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RESEARCH ARTICLE

THE BOUNDARIES OF SCIENCE

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Abstract

This paper delves into the intrinsic boundaries and limitations of the scientific method and its applications from an ontological, epistemic and moral perspective. It poses essential questions surrounding underlying presuppositions, basal unobservability and impracticality in science while aiming to be cognizant of the intricacies and subtleties that one encounters while asking questions that are elementary in nature. It seeks to give insight about the use of epistemic tools in science following which the applications of the scientific method are examined in purely human and moral domains. The latter part of the paper examines systemic issues that may inhibit the preservation of the Mertonian norms, intellectual honesty andhumility and scientific progress. The goal of the paper is to marry both philosophical and technical concerns surrounding the scientific method and to promote a newly emancipated science that is free from all intellectual dishonesty and needless conviction while maintaining a keen awareness of its own intrinsic limitations and presuppositions.

Introduction:-

The scientific method, in essence, is the process by which a truly scientific conclusion is derived. It is based on a posteriori knowledge; this means it is based on experience and observation. Now, based on this a posteriori knowledge we use deductive reasoning to form scientific hypotheses and theories. We can also arrive at a hypotheses or theory through inductive, a priori conceptualization. A theory is the highest level of scientific approval a particular model can gain. In short, science is based on deductive reasoning which is then used to form conclusions that establish (largely true) generalizations. There can, however, be faulty conclusions derived from true premises or vice versa so we can only say that we are as certain as one can be that a theory holds true and never that we are unquestioningly assured. Therefore, science permits and needs broad skepticism of even the most successful theories that are accurate to well beyond the margin of error. The ethics that apply to this method of inquiry are divided into four categories as per the Mertonian Norms (Fidler & Wilcox, 2018). The four norms are:

1. Communism, which is the common ownership of science and the existence of the scientific community as an open and wholly collaborative community.
2. Universalism, which is treating all scientists and scientific research with the same principles regardless of the proponent or the institution by which it is published.
3. Disinterestedness, which is ensuring impartiality and a lack of ulterior motives in scientific research. For e.g., looking at data and research with complete honesty and in a dispassionate manner regardless of what it might mean for one's career or reputation.

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4. Organized Skepticism, which is scrutinizing and critiquing all pieces of scientific research in an objective manner and being nonjudgmental and detached enough to delay all verdicts on said research until it is rigorously reviewed.

This paper will examine the barriers encountered by Science and will analyze the intrinsic limitations of the empirical methodology employed by science as well as various threats to the upholding of Mertonian Norms and Ideals.

'**All knowledge degenerates into probability**'(Hume, 1896)

In scientific models there exist two kinds of knowledge: Ontic observations are about the nature of existence of 'real things', real meaning things that exist as a part of reality and epistemological tools which are concepts conjured up by humans that increase the accuracy of the model in terms of representing nature herself.

Examples of ontic observations and epistemic tools
An example of ontic observations and epistemic tools being part of the same model would be the standard model of particle physics (Fig. 1): while hadrons and leptons (the standard model of CERN) like the proton and electron are likely ontic observations, the imaginary exchange of the carrier particles of the fundamental forces (bosons) are more likely to be epistemic tools.

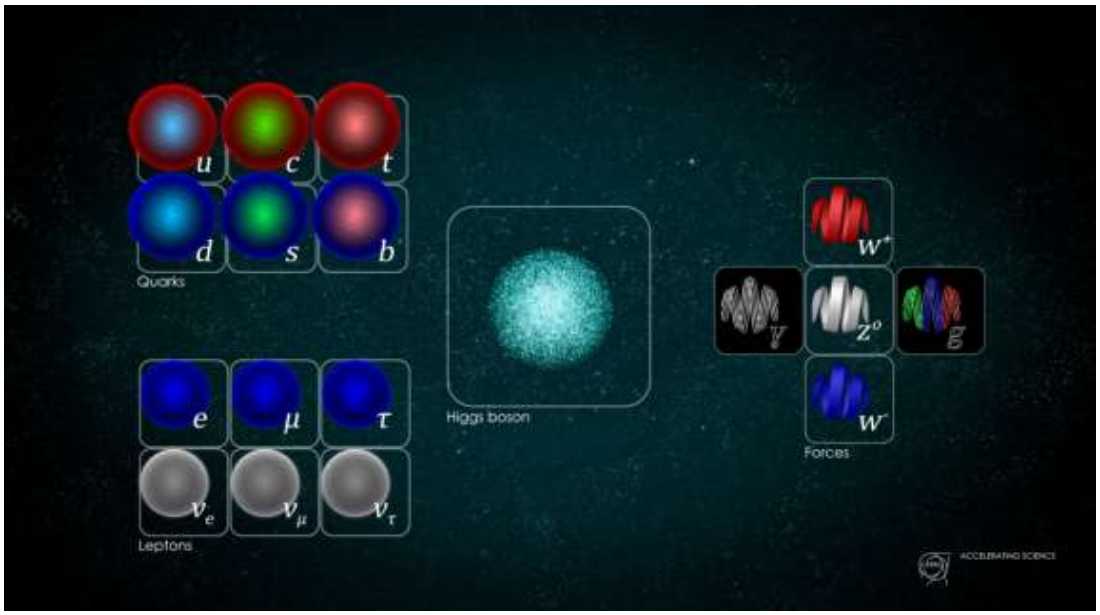

Figure1:-Particles of the standard model of particle physics **(**Cern, 2023).

