Mathematical Logic*, Logica Universalis. Vol.1 No.1, 2007,1.//Perspectives on Universal Logic, Polimetrica International Scientific Publisher, Edited by Jean Yves Beziau, et al. 2007.9
- [11] Yixin Zhong. Principles of Knowledge Machine: *Information, knowledge, wisdom, transformation and unification theory*[M] Beijing: Science Press,2007
- [12] Huacan He, *Intelligent -- On the human brain and various other information processing system of scientific laws*, Artificial Intelligence Journal, No.3, 1982 1-18.

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