PERCEPTIONS OF THE UNIVERSE: THE PARADIGM SHIFT

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ABSTRACT. This essay explores the development of people perception about the universe. There have been paradigms shift regarding time, space, and matter over the entire universe. What have the paradigms been? What is knowledge, how it relates to the reality and its implication to the human being in general and to the social sciences in particular?

Keywords: Universe, time, space, matter, paradigm, social sciences

ABSTRAK. Esei ini mencoba mengeksplorasi perkembangan persepsi masyarakat mengenai alam semesta (*universe*). Telah terjadi pergantian pandangan (paradigma) mengenai ruang, waktu, dan materi. Apakah paradigma-paradigma itu? Apakah pengetahuan, bagaimana keterkaitannya dengan realitas dan implikasinya pada manusia dan ilmu-ilmu social?

Kata kunci :Semesta, waktu, ruang, materi, paradigma, ilmu-ilmu sosial

INTRODUCTION

Theories are usually introduced when previous study of a class of phenomena has revealed a system of uniformity that can be expressed in the form of empirical laws. To understand the original development of theory, we have to trace back to the past. In the words of Bohannan and Glazer (1973:xi) when we theorize it means that "we extend our conceptualizations into the past, to periods before the word was even coined, and certainty to periods when the words meant something very different from what we mean by it today." Many thinkers presented their theories and these had been used for some times. Then, a new theory or law has been created to replace the old one. We can learn that all former laws were used and accepted only at certain period. To say that we have made a major new discovery about nature is one side of the coin. The other side of the coin is to say that we have found the limit of our previous theories. What we actually discover is that what we look at nature is no longer comprehensive enough to explain all that we can observe. Regarding this, Einstein once was saying:

> ...creating a new theory is not like destroying an old barn and erecting a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connection between our starting point and its rich environment. But

> the point from which we started out still exists and can be seen, although it appears smaller and forms a tiny part of our broad view gained by the mastery of the obstacles on our adventurous way up.

Theories and laws for looking at the world—the universe—have been changing up to now. This is important then to study the early stages as the primary source or cause of something. How the thinkers of the past and nowadays try to explain the natural phenomena or reality and what the differences are. At the beginning of the development, other branches of knowledge were not separated from science; almost all human and the universe were explained by physics.

ANCIENT PERCEPTION UP TO 17TH CENTURY

Ancient people seemed to have no conception on the true nature of the universe: the sun, moon, planets, and stars. Unable to understand the universe what they observed, primitive people associated its mysteries with their beliefs. Earlier attempts to study these phenomena are found among the Mesopotamian, Babylonian, Egyptian, and Hebrew. For Egyptian as well as the Babylonian and Hebrews, the universe was pictured as a rectangular box with a north-south orientation and with a slightly concave surface consisting of a solid and liquid part, and the sky as the realm of light in which heavenly bodies move (Encyclopaedia Americana [EA] vol. 8 1993:38-9). This notion lasts for centuries until another conception challenged it.

The first important efforts to determine the actual structure of the universe were made in ancient Greece. The Greek philosophers[1] like Pythagoras, Aristotle, Plato, Ptolemy, and their followers, saw the earth as a spherical body, rather than a flat plate, at the centre of the universe around which the other heavenly bodies—the sun, moon, stars, and planets—encircled. Aristotle exerted an argument on this notion because he realized that during the moon eclipses, the earth's shadow on the moon always round. The Greek even had an argument that the earth must be round since they observed that it was the sail first seen and only after the hull. These were the confirmation that the earth was spherical and hence influenced the people's idea and belief of the earth (EA vol. 8 1993:39; Hawking 1989:2).

Pythagoras and his followers even said that everything in nature is controlled by numerical relationships, as in the regularity of celestial bodies. Eudoxus of Cnidus, a disciple of Plato, was able to account for the motion of the celestial bodies by proposing that the sun, moon, and planets were carried transparent spheres arranged concentrically around the earth. This notion was then developed by Ptolemy in the first half of the second century A.D. By means of deferents and

[1] At that time up to the nineteenth century the term 'philosophy' was used in a very broad sense and included what we now call 'science,' and hence, a philosopher was also an astronomer, mathematician, physicist, biologist, and even musician.

epicycles, however, Ptolemy was able to explain the motion of heavenly bodies about the earth in a more satisfactory way than his predecessors (EA vol. 8 1993:39; Hawking 1989:2-4). The Ptolemaic system was generally adopted throughout the western world, especially by the Christian church, as the picture of the universe that was in accordance with the Scripture.