Likewise, quasi-particles, various mathematical shortcuts, and the collapse of the wave function are more likely to simply be generated as place holders for some deeper undercurrent in nature. The addition of extra dimensions or properties to describe quantization in grand unified field theories like string theory could also simply be epistemological tools. There are also more subtle ways in which the use of epistemic tools could be more widespread. Let's take the example of a proton, the experiments match the theoretical model to a high degree of accuracy; however, this does not mean that we have definitive evidence of a proton as the observation could simply be indicative of a proton like particle (perhaps not even a particle) that produces the same or very similar results. The likelihood of this predictability being just epistemic happenstance is significantly higher with a model that has been built to fit a certain set of data and does not end up predicting anything else while having an accurate theory that is built from the 'ground-up' and in a purely logical, a priori manner has a much better claim at representing the true properties of nature. The same would be the case with a model that is built to fit a certain set of data but ends up inadvertently predicting many other seemingly impertinent and extraneous pieces of data.

Practical limitations of scientific method

There also exist practical limitations of the scientific method such as certain models requiring experiments, that would be necessary to test their veracity, that are too far-fetched and expensive. As an example, string theory would require an impossibly large particle accelerator to test directly. Keeping in mind the above examples, we can already conclusively determine that science does not, in fact, have some miraculous connection to a pantheistic God or truth itself.

More importantly, there is nothing that necessitates nature to be directly observable. For example, elements of quantum physics are fundamentally unobservable: the Heisenberg principle states ($\Delta p\ \Delta q \geq h/4\pi$) that you cannot observe the momentum and position of a subatomic particle like the electron at the same time; you also cannot distinguish between two systems with the same probability density matrix (Libre texts, 2023). These are not merely trivial procedural shortcomings, but a legitimate part of quantum physics.

There also lies the question of whether nature has habits or simply happens to repeat certain actions and even if the latter is true (as is implied and presupposed by the scientific method, in a somewhat anthropomorphic manner), are these same habits followed everywhere? In other words, whether all of nature is amenable to the same laws of nature. The latter may be impossible to answer as we will never be able to, by definition, observe natural phenomena beyond the boundaries of the observable universe. This perhaps fundamentally unanswerable question entails an answer that would have a profound effect on our view of science.

When observing objects at extremely large distances, another caveat emerges; we view objects at these distances as they were far in the past, not as they are in the present. While this is inconsequential for most observations, it can have an impact on the observations of natural law at extremely large distances as the physics of the early universe was vastly different from what it is now and there is no knowing whether the physics of the far future will also vary in a similar or different manner.

To demonstrate the time and thus distance-dependent limitations due to which fundamental physical laws can themselves vary, we can look at two examples. When $t \to 0$, T$\approx 10^{32}$K and the four fundamental forces of nature (Fig. 2) which are the strong nuclear force, weak nuclear, gravity and electromagnetism merge into one (Libre texts, 2022). At this stage, before the breaking of electroweak symmetry (Figs. 3 & 4), the Higgs field also exists in a uniquely unstable state and then transitions to a lower energy state with higher stability at lower temperatures (Djouadi, 1970). Hypothetically speaking, the more stable Higgs Field of today could also exist in a metastable state and given $t \to \infty$ exhibit a non-zero probability of decaying (Fig. 5) into a lower energy state which would again alter physical laws as we know them (Ellis & Gaillard, 2016).

