Applications Of The Higgs Boson

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Abstract

An overview at the development of engineering over the recent years shows us that practical applications of theoretical concepts have greatly accelerated the development of new technologies. To be able to predict the direction technologies of the future will take, we must turn our attention to the theoretical concepts being developed today. One of the newest confirmations in the standard atomic model is that of the Higgs Boson. This paper will attempt to consolidate what varied directions different branches of engineering would take should we be able to manipulate the Higgs field

Keywords ; Bosons ,Heat Transfer,Manufacturing, Std Atomic model,

I. INTRODUCTION

A brief glance at the development of engineering over the recent years shows us that practical applications of theoretical concepts have greatly accelerated our progress. This is obvious from the earliest development of radio waves, the discovery of X- rays, studies in the field of radioactivity, the quantum theory of solids leading to semiconductors and computer chips, nuclear magnetic resonance leading to MRI imaging, particle accelerators leading to beams for cancer treatment etc. Today, we can hardly imagine a world without nuclear power, cell phones or fast computers to help us in our everyday life. All these stem from concepts that were not even dreamt of during the development of the theories that form their bases. As an example: When Einstein finalized his theory of gravity and curved spacetime in November 1915, ending a quest which he began with his 1905 special relativity, he had little concern for practical or observable consequences. But strangely enough, relativity plays a key role in a multi-billion dollar growth industry centered around the Global Positioning System (GPS). The system is based on an array of 24 satellites orbiting the earth, each carrying a precise atomic clock. Using a hand-held GPS receiver which detects radio emissions from any of the satellites which happen to be overhead, users of even moderately priced devices can determine latitude, longitude and altitude to an accuracy which can currently reach 15 meters, and local time to 50 billionths of a second. The satellite clocks are moving at 14,000 km/hr in orbits that

circle the Earth twice per day, much faster than clocks on the surface of the Earth, and Einstein's theory of special relativity says that rapidly moving clocks tick more slowly, by about seven microseconds (millionths of a second) per day. Also, the orbiting clocks are 20,000 km above the Earth, and experience gravity that is four times weaker than that on the ground. Einstein's general relativity theory says that gravity curves space and time, resulting in a tendency for the orbiting clocks to tick slightly faster, by about 45 microseconds per day. The net result is that time on a GPS satellite clock advances faster than a clock on the ground by about 38 microseconds per day. But at 38 microseconds per day, the relativistic offset in the rates of the satellite clocks is so large that, if left uncompensated, it would cause navigational errors that accumulate faster than 10 km per day. GPS accounts for relativity by electronically adjusting the rates of the satellite clocks, and by building mathematical corrections into the computer chips which solve for the user's location. Without the proper application of relativity, GPS would fail in its navigational functions.
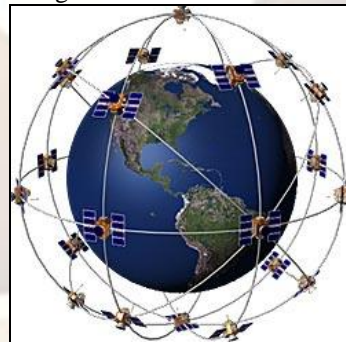

Fig.1 Schematic Diagram Representing GPS system

Thus to be able to predict the direction technologies of the future will take, we must turn our attention to the theoretical concepts being developed today. A theory being tested is that of the Higgs Boson. This paper will attempt to consolidate what varied directions different branches of engineering would take should we be able to manipulate the field created by this particle or in other words, the Higgs field.

We must note, since the researches into this particular field of nuclear physics are still in their preliminary stages the practical aspects of it have not, so far, been examined. As such the ideas put

forward in this paper, allow us a brief insight into what the future uses might be. The method of modifying the Higgs field will greatly change the circumstances in which it will be possible to use thus precluding some uses herein mentioned. The practical applications will also depend on cost and viability, which is beyond the scope of this paper. We must also remember that it has taken the most expensive and complicated machine in the world today; several years, just to confirm its existence. Finding a method to modify this field and using this method might well be beyond the years we are destined to see.

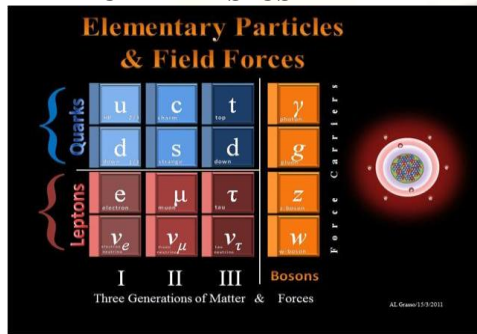## 2. THE STANDARD MODEL IN PARTICLE PHYSICS

Fig.2 Standard Model of The Atom

The Standard Model theory of particle physics, describes the mediation of the electromagnetic, weak, and strong nuclear interactions in the dynamics of known subatomic particles. The development of the Standard Model has been a collaborative effort between experimental physicists and theorists, spanning continents and decades of research. The current formulation is derived from the experimental confirmation of the existence of quarks. Since the mid-1970s, discoveries of the bottom quark (1977), the top quark (1995), and the tau neutrino (2000) have given further credence to the Standard Model. However it is the recent CERN experiment that confirms the detection of the Higgs boson that completes the set of predicted particles.
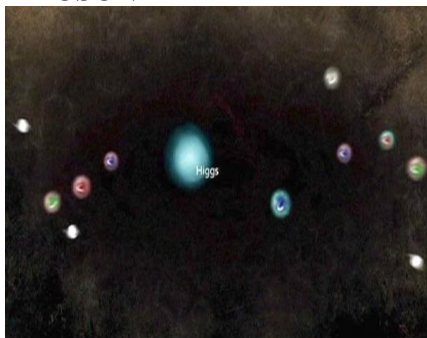
3. CHARACTERISTIC PROPERTIES OF A BOSON