The Ptolemaic idea of the universe lasted for more than 14 centuries, not until a Polish astronomer, Nicolas Copernicus (1473-1543) came to understand that the old model was not satisfactory so it needed for replacing. He held an idea that the sun, as the source of light and heat, should occupy the centre of the universe. The earth and other planets therefore moved in orbit around the sun. The variations in the apparent position of the planets were produced by the combination of their own motion with that of the earth (EA vol. 8 1993:39). By this Copernican model, the geocentric model of Ptolemy and the Church that had been accepted dogma for centuries was ended. This was a scientific revolution. Copernicus was fully aware that his view would deeply offend the religious consciousness of his time. Being 'afraid' to be accused heretic, he circulated his achievement anonymously and delayed it publication until 1543, the year of his death. He even presented the heliocentric model merely as a hypothesis (Capra 1983:54; Hawking 1989:4). His idea had to wait for about a century to be fully developed.

It was Johannes Kepler (1571-1630), a German scientist, who was able to formulate a mathematical law for planetary motion which gave further support to the Copernican system. He also corrected Copernicus' theory, suggesting that the planets moved not in circle, but in ellipses (Hawking 1989:4-5). However, the real change in scientific opinion was brought about by Galileo Galilei (1564-1642), an Italian astronomer, physicist and mathematician (Capra 1989:54). Galileo continued the scientific revolution of the 17th century. He linked physics and astronomy to mathematics rather than to traditional philosophy. He applied mathematics to physics which producing some theorems on the centres of gravity of solid bodies (EA vol. 12 1993:240).

In 1610, Galileo published a book entitled *Sidereus Nuncius* (Starry Messenger) that confirms Copernicus' heliocentric model of the universe. By using a telescope, which he had newly invented, Galileo discovered the four brightest moons of Jupiter. He said that not all heavenly bodies revolved about the earth. Furthermore, he also discovered the mountainous surface of the moon and saw the phases of Venus, which convinced him that its orbit encircled the sun rather than the earth. In this book, Galileo publicly supported Copernicus's theory as a valid scientific theory which was, at that time, against the church's belief and this really caused him a lot of trouble in court (EA vol. 12 1993:241-3).

Galileo was also known to be the first scientist to combine scientific experimentation with the used of mathematical language to formulate the laws of nature. Physics before Galileo was treated as a branch of Aristotelian philosophy and not as an experimental science. Aristotelian physics saw that heavy bodies were supposed to fall at speed proportional to their weights, seeking to reach their natural place, which was the centre of the universe. This was the central argument of the Aristotelian view of the motion and Galileo disputed nearly all of its assumptions (EA vol. 12 1993:240). These Galileo's exercises were considered to be the real challenge to the supremacy and authority of the Greek, which was established throughout the Europe for more than 14 centuries.

The two aspects of Galileo's pioneering works—the empirical approach and mathematical formulation—became the dominant features of science in the 17th century and have remained important criteria of scientific theories up to present day. While Galileo derived ingenious experiment in Italy, Sir Francis Bacon (1561-1626) set forth the empirical method of science explicitly in England. He was the one who first to formulate a clear theory of the inductive procedure—to make experiments and draw general conclusion from them to be tested in further experiments (Capra 1983:55).

The Baconian spirit changed the value and purpose of the scientific quest from the time of the ancient up to modern time. The ultimate goals of the ancient enterprise had been wisdom, understanding the natural order and living in harmony with it—to follow the natural order or for the glory of God (*ad majorem Dei Gloriam*). In the 17th century, this attitude changed into its polar opposite, form integration to self-assertion. Since Bacon, the goal of science has been knowledge that is applied to dominate and control nature. This was indeed considered as an important scientific revolution proceeds to replace the organic view of the nature with metaphor of the world as machine (Capra 1983:55-6). This paradigm shift was initiated and completed by two scientists of the 17th century, René Descartes (1596-1650) and Sir Isaac Newton (1642-1727).