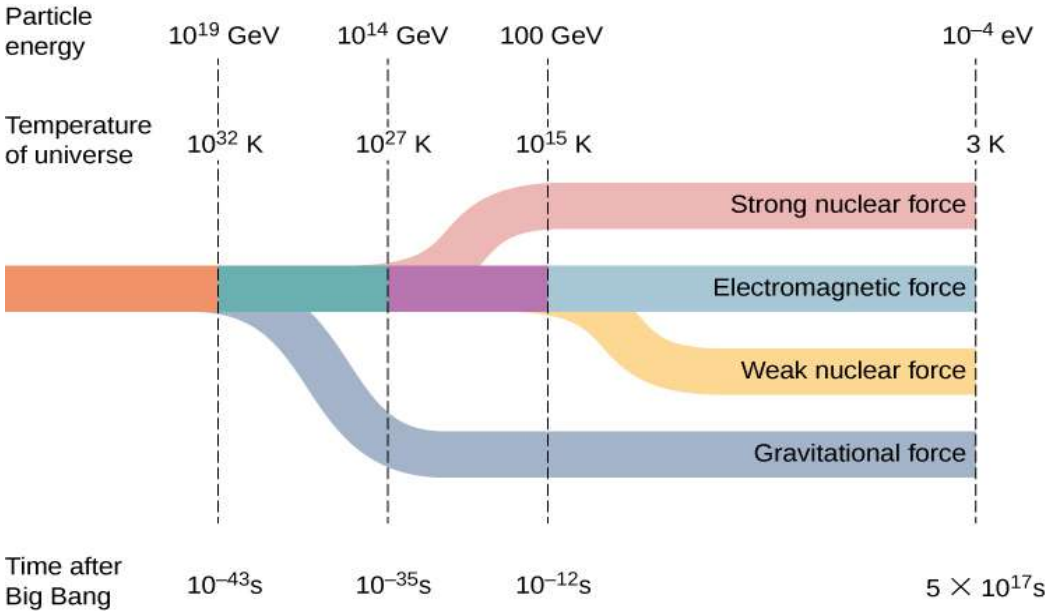

Figure2:- Merger of the four fundamental forces (Libre texts, 2022).

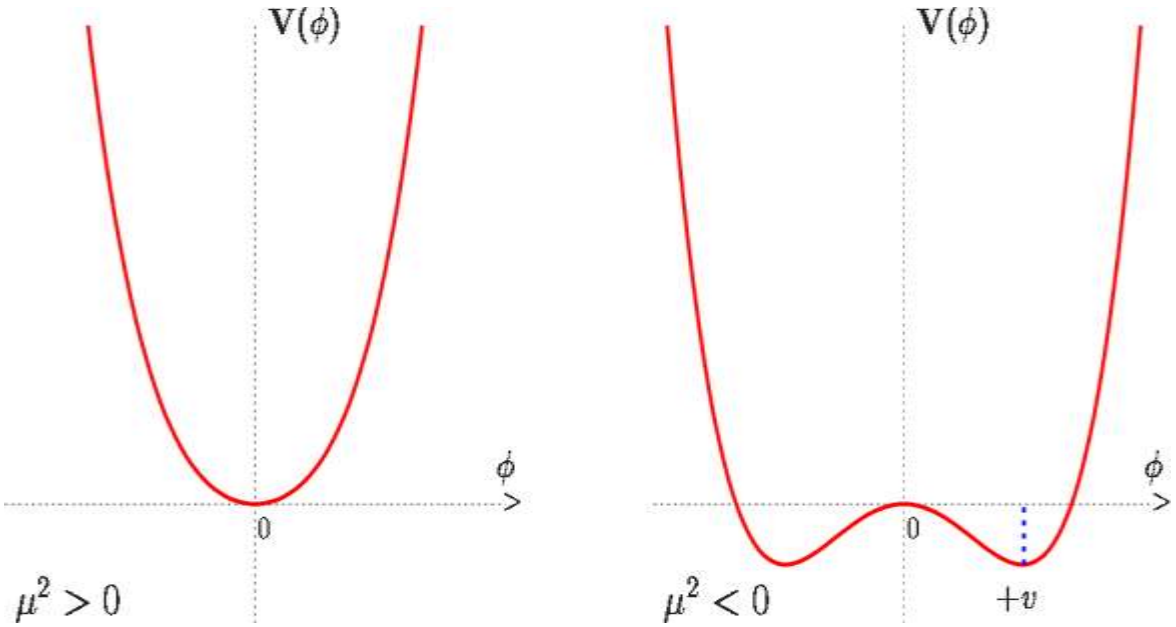

Figure3:- Electroweak symmetry and breaking of electroweak symmetry (Djouadi, 1970).