Fig.3 Representative Appearance of a Boson

The term Boson was coined by Paul Dirac in honour of Satyendra Nath Bose who along with Albert Einstein formed the theory that explains their presence. We know that the atom is made up of more than just the protons, neutrons and electrons as projected by the rudimentary models in all our high school classrooms. A more elegant understanding of the atom, assumes interatomic particles to be of two types- Bosons and Fermions. Fermions are matter particles, they occupy space in the atom and hence, more than two fermions cannot occupy the same space at the same time. Bosons are energy particles, they are responsible for the forces present in the atom. Thus more than two bosons can occupy the same state at the same time.

How do we explain this? We know by Einstein's theory of relativity, that mass and energy are interconvertable by the equation **e=mc^2.** Hence to observe the independent forces acting within the confines of the atom we must first manifest these forces as particles. Basically speaking, Bosons are merely forces manifested as particles.
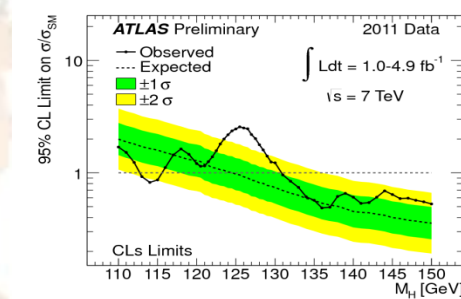
4. FUNDAMENTALS OF THE HIGGS BOSON

Fig.4 Observed Energy Ranges of the Higgs Boson
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The Standard Model does not predict the mass of the Higgs boson, but does predict the production cross section once the mass is known. The "cross section" is the likelihood of a collision event of a particular type.

The Higgs boson or Higgs particle is this elementary particle in the Standard Model of particle physics. The Higgs boson is named after Peter Higgs, who proposed the mechanism that suggested such a particle in 1964. He was the only one to explicitly predict the massive particle (125–127 GeV/c2) and identify some of its theoretical properties. In mainstream media it is often referred to as the "God particle", after the title of Leon Lederman's book on the topic. It is also very unstable, decaying into other particles almost immediately. The currently accepted 'Standard Model' states that a particular kind of "field" (known as the Higgs field) exists, which in contrast to the more familiar gravitational field and electromagnetic field has constant strength everywhere. This kind of field was shown to be theoretically capable of producing a Higgs

mechanism in nature, and particles interacting with this field will acquire mass. The Standard Model of physics was developed on this basis, and it included a prediction and requirement that for these things to be true, there had to be an undiscovered fundamental particle as the counterpart of this field. This particle would be the Higgs boson (or "Higgs particle"), the last unobserved particle of the Standard Model

5. THE MASS MECHANISM OF THE HIGGS FIELD
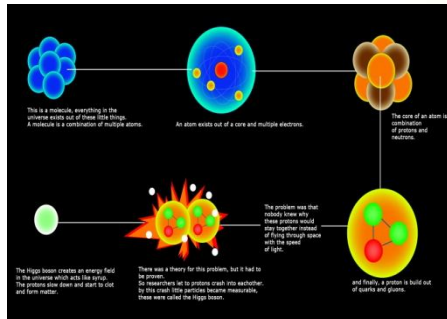
Fig.5 Mass Mechanism of the Higgs Field

Each elementary particle acquires its unique set of attributes by interacting with invisible entities called fields. One such field is the electromagnetic field. Each particle interacts with the electromagnetic field in a way that depends on its electric charge. For example, electrons tend to move through the field toward the positive ends of bar magnets, and group together with positively charged protons. The electromagnetic field is associated with the photon, or particle of light. This correspondence can be seen in two ways: First, when the EM field is "excited," meaning its energy is flared up in a certain spot, that flare-up is, itself, a photon..Secondly, when particles interact with the EM field (for example, when they are drawn toward the oppositely charged end of a magnet), they experience the field by absorbing and emitting a constant stream of "virtual photons", photons that are momentarily created and then destroyed just for the purpose of mediating the particle-field interaction.

There exists a Higgs field. It gives particles mass. Except for massless photons and gluons, all elementary particles get their masses from their interactions with the Higgs field, similar to being 'slowed down' by passing through a viscous fluid. Some particles have a harder time moving through the viscous Higgs field than others and as a result, they are heavier. Just as the photon mediates interactions with the EM field and is itself an excitation of the EM field, the Higgs particle mediates interactions with the Higgs field, and is itself an excitation of the Higgs field.

