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The validity of the scientific method in modern physics

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Abstract

The scientific method is described clearly for the first time at Kitab al-Manazir (Book of Optics) of Ibn al-Haytham (Alhazen 965 – 1040*). But recently there is some debate regarding its validity of theories describing our universe like string theory and multiverse. It is well known that scientific method paved the way for true science and technology through more than thousand years ago. We argue here that, scientific method should remain to be the only way to get and verify natural sciences.*

Keywords: scientific method, String theory, multiverse, Universe.

Figure 1: Alhazen (965-1040)

The feature associated with Alhazen's (Fig. 1) researches is related to systemic and methodological reliance on experimentation and controlled testing in his scientific inquiries. Furthermore, his experimental directives rested on combining classical physics with mathematics. This mathematical physical approach to experimental science supported most of his propositions in his famous book Kitab al-Manazir (The book of Optics) and grounded his theories of vision, light and color, as well as his research in catoptrics and dioptrics (the study of the refraction of light). [1] Bradley Steffens said in his book “Ibn Al-Haytham”: First Scientist has argued that Alhazen's approach to testing and experimentation made an important contribution to the scientific method.

It is worth mentioning that, the main motivation for Alhazen’s scientific method was absolutely religious; he thought that realizing the fact is an Islamic worship in itself, and regardless of the ability of the mind to think he must be mistaken, and that of ever protect science of error is the experiment. Alhazen is considered to be the "first true scientist" in the history based on his pioneering work on the scientific method [2].

As the scientific method commonly defined, this is the approach to investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge, based on the gathering of data through observation and measurement, followed by the formulation and testing of hypotheses to explain the data.

But the development and elaboration of rules for scientific reasoning and investigation has not been straightforward; scientific method has been the subject of intense and recurring debate throughout the history of science, and many eminent natural philosophers and scientists have argued for the primacy of one or another approach to establishing scientific knowledge.

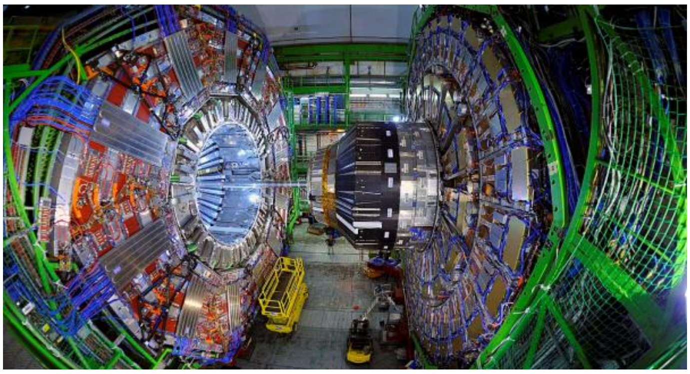

Figure 2: the Large Hadron Collider at CERN

Recent advances in elementary particle physics reached to the upper limit of the cost, and the technology in detection and discovery. In the other hand, we still have a lot of big mysteries without any clue. The most recent discovery of Higgs Boson (The Higgs boson is an

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elementary particle in the Standard Model of particle physics) was one of those issues. Despite being present everywhere, the existence of the Higgs field has been very difficult to confirm, because it is extremely hard to create excitations Because Higgs boson production in a particle collision is likely to be very rare (1 in 10 billion at the Large Hadron Collider LHC). The search for this elusive particle has taken more than 40 years and led to the construction of one of the world's most expensive and complex experimental facilities to date (With a budget of 7.5 billion euros), CERN's Large Hadron Collider LHC at Switzerland [3], able to create Higgs bosons and other particles for observation and study.

The LHC was built in collaboration with over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories [4]. It lies in a tunnel 27 kilometers (17 mi) in circumference, as deep as 175 meters (574 ft) beneath the Franco-Swiss border near Geneva, Switzerland. It is also the longest machine ever built. As of 2014, the LHC remains the largest and most complex experimental facility ever built [5]. By 2012 the LHC Computing Grid was the world's largest computing grid, comprising over 170 computing facilities in a worldwide network across 36 countries.