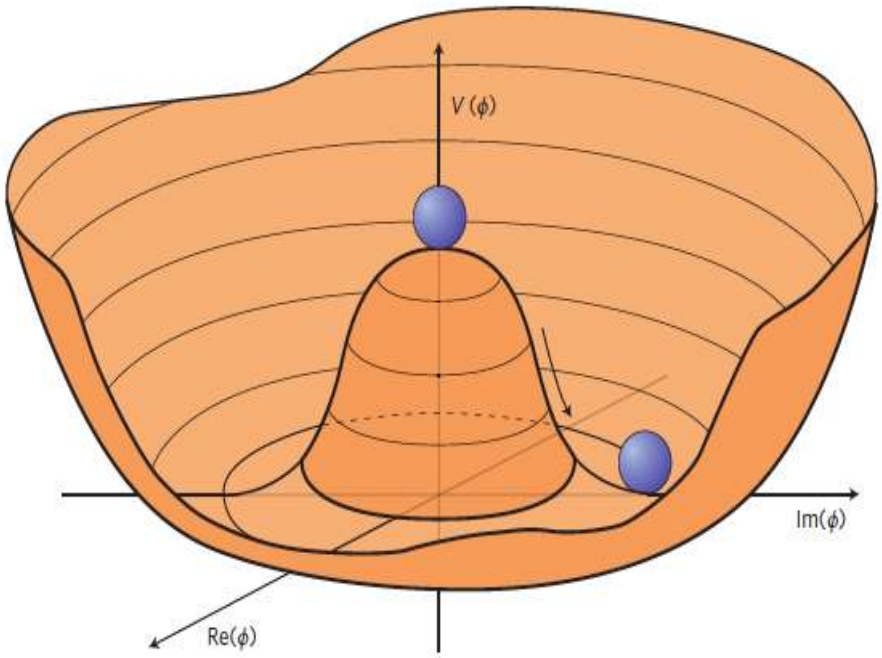

Figure4:- 'Mexican Hat' Potential after the breakage of electroweak symmetry (Ellis and Gaillard, 2016).

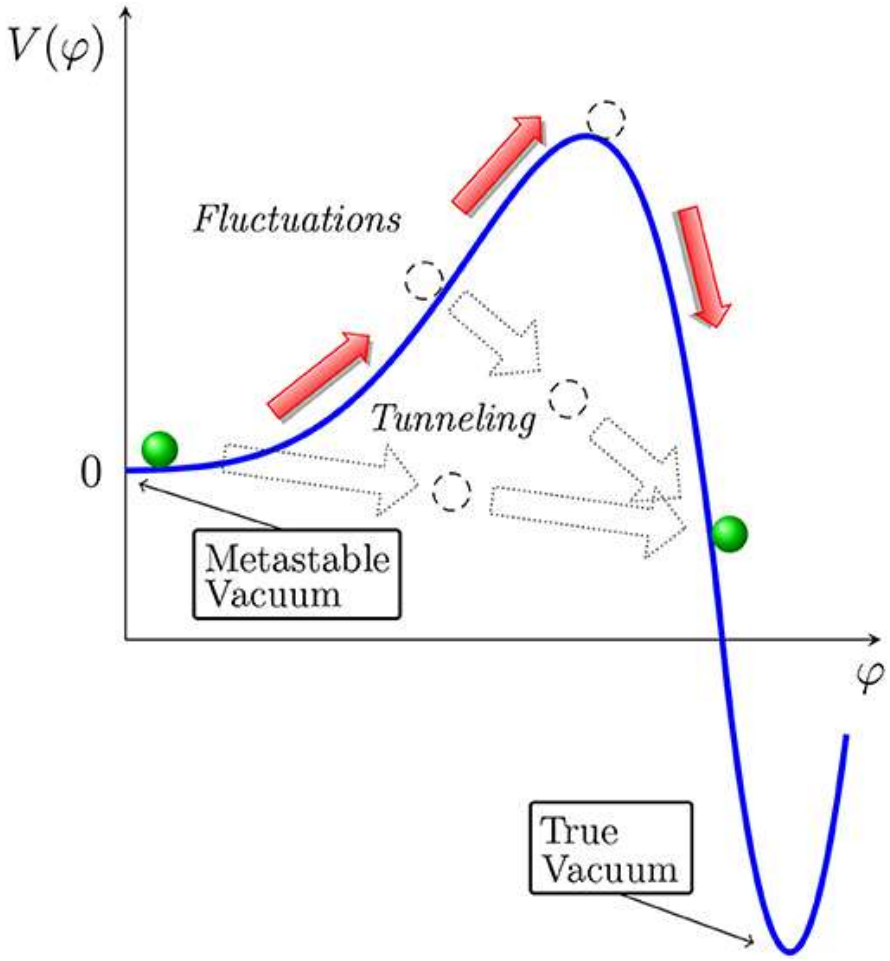

Figure 5:- Hypothetical Higgs decay (Markkanen et al., 2018).

Applicability of rationality and empiricism in morality and as the foundation of contentment

We can say that moral decisions should be based not on rationality, but that they should be based on certain codified doctrines largely found in several seminal texts of yesteryear or on our own visions of morality based on sensibilities, aesthetics, and sentiments as justification for a codified doctrine is difficult to find outside of organized religion. In taking this position, I tend to lean towards Hume's moral predilections as opposed to Kant's. Science cannot distinguish and discern an 'ought' from an 'is' because it is, at its essence, amoral and thus while moral justifications based on sensibilities and sentiments are valid and can be true, they cannot be construed as having held the same sort of truth as scientific truth which is altogether distinct, dichotomous even, to moral truths.