Particles move through the Higgs field by exchanging virtual Higgs particles with it. And a real Higgs particle surfaces when the field becomes excited.

6. EFFECTS ON MASS DUE TO MANIPULATION OF THE HIGGS FIELD

From the above discussions we could easily draw some basic conclusions:

a)   If a particle gains mass only when slowed down by the Higgs field, removing or nullifying this field would cause the particle to lose its mass, all other properties remaining constant.

b)   When the causative agent that nullifies this field is removed the particle would regain its original mass.

c)   If we can assume the Higgs field to be analogous to all other fields present in our universe except for the fact that it is present everywhere, we can also assume that this field can be varied in terms of strength.

d)   This can further be supported by the fact that some particles are heavier than others and so the interactions of the particles with respect to the field must also vary.

7.THE PRACTICAL APPLICATIONS

Affecting the mass of a particle and hence subsequently the material it is associated with can be majorly beneficial to engineering. Various practical uses can be found for the application this theory:

7.1   In Manufacturing:

(a)   By reducing the effect of the Higgs field on a metal, its mass will reduce. Consequently the heat absorbed by the metal given by $Q=m.C_p.dt$ will also reduce. Lesser heat required will allow for metal working at lower temperatures. As the metal will have low mass, metal working will be easier and the alloys formed can be more homogenous and of better quality. Oxidation and wastage caused due to high temperatures will also be reduced.

(b)   By increasing the effect of the Higgs field, the mass of the metal can be increased allowing for high mass compaction of materials. During the compaction process, the mass of the metal can be increased allowing the metal to be densely packed due to its weight, thus producing highly dense, stronger and more durable materials.

(c)   By reducing the mass of materials, the force required for machining would also reduce thereby enabling us to achieve greater tolerances with lower powered tools.

(d)   Damages caused due to work hardening would be reduced as operations performed on low mass work pieces would be analogous to hot working.

7.2   In Transportation:

(a)   Every day large loads of various materials have to be transported from place to place. Reducing the mass of these loads in whatever circumstances they may be will reduce the motive power required for their transportation. Thus allowing the use of smaller engines and allowing ease of transport.

(b)   Transport of heavy construction equipment to remote locations would be both easier and speedier if the mass of the payload could be reduced.

(c)   Reducing the mass of payloads will also reduce the effect that gravity has on these materials. Sending satellites and research equipment into orbit might become only a question of determining to what extent the mass of an object can be reduced.

(d)   Even in normal road transport, we find that most of the weight in transit is that of the vehicle itself. Reducing this weight will allow smaller engines to achieve greater speed as well as greatly reduce energy consumption.

7.3   Heat Transfer:

(a)   As a higher mass will absorb more heat, increasing the mass of heat sinks will improve their heat absorption capacity. Coolant could be made more efficient by increasing their mass as they passed the engine and lowering their mass in the radiator so as to dissipate heat quickly.

(b)   Heat transfer systems such as those used in CPUs could handle more heat if their mass were to be increased, allowing for longer periods of use, greater efficiency and faster operation.

7.4   In Defence:

(a)   Increasing the mass of armor plates on the detection of incoming fire could render the projectiles harmless as a greater mass would absorb more momentum. Reducing the Mass of the armor during transportation would decrease the time and energy required.

(b)   Low mass projectiles could be accelerated to higher speeds thus increasing their penetrative power seeking to cut through armor plates instead of striking against them causing contact damage to enemy forces.

(c)   Explosive payloads could be transported to required sites at higher speeds and using lesser energy, if their mass could be reduced.

7.5   Miscellaneous:

(a)   Vapour deposition using low mass vapour would make the process easier to use and more viable for low temperature applications. Also vapour once deposited could also be hardened using high mass fields, creating more durable coatings.

(b)   Printing of computer chips could be made more accurate using low mass fields, leading to the development of smaller circuits and hence smaller devices.

(c) Difficult to handle gases and other volatile substances could be stored and transported safely by increasing their mass and limiting their movement.

8. CONCLUSION:

The most important questions that have yet to be answered are: How will we modify the Higgs field? And To what extent can we modify the Higgs field?

As to the first question, further studies into the nature of this incredible field are required to determine exactly the nature of the energy that makes up the Higgs field. Finding the field was merely the first step in this direction. Although the theoretical aspects of the composition of the field are known, what sort of energies affect this field is largely unknown. Like electricity, can we generate Higgs fields of our own? Do they already exist? What would be the cost of generating these fields? These are questions that must be answered before we can seek to modify these very fundamental of the building blocks of our universe.

When we consider the second question, we already have a slight understanding of effects of removing the Higgs field completely. The forces that hold an atom together are very closely related and completely removing the Higgs field causes breakdown of the fundamental atomic structure. This is undesirable as for most of the uses herein mentioned, the main advantage stems from manipulating the mass while keeping all other factors of a material or object unchanged. This however does not preclude the modification of the field. A change in the magnitude of the field without its complete removal can still be implemented. After all even an electric current of too great a magnitude is destructive in nature. Still we seem to use these fields and currents in nearly all aspects of technology today.

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