THE WORLD-MACHINE

The dominant view of the universe in the 17th century has been metaphorically called "the world-machine." This metaphor came into being as the logical consequences of Descartes' view of the nature. He viewed the nature as a perfect machine governed by exact mathematical laws. Material universe was a machine and nothing but a machine. He even extended this mechanistic view of matter to living organisms: plants and animal, and human body, as far as it is concerned, were simply machine (Capra 1983:60; Zukav 1979:48). The drastic change in the image of nature from organism to machine had a strong effect on people's attitudes toward the natural environment.[2]

Descartes firmly believed in the certainty of scientific knowledge, as he said, "All science is certain, evident knowledge. We reject all knowledge which is merely probable and judge that only those things should be believed which are perfectly known and about which there can be no doubts" (Capra 1983:57). He boldly proposed his whole view on nature on the fundamental division between two

[2] The Cartesian view of the universe as mechanical system provided a 'scientific' justification for the manipulation and exploitation of nature.

independent and separate realms: the mind or *res cogitans* (the "thinking thing") and the matter or *res extensa* (the "extended thing"). Both mind and matter were creation of God. Thus for him, the existence of God was essential to his scientific philosophy. God represented the common point of reference, being the source of the exact natural order and light of reason that enabled the human mind to recognize this order (Capra 1983:60).

Descartes created the conceptual framework for the 17th century science but his view of nature as perfect machine governed by exact mathematical laws had to remain a vision during his life. An Englishman scientist, Sir Isaac Newton, then completed this dream. Newton developed a complete mathematical formulation of the mechanistic view of nature and hence accomplished a grand synthesis of the works of Copernicus and Kepler, Bacon, Galileo, and Descartes.

Newton combined the works of Kepler and Galileo by formulating the general law of motion governing all objects under the influence of the force of gravity, which were found to be valid throughout the solar system. This, thus, seemed to confirm Cartesian view of nature (Zukav 1979:47-50; Capra 1983:63). The Newtonian universe was, indeed, one huge mechanical system, operating according to exact mathematical laws. Thus, Newton's great contributions to science were the law of motion and the law of gravity. Newton's laws of motion describe what happen to a moving object. Once we know the laws of motion, we can predict the future of a moving object provided that we know certain things about it initially. We also can retrodict the past history of a given object. For example, if we know the present position and velocity of the earth, the moon, and the sun, we can predict where earth will be in relation to the moon and the sun at any particular time in the future, giving us a foreknowledge of eclipses, seasons, and so on.

Newton also combined the works of Bacon on the empirical inductive method and that of Descartes' on the rational deductive method. He introduced the proper mixture of both methods emphasizing that neither experiment without systematic interpretation not deduction from first principles without experimental evidence will lead to a reliable theory (Capra 1983:64). The criteria for validity of everything that he wrote should be able to reproduce his experiments and come up with the same result. If it could be verified experimentally, it was true and if could not, it was suspect (Zukav 1979:48).

For Newton, the universe, on which all physical phenomena took place, was the three-dimensional space. It was an absolute space, an empty container that was independent of the physical phenomena occurring in it. Absolute space remains similar and immovable. All changes in the physical world were described in terms of separate dimension, time, which was absolute having no connection with the material world. The elements of the Newtonian world, which moved in this absolute space and absolute time, were material particles. The motion of particles—matter or object—was caused by the force of gravity (Capra 1983:65). He believed that one could measure the interval of time between two events, and the time would be the same whoever measured it if they used a good clock. For Newton, time is completely separate from and independent of space (Hawking 1989:18).

In 17th century, physics has been used a mechanistic model to explain the reality or natural phenomena known as classical physics. All reality has been explained based on the ideas of mathematical theory of Newton. This theory has been applied through out the 19th century. Matter was thought to be the basic of all existence and the material world was seen as a multitude of separate objects assembled into a huge machine. All complex phenomena could be understood by reducing them into their basic building blocks and by looking for the mechanisms through which these interacted. This attitude called reductionism has become deeply ingrained in culture that it has often been identified with the scientific method. Other sciences accepted the mechanistic and reductionism views of classical physics as the correct description of reality and modelled their own theories accordingly. Whenever psychologist, sociologist, or economists wanted to be scientific, they used the basic concept of Newtonian physics to explain all phenomena (Capra 1983:47). From this statement, we can conclude that all sciences were explained and understood by the basic notion of Newtonian physics, looking at everything as machines. The mechanistic view of nature is deterministic. All that happened had a definite cause and definite effect. The future can be predicted with absolute certainty of its state at any time was known in all detail. The world could be described objectively without ever mentioning the human observers.

Newtonian universe was so influential not only to the scientific thinking at his time but also up to the present day. The thinkers of the 18th century carries out this programme further by applying the principles of Newtonian mechanics to the sciences of human nature and human society. Newly created social sciences generated great enthusiasm and some of their proponents even claimed to have discovered a 'social physics.' The Newtonian theory of the universe spread rapidly in the 18th century and became the "Age of Enlightenment." One of the dominant figure in this development was John Locke (1632-1704) who was know for his celebrated metaphor compared the human mind at birth to a *tabula rasa*, a completely blank state on which knowledge imprinted once it is acquired through sensory experience.