If we were to base moral decisions on pure reason, then one would simply plot different data points on a hypergraph, run the data through an automaton-like object, hypothetically through a system such as LaPlace's causally deterministic 'demon' and calculate the biggest causal link. In a strictly rational system, things most associated with this link would be punished. This is a far cry from our current moral system and would produce ostensibly absurd results (Hoefer & Spring, 2023). Another fundamental dissonance between rationality and morality is that morality presupposes that a human being is valuable. If we were to stick with strict rationality, then one may be inclined to agree with a nihilistic perspective. The consequences of this are either very good or very bad (if we are to presuppose the fundamental value of a human being). This means that there is no meaning to life and that you can make it what you want. All ideas of morality, righteousness, goodness, and evil are gone. Commit suicide, genocide or live a happy life, none of it matters since natural laws aren't changed by any of these actions.

We further remove ourselves from true scientific truth through the subliminal extrapolated imposition of anthropomorphic ideas and intuition on empirical laws and observations or the lack of the will to truth. In science, there exists only one branch of truth, a truth which is independent of us and truth which cares not about what we

think. There are two ways in which this idea of scientific truth has been violated. Firstly, there exists the imposition of anthropomorphic ideas and intuition on empirical laws and observations. In essence, we fail to recognize concepts that are solely human, such as ideas of morality and then impose them on nature or as an example in evolutionary biology (Wilson and Denis, 2022). Clearer examples are given by how we seek to impose morality on A.I., when we seek to impose morality among animals and when we argue for the application of certain, supposedly universal, moral values on purely aesthetic or cultural grounds. To observe this phenomenon, simply think about the number of people that would fault you for killing a ground beetle and compare that to the outrage that would arise should you choose to kill an animal that is seen as supposedly congenial, say a cat. Being wary of going down lines of reasoning because they may pose uncomfortable questions can be of great detriment to scientific advancement as nature does not owe humanity the privilege of following moral conventions and dictating research on these lines would serve no purpose besides placing arbitrary limitations.

'**Let us beware of attributing to it heartlessness and unreason or their opposites: it is neither perfect nor beautiful, nor noble, nor does it wish to become any of these things. Let us beware of saying that there are laws in nature. There are only necessities: there is nobody who commands, nobody who obeys, nobody who trespasses. But when will we ever be done with our caution and care? When will all these shadows of God cease to darken our minds? When will we complete our de-deification of nature? When may we begin to "naturalize" humanity in terms of a pure, newly discovered, newly redeemed nature?'**(Nietzsche, 1974)

As we can see, basing rationality on reason and science alone gives birth to a paradox. Born out of this we have a system that is both humane and inhumane simultaneously; how is one to determine morality when the presupposition behind all morality, namely that (human) life is valuable, can bear no judgment from science and reason? This selective imposition of the scientific method clearly begets fallacious conclusions.

What is happiness? As per the scientific consensus of modernity, it is simply the production of 'positive' hormones such as Endorphin, Oxytocin, Serotonin and Dopamine either through artificial means or through 'natural' means such as pursuing other pleasure-seeking activities (Arora, A, 2021). Are we to spend our whole lives stimulating our brains? To me, this leaves us with an unmistakably melancholic conclusion that we are nothing but biological machines striving for pleasure. In a system where such is the occurrence, we are nothing but subservient to the next opportunities that enable us to experience pleasure. In the moments where we are deprived of the modes of fulfilling heightened levels of cupidity and covetousness we would be totally exposed to the bitter truth, the truth that such a life is meaningless. One would be utterly distraught, only living for the next dose of pleasure and the one after in a perpetual cycle of extremes.

The elimination of this cycle and the usage of methods that eliminate displeasure are arguably worse for without the knowledge of physical or mental affliction how are we to determine the value or indeed definition of its antithesis. Indeed, a state of pure pleasure would cease to be pleasurable, as this is a relative term, rather it would simply become the new norm that seals humanity in a coffin of jaded indifference in relation to anything but pleasure-seeking. As is apparent, none of the conclusions one can draw from the strictly biological perspective of happiness are satisfactory. We can see the influence of this model of 'rational' hedonism in the modern world, particularly the western world.

'A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it'(Max Planck, 1949).

Institutional threats to the upholding of the scientific method and Mertonian norms

Within the last few decades, there has been an unprecedented regimentation and institutionalization within science, particularly within relatively advanced and mature disciplines such as theoretical physics and biology where potentially geriatric models are still in use due to general dogma and a stifling of creative thought through an overarching bureaucratic structure at some institutions. For example, newer models like a cyclical picture of cosmology, twistor theory and loop quantum gravity are not given nearly as much mainstream attention or funding as string theory, string theory here being the institutionally validated model.

Belief in science is thrown around by both political sides, with each side claiming that the authority of science reigns supreme when it suits them and flat out denying it when it doesn't match their beliefs. For example, right leaning

individuals may tend to deny climate science as it doesn't fit with their ideal economic model (relatively unregulated capitalism) while left leaning individuals may tend to deny the benefits of nuclear energy purely because it doesn't align with their pre-existing political beliefs (Grabmeier J, 2015). On topics such as climate change, there should be no politically fueled viewpoints as such, only the word of science and if either side chooses to supersede science with their own view on any relevant topics, then they are being intellectually dishonest when using science in other areas. Disbelief in science purely based on 'feelings' indicates a general distrust in the scientific method, as one cannot use a particular application of a premise while denying another. Both sides of the political aisle seem to selectively ignore and then selectively apply external scientific truth that is independent of them according to their own vested interests in a manner that is entirely dishonest.