Spending billions of Euros or US dollars for constructing those gigantic machines like the LHC and VLHC will help answer some of the fundamental open questions in physics, concerning the basic laws governing the interactions and forces among the elementary objects, the deep structure of space and time, and in particular the interrelation between quantum mechanics and general relativity, where current theories and knowledge are unclear or break down altogether.

Although, we have many elegant theories concerning these issues but we still need the experimental verification for any of them. Experiments will protects us from the wrong perceptions. So, Data are necessary from high energy particle experiments to suggest which versions of current scientific models are more likely to be correct – in particular to choose between the Standard Model and Higgsless models and to validate their predictions and allow further theoretical development.

On 4 July 2012, the discovery of a new particle with a mass between 125 and 127 GeV/c2 was announced; physicists suspected that it was the Higgs boson [6-8]. By March 2013, after analysis of extremely huge amount of data, the particle had been proven to behave, interact and decay in many of the ways predicted by the Standard Model, and was also tentatively confirmed to have positive parity and zero spin [9], two fundamental attributes of a Higgs boson. There are many theoretical physicists still expected new physics beyond the Standard

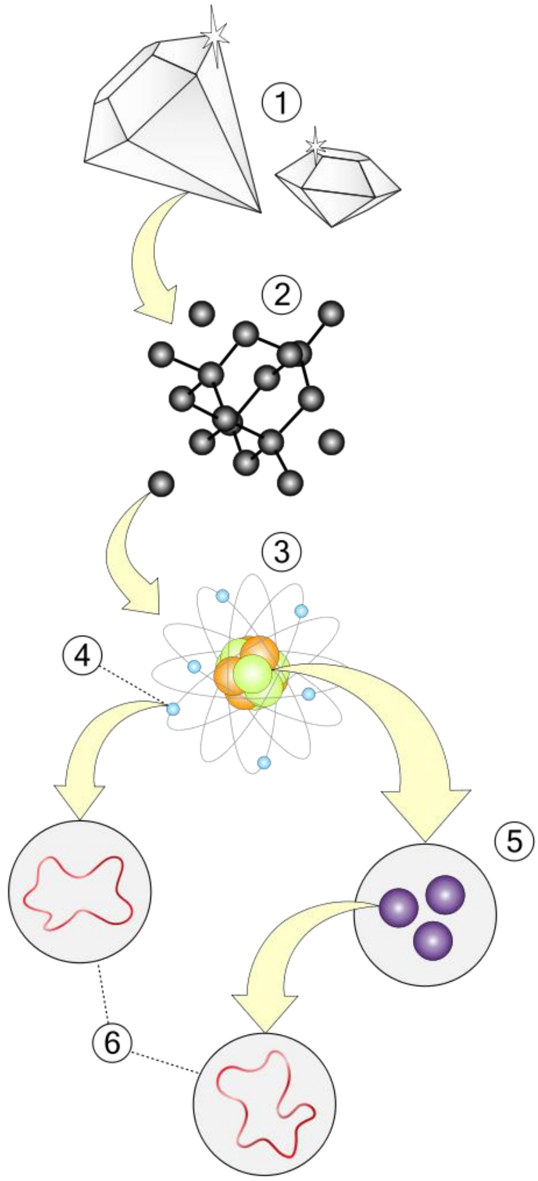

Figure 3: Different levels of magnification of matter, ending with the string level. 1. Matter, 2. Molecular structure (atoms), 3. Atom (protons, neutrons, electrons), 4. Electron, 5. Quarks, 6. Strings. [10]

Model to emerge at the TeV energy level, as the Standard Model appears to be unsatisfactory.

Indeed, it is a very long and costly process to verify something experimentally related to the structure of the universe. Therefore, debates in some physics groups took a distressing turn. Confronted with difficulties in applying fundamental theories to the observed Universe, some researchers called for a change in how theoretical physics is done. They began to argue — explicitly — that if a theory is sufficiently elegant and explanatory, it need not be tested experimentally, contravention with centuries of basic tradition of defining scientific knowledge as empirical.

We discuss here our opinion that totally complies with the necessity of the scientific method as the only way for the true science. As Alhazen and Karl Popper-the philosopher of science- said: a theory must be falsifiable to be scientific.