THE NEW PHYSICS

At the end of 19th century, Newtonian mechanics had lost its role as the fundamental theory of natural phenomena. Maxwell's electrodynamics and Darwin's theory of evolution involved concepts that clearly beyond the Newtonian models and indicated that the universe was far more complex than Descartes and Newton had imagined (Capra 1983:74). In the early 20th century, two developments in physics, that is quantum and relativity theories—theories that attributed to work of Einstein—altered the Cartesian worldview and Newtonian mechanics.

At the beginning of modern physics stands the extraordinary intellectual achievement of Albert Einstein (1879-1955), a German-American scientist. He initiated two trends in scientific thought, that is the theory of relativity and the other was a new way of looking at electromagnetic radiation which was become characteristic of quantum theory or quantum mechanics. In the theory of relativity, Einstein combined light to time, and time to space; energy to matter, matter to space, and space to gravitation (Bronowski 1973:122).

The quantum theory was formulated during in the first decade of the 20th century by an international group of physicists including Max Planck, Albert Einstein, Niels Bohr, Louis de Broglie, Erwin Schroedinger, Wolfgang Pauli, Werner Heisenberg, and Paul Dirac. A 'quantum' is a quantity of something, a specific amount; 'mechanics' is the study of the motion, therefore quantum mechanics is the study of the motion of quantities. Quantum theory says that nature comes in bits and pieces 'quanta' (Zukav 1979:45), so that it deals with phenomena on extremely small scales, subatomic—the elementary particles.

Quantum theory made it clear that subatomic units of matter are very abstract entities, which have a dual aspect. Depending on how we look at them, they appear sometimes as particles, and sometimes as wave. This dual nature is also exhibited by light that can take the form of electromagnetic wave or particles. These particles light are called quanta. Here occurs the paradox: it seems impossible to accept that something can be, at the same time, a particle and a wave. But later it was realized that an electron is neither a particle nor a wave. Nevertheless, it may show particle-like in some situation and wave-like aspects in others. While it acts like a particle, it is capable of developing its wave nature at the expense of its particle nature, and vice versa. This means that electron and any other atomic object do not have any intrinsic properties independent of its environment. The properties it shows will depend on the experimental situation, that is, on the apparatus it is forced to interact with (Capra 1983:79).

Based on the particle-wave paradox, the new concept of the reality of matter evolved. Reality is basically a set of probabilities. At the subatomic level, matter does not exist with certainty, but rather shows 'tendencies to exist,' and atomic events do not occur with certainty at definite time and definite way, but rather shows 'tendencies to occur' (Capra 1983:80). In the formalism of quantum mechanics, these tendencies are expressed as probabilities.

Space and time are dynamic quantities: when a body moves, or a force acts, it affects the curvature of space and time—and in turn the structure of space-time affects the way in which the bodies move and forces act. Time was not absolute**,** especially when thing moving near the speed of light. In the theory of relativity, there is no absolute time, but instead each individual has his own personal measure of time that depends on where he is and how he is moving. Besides Heisenberg (the German school) presented the limitations of classical concepts in a precise mathematical form, which is known as the uncertainty principle.

These are not actually probabilities of things but the probabilities of interconnections. Thus subatomic particles are not 'things' but are interconnection between 'things,' and these 'things' in turn are interconnection between other 'things' and so forth. Here the basic oneness of the universe is revealed. The world cannot be decomposed into independently existing smallest unit. Natural matter appears as a complicated web of relations. Matters are related in local and non-local connection. The world cannot be analyzed in independently existing isolated elements from other elements.

Aside from viewing time, matter and space the new physics have departed from the old one with regard to basic notion that governs the phenomena. Newtonian physics is based upon the idea of laws which govern phenomena and the power inherent in understanding them, but it leads to impotence in the face of a Great Machine which is the universe. Quantum mechanics is based upon the idea of minimal knowledge of future phenomena but leads to the possibility that our reality is what we choose to make it. Another fundamental difference is that the old physics assumes that there is an external world—reality—which exists apart from us. We can observe, measure, and speculate about the external world without changing it. According to the old physics, the external world is indifferent to us and to our needs.