This political bias impacts not only the discourse of the public but also has a restrictive impact on scientific institutions and the implementation of the scientific method itself. It can lead to research in certain fields such as evolutionary biology or psychology being, at times, needlessly constricted anda lack of funding for those that disagree with the mainstream consensus. These restrictions are clearly not desirable as you need the absolute best to do research in fields like theoretical physics and evolutionary biology, fields where progress is hard to come by regardless of themanner in which it is conducted and placing arbitrary restrictions on it does not make it any easier especially if these restricitions serve to enforce anything but the Mertonian norms. The ideal of absolute scientific and academic freedom must be upheld as the point of science is to seek out the objective truth, regardless of the anthropormphisedjudgements we may be inclined to cast on such truths.

'Convictions are more dangerous enemies of truth than lies' (Nietzsche, 1986).

This is not to say that scientists themselves cannot carry political beliefs, a political viewpoint carries with it no detriment to the scientific cause that is the search for truth insofar as it does not lead to dogma or needlessly ossified lines of thought and does not impede an individual's ability to uphold the Mertonian norms.

Conclusion:-

To conclude, this paper has examined the shortcomings of the Scientific method. The scientific process will face an everlasting threat in the future, and it is the duty of our generation to ensure impartiality within science for years to come. It is also our duty to carry forward the torch of humanity and to explore key questions surrounding the very methodological substrate of science as well as its applications within human and moralistic domains.

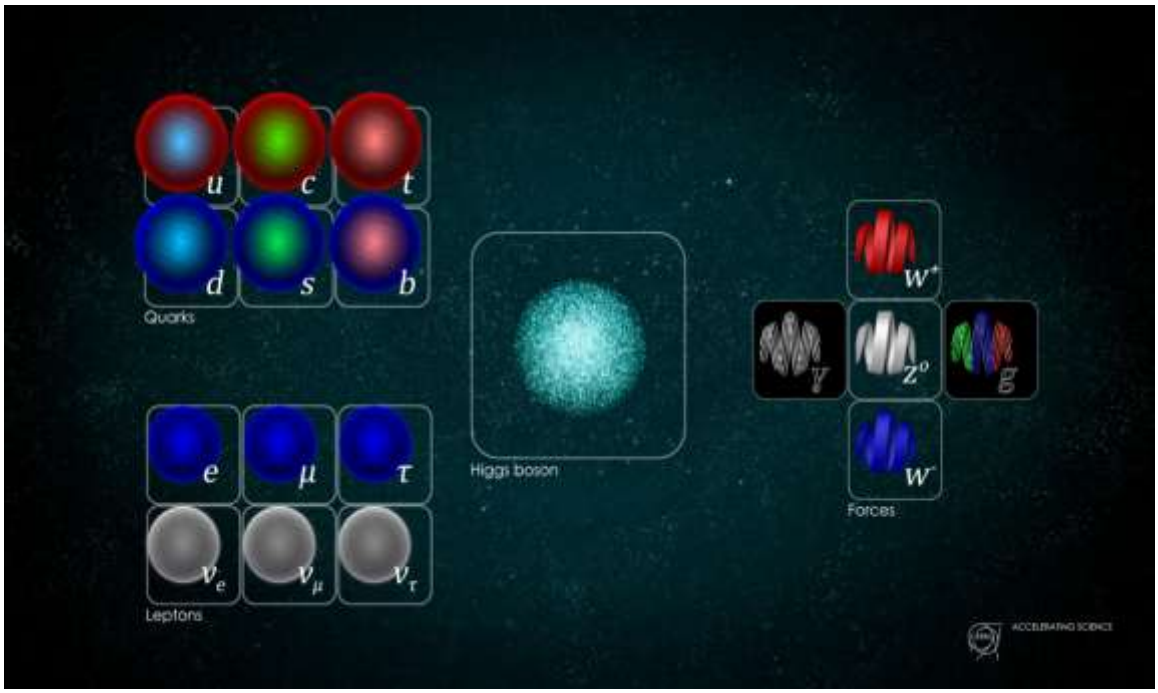

Fig. 1:- Particles of the standard model of particle physics (adapted from CERN, 2023).