These upcoming ideas are circulating by two distincted groups, String theory and cosmology theorists. These unprovable hypotheses of string theory and multiverse are completely different from those that relate directly to the reality and that are testable through observations by using the most recent technology — such as the standard model of particle physics and the existence of dark matter.

STRING THEORY

Some string theorists claim to bypass the theory from any experimental verification. They believe that it must include one face of truth even though it relies on extra dimensions that we can never observe. No doubt that string theory is an elegant theoretical framework in which the point-like particles of particle physics are replaced by strings (one-dimensional space entities) and membranes (higher-dimensional extensions) existing in higher-dimensional spaces [11]. These strings could explain all types of observed elementary particles using quantum states of these strings. But the higher dimensions are wound so tightly that they are too small to observe at energies accessible through collisions in any practicable future particle detector. In addition to the particles postulated by the standard model of particle physics, string theory naturally incorporates gravity and so is a candidate for a theory of everything, a self-contained mathematical model that describes all fundamental forces and forms of matter. String theory is supposedly the only source of knowledge available that capable of unifying the four fundamental forces. Besides this prospective role, string theory is now widely used as a theoretical tool and has shed light on many aspects of quantum field theory and quantum gravity [12].

Although a great deal of recent work of using string theory to construct realistic models of particle physics, several major difficulties complicate efforts to test models based on string theory. The most significant is the extremely small size of the Planck length, which is expected to be close to the string length (the characteristic size of a string, where strings become easily distinguishable from particles). Another issue is the huge number of meta-stable vacua of string theory, which might be sufficiently diverse to accommodate almost any phenomena we might observe at lower energies. Richard Feynman [13, 14], Roger Penrose [15] and Sheldon Lee Glashow [16], have recognized and criticized string theory for not providing novel experimental predictions at accessible energy scales. Some scientists went far than this by saying that it is a failure as a theory of everything. On the other hand, many theoretical physicists, including Stephen Hawking, Edward Witten and Juan Maldacena, believe that string theory is a step towards the correct fundamental description of nature: it accommodates a consistent combination of quantum field theory and general relativity, agrees with insights in quantum gravity and has passed many non-trivial checks of its internal consistency.

In principle, some aspects of string theory can be tested experimentally. For example, a hypothesized symmetry between fermions and bosons central to string theory — supersymmetry — predicts that each kind of particle has an as-yet-unseen partner. No such partners have yet been detected by the LHC, restricting the range of energies at which supersymmetry might exist. If these partners continue to elude detection, then we may never know whether they exist. Proponents could always claim that the particles' masses are higher than the energies probed.

By Mentioning Bayesian analysis (a statistical method for inferring the likelihood that an explanation fits a set of facts), Theorist and philosopher Richard Dawid [18] argues that the veracity of string theory can be established through philosophical and probabilistic arguments about the research process. But that increase of probability can be purely theoretical. Because "no-one has found a good alternative" and "theories without alternatives tended to be viable in the past", he reasons that string theory should be taken to be valid.

Actually, this reminds us with the dilemma of Luminiferous aether and how many scientists and philosophers tried by different means to validate the idea philosophically after many experimental failure. Instead of belief in a scientific theory increasing when observational evidence arises to support it, he suggests that theoretical discoveries bolster belief. History of science proved that conclusions arising logically from mathematics need not apply to the real world. There are many experiments have proved many beautiful and simple theories wrong, from the steady-state theory of cosmology to the SU 5 Grand Unified Theory of particle physics, which aimed to unify the electroweak force and the strong force. Inductivism was overturned by Popper and other twentieth-century philosophers.

We cannot ensure that there are no alternative theories in the future. We may not have the appropriate technology to found them yet. Or the hypothesis might be wrong.

Multiverse

The cosmologists group, too, are seeking to abandon experimental verification of grand hypotheses that invoke imperceptible domains such as the multiverse, the 'many worlds' version of quantum reality (in which observations spawn parallel branches of reality) and pre-Big Bang concepts [19].