There are similarities between the structure of matter and the structure of mind since human consciousness plays a crucial role in the processes of observation and determine to a large extent the properties of the observed phenomena. Thus, we cannot speak about the nature without speaking about ourselves. According to quantum physics, matter is dynamic. In addition, theory of relativity has made the cosmic web come alive by revealing its intrinsically dynamic character, by showing that its gravity is the very essence of it being. The universe is a dynamic whole whose parts are interrelated.

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The 20th century saw that Physics has gone through several conceptual revolutions that reveal the limitations of the mechanistic worldview and lead to an organic, ecological view of the world, which shows great similarities to the views of mystics of all ages and traditions. The universe is no longer seen as a machine, which made up of separate objects. It appears to be a harmonious indivisible whole. Physicists learnt the fact that they could not use the Newtonian concepts and theories to describe all natural phenomena or reality any more. They turned to holism. Scientific theories can never provide a complete and definitive description of reality. They can only give approximations to the true nature of things.

THE IMPLICATION FOR SOCIAL SCIENCE: A DANGEROUS VOCATION?

Scientific knowledge has developed a lot up to the 20th century. It is the highest point of development and the important point of changing attitude toward sciences. Newton and his predecessors saw time exist independently of matter and of human mind. Time, matter and mind are separate entities, which are subjected to one absolute law. Einstein and German school considered time and matter are dynamic, relative, and interconnected. Time and matter depend on the observer, on the human mind. There are no fundamental contact laws, or equations. Consequently, there is no universal time. We may discover the same law but the actual might be different to each of us (Bronowski 1973:248).

In mechanistic model, 'pure objectivity' is possible in physical science and the way to do it is mathematical language. The new physics rejects such notion because there is no absolute knowledge—the principle of uncertainty. The principle means that no events, not even atomic events, can be described with certainty (Bronowski 1973:365).

The two paradigms have very different implication to social sciences and to the human beings as the whole. Concerning, the relationship between human beings and their environment, these two paradigms can be divided into the so-called "immanent" and "transcendent" (see Soemarwoto 1983). The immanent is a paradigm in which humans are seen as united with the nature rather than separate from her. Humans considered themselves only a little part of the natural. As part of the nature, humans assume the responsibility for maintaining harmony and natural order of things rather than to dominate or change nature. In contrast to the immanent, the transcendent view of the world sees that humans separate from nature and their role as its conqueror. Instead of living in harmony with natural environment, they seek to dominate, subdue it and transform it to suit their perceived need. Instead of emphasizing the unchanging nature of the universe and placing humanity within this natural order, the transcendent worldview stresses human separation and domination over nature, with the assistance of science and technology, humans proclaim themselves as the 'master of the universe.'

As history attested much, doing sciences can be both dangerous and not dangerous to the person and to the society. It depends on how we use the scientific knowledge. If we know how to use it in a right way, scientific knowledge can provide benefits to the society. Nevertheless, if we use the scientific knowledge in the wrong way, it can be dangerous to the society. In the 20th century, Einstein could find the formula to make use of the subatomic theories in developing nuclear energy. The energy is cheap and economical. We can make use of it to produce energy in the submarine and electricity. On the other hand, using this scientific knowledge in the wrong way can cause a tragedy of humankind. Scientists used this knowledge to produce atomic bombs, which were first used at Hiroshima and Nagasaki in Japan. It caused a lot of disaster; not only the power of destruction but also its reactor spills can develop cancer and genetic diseases. From this point, we have learnt that doing sciences can cause both benefit and danger depending on how we use it.

From the past experience, doing sciences sometimes can be dangerous to the scientist's own life if the scientific finding contrasted with the authoritarian. The story of Copernicus gave us the reality that doing sciences can be dangerous. And when Galileo observed the stars and insisted that Copernicus's findings were right, he had to undergo punishment because his 'belief' was considered as being heretic. The danger might occur when the scientists based their studies on the belief that knowledge is absolute, as Bronowski (1973:353) pointed out, "And those who claim it, whether they are scientists or dogmatists, open the door to tragedy....

Reflecting on the discussion above, it is clear that social science can learn much about it. Social theory has developed through many centuries. It is very important to understand the theory at each period because it influences human's thought toward the world. Certain laws and theories which held true or explaining reality or phenomenon in a particular time may not hold true and cannot fully explain the reality now. It keeps changing through time. Physics theory had been applied to explain reality and the universe for centuries then the new physics comes about offering a more plausible explanation to the reality and the universe today. Human learn something from the past experience and will always do as studying social phenomena has developed to be holism now.

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