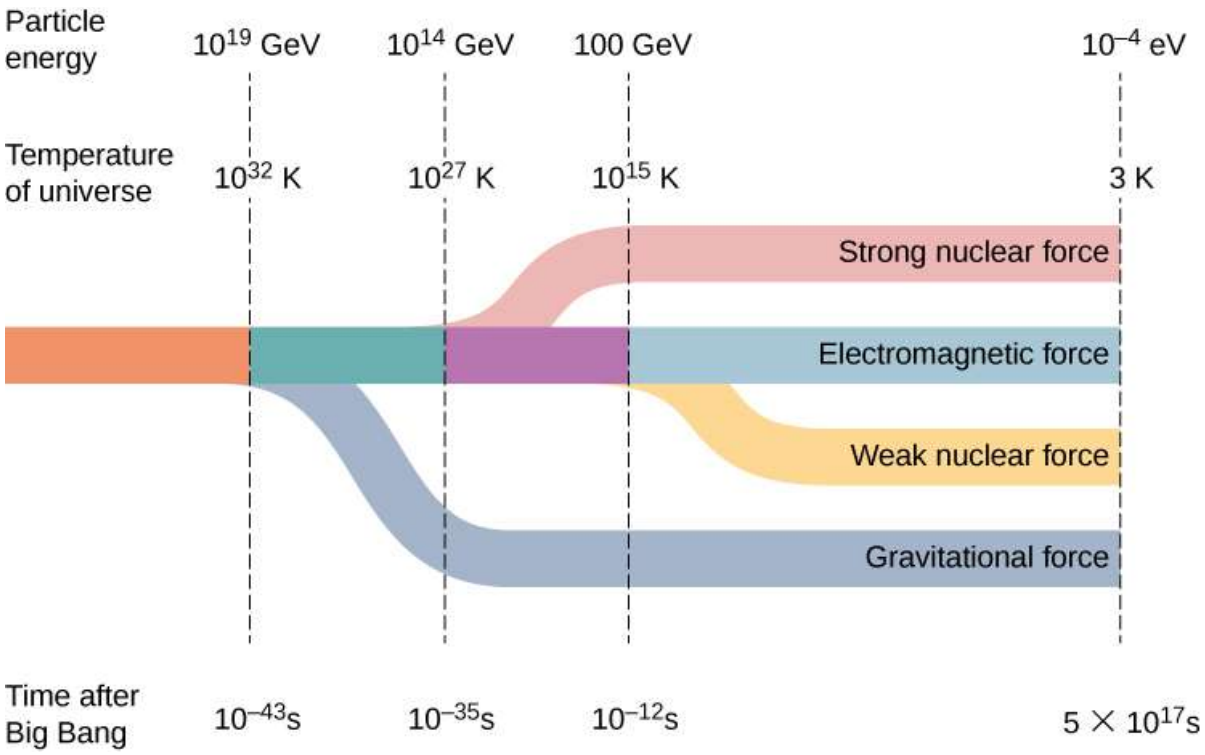

Fig. 2. Merger of the four fundamental forces (adapted from 'evolution of the early universe', Physics Libre Texts, 2022).

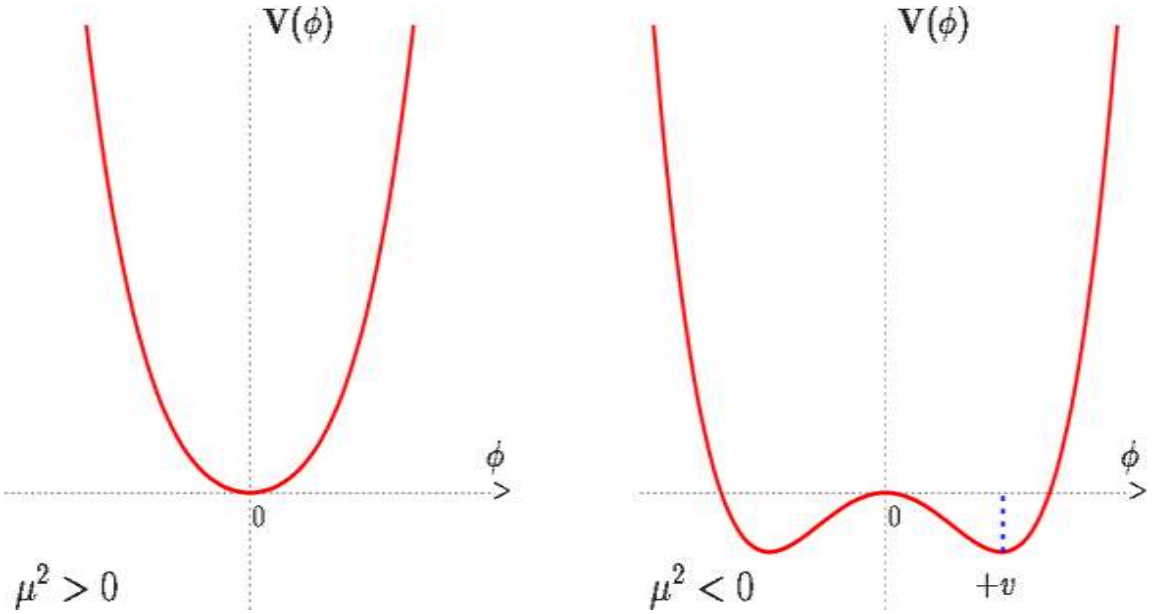

Fig. 3. Electroweak symmetry breaking of electroweak symmetry (adapted from Djouadi, 1970).