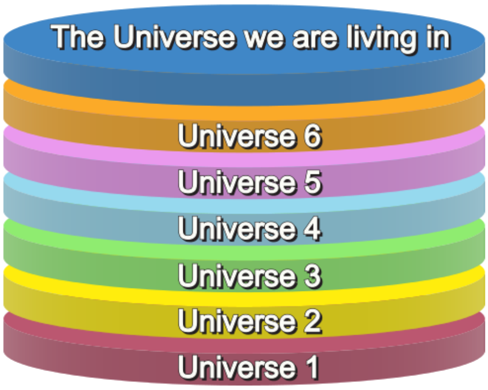

Figure 4: "Bubble universes": every disk is a bubble universe (Universe 1 to Universe 6 are different bubbles; they have physical constants that are different from our universe); our universe is just one of the bubbles. [20]

The term 'multiverse' was coined in 1895 by the American philosopher and psychologist William James in a different context [21]. The scientific (Fig. 4) hypothesis for the multiverse is the set of infinite or finite possible universes (including the universe we consistently experience) that together comprise everything that exists: the entirety of space, time, matter, and energy as well as the physical laws and constants that describe them. The various universes within the multiverse are sometimes called parallel universes or "alternate universes". The structure of the multiverse, the nature of each universe within it and the relationships among the various constituent universes, depend on the specific multiverse hypothesis considered.

The idea of multiverse is motivated by an enigma: why fundamental constants of nature, such as the fine-structure constant that characterizes the strength of electromagnetic interactions between particles and the cosmological constant associated with the acceleration of the expansion of the Universe, have values that lie in the small range that allows life to exist.

There are deep debates within the physics community concerning the multiverse hypothesis. Physicists disagree about whether the multiverse exists, and whether the multiverse is a proper subject of scientific inquiry [22]. Basically, the multiverse explanation relies on string theory, which is as yet unverified, and on speculative mechanisms for realizing different physics in different sister universes. It is not, in our opinion, robust, let alone testable.

We can find supporters for one of the multiverse hypotheses from the big names in theoretical physics like Stephen Hawking [23], Steven Weinberg [24], Brian Greene [25, 26], Max Tegmark [27], Alan Guth [28], Andrei Linde [29], Michio Kaku [30], David Deutsch [31], Leonard Susskind [32], Raj Pathria [33], Sean Carroll, Alex Vilenkin [34], Laura Mersini-Houghton [35, 36], and Neil deGrasse Tyson [37]. In contrast, critics such as Jim Baggott [38], David Gross [39], Paul Steinhardt [40], George Ellis [41, 42] and Paul Davies have argued that the multiverse question is philosophical rather than scientific, that the multiverse cannot be a scientific question because it lacks falsifiability, or even that the multiverse hypothesis is harmful or pseudoscientific.

We are “authors” support the critics for the idea of the multiverse as long as we do not have experimental evidence. There is a lot of illogic situations come from that idea and till now, we do not have even a philosophical interpretation. Simply because according to that idea there are Billions of universes — and of galaxies and copies of each of us — accumulate with no possibility of communication between them or of testing their reality.

Accepting the string theory and multiverse without experimental verification will not only mislead the integrity of physics but also will destructively affect the naturalized epistemology. This collection of philosophic views concerned with the theory of knowledge that emphasize the role of natural scientific methods as the main objective of naturalized epistemology will be missed and without meaning. This shared emphasis on scientific methods of studying knowledge shifts focus to the empirical processes of knowledge acquisition and away from many traditional philosophic questions. There are noteworthy distinctions within naturalized epistemology.

Substitution of the naturalism maintains that traditional epistemology should be abandoned and replaced with the methodologies of the natural sciences which coined in the scientific method. The general thesis of cooperative naturalism is that traditional epistemology can benefit in its inquiry by using the knowledge we have gained from the cognitive sciences.

We believe that, the consequences of over-claiming the significance of certain theories are insightful — the scientific method is at hazard. To state that a theory is so good that its existence supplants the need for data and testing in our opinion risks misleading students and the public as to how science should be done and could open the door for pseudoscientists to claim that their ideas meet similar requirements. The scientific research will turn to be science fiction.

In order to find a solution for this issue, we should look at the history of science. How many problems like this happened before? No one can predict the future of the physics. No one can block the way in front of revolutional ideas that may open a completely new era of physics and this happened many times before.

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