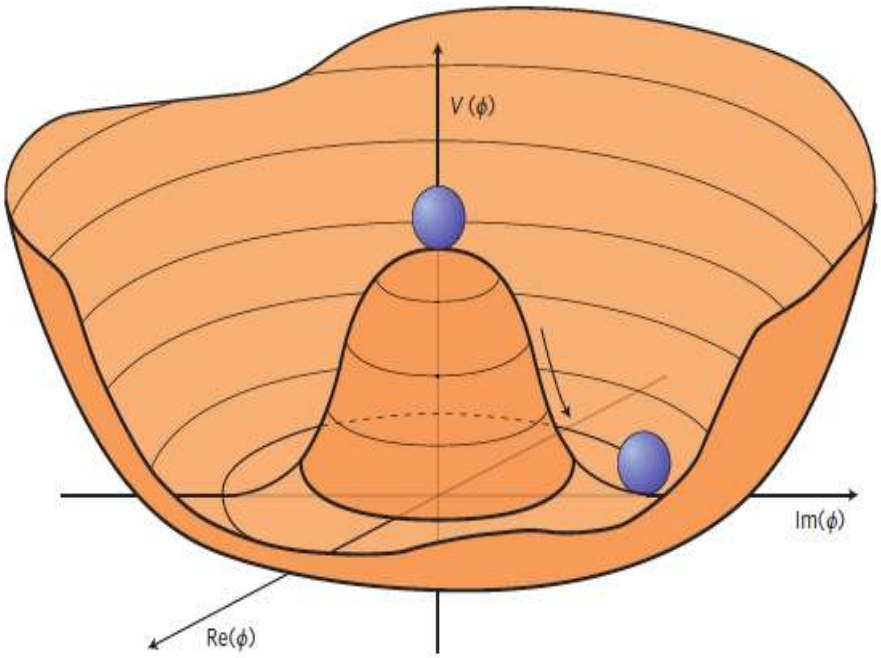

Fig. 4:- 'Mexican Hat' Potential after the breakage of electroweak symmetry (adapted from 'A historical profile of the Higgs Boson', CERN Document Server, 2015).

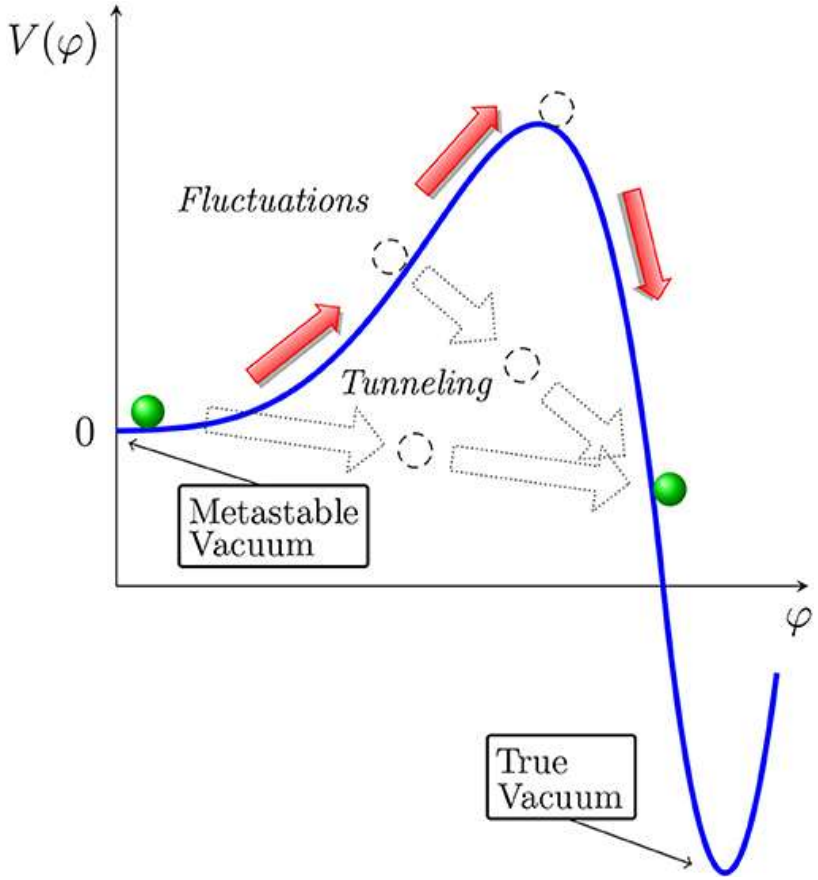

Fig. 5:- Hypothetical Higgs decay (adapted from Markkanen et al., 2018).

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