21^{st} Century Science: Redefining Progress

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Abstract

In the last several decades, there have been no major breakthroughs in physics, despite knowing it is incomplete, the standard model still hasn't fundamentally changed. We have theorized most of the discoveries up until now. Publicly, it is somewhat failing to answer Humanity's most fundamental questions. The golden age of physics, mainly characterised by the development of quantum mechanics has passed. Efforts to find a "theory of everything" or solving problems on gravity, understanding quantum mechanics, dimensions of space and time, dark matter, etc. all have all disappointed. There are still unanswered questions everywhere: from the tiniest of the small, to the biggest of the big, from the past, to the present and to the future, physics must set the unrealistic goal of solving every problem anchored in reality. This paper focuses on discussing the challenges this field has long been facing, finding answers where the issue lies, and how to break free from the curse to move forward.

1 Introduction

Since the 1970s, the theoretical field of fundamental physics has stagnated, perhaps the last major addition to the standard model has been made by Frank Wilczek, David Gross, and David Politzer in 1973 on asymptotic freedom in the strong interaction [1]. The last particle –the Higgs boson- was theorized in 1964, and observed in 2012 [2]. This is why some scientists, as Stephen Hawking did in 2001, fear the end of theoretical physics, it is undeniable that the lack of successful results is worrying. This might indicate that the efforts from the scientific community may not have been in the right direction. Philosophers Thomas Kuhn and Michel Foucault argued that scientific knowledge is not objective, but is instead shaped by the social and cultural context in which it is produced. Therefore, as scientific equipment have gotten better and more precise, our scientific methods have not followed [3].

We will be discussing science with the scope of the fundamental principles of nature in mind: through physics. One could argue that science has made progress in that we can apply it more rigorously, test results experimentally, and it is becoming more accessible. While this is true, it does not accurately represent the lack of innovation from the high-prestige field of analytical and theoretical science. It is an engineer's dream to incorporate new discoveries into our technologies (i.e. Quantum computing, Nuclear Physics, Molecular Physics, Astronomy, Medical instruments, etc.) We will explore the ways in which scientific revolutions happen, and some ways in which we can start uncovering new truths about are reality.

We must employ new research strategies to address the sluggish progress of the last 40 years. A scientific revolution is a fundamental shift in the way scientists and society at large view and understand the natural world. It typically involves a paradigm shift, where a new theory or explanation for observed phenomena is proposed that fundamentally changes the way we think about physics. Several factors are indicative of a scientific revolution, in the past when insurmountable evidence against the status quo, or new instruments and better technology was being developed, or when society underwent strong cultural shifts, etc. Those are some of the factors from which scientific revolutions are driven. But we already know that our theories are wrong, or at least need readjustments, we are just waiting for the spark to light the flame. Author Mark Buchanan stated that "If physics is dead, or at least in decline, then the methodology of physics is, by contrast, thriving"[4]. But this statement is not accurate in current affairs, as we are not witnessing and end, rather a stall.

Science is a multi-layered, and complex system involved in the acquisition and discovery of new knowledge. I believe it to be external to consciousness, in other worlds, the knowledge is there, waiting for scientists to discover it. It all relies on us to come up with the most flawless reasoning, and carry out the best experiments possible, always with more accuracy, and by interpreting the correct results. But it's not as easy as it sounds. We propose here, not the fundamental factors, alternatively new standards on which science should be based to drive progress in our day and age:

1. **No Politics in Science**
2. **Go Crazy with Experiments**
3. **No Theories Dismissed**
4. **Question Every Result**
5. **New, More Debates**

2 No Politics in Science

Science, should by definition be an objective study of the world, after making hypotheses it should focus on the facts [5]. Paradoxically it is subject to wild interpretations, and heavily influenced by the different cultural actors. For the sake of an illustration, we can observe that most of the physics research community is concentrated in universities, we must ask ourselves whether or not the liberal nature of western institutions is influencing the ways in which we study the world. Scientists all have a different approach when it comes to conducting new research. Their past experiences, mindset, political pressures, and generally cultural setting all heavily influence the field of study they might decide to pursue, the methods they will employ, or the interpretation of a result. This is how politics, culture, and science are heavily intertwined. Politically, the direct effects on science are double edged: On the one hand, governments and other political organizations can provide grants, scholarships, and other financial resources that allow scientists to pursue their research interests. On the other hands, political pressure can often influences the direction and findings of scientific research, leading to biased or inaccurate results.

Universities have been known to prioritize liberal values, which they may promote within their own institutional frameworks. For instance, many institutions value the concept of inclusion, which fosters a diverse environment where individuals from various cultural backgrounds can share their experiences and ideas. This value of inclusion is seen as essential in enhancing the quality and safety of teaching and research. However, it is important to note that equity should not be equated with lowering academic standards, as this can lead to under-qualification and undermine the integrity of the field. There are many ways for an institution to adopt measures to promote diversity and inclusion without compromising its academic rigor.

2.1 Modern Universities

The 12^{th} and 13^{th} centuries were a turning point in the evolution of education in Europe. Before then, academia was ruled by the christian church, influencing fields of study along with study itself. It was the beginning of the biggest paradigm shift in the power structures influencing academia. In the Middle-Ages, "Thinkers" were all christian believers and therefore could not step out these bounds. They were taught, ready to enter the ranks of the church. The aforementioned situation illustrates a somewhat contradictory situation both enabled and halted progress in theories [5]. This shows the importance of having independent thinkers, able to ask the right questions. Most of the research was dedicated to reinforcing faith, and institutions had so much power, that simply questioning the normality was enough to be humiliated and rejected from society. With hindsight, we can testify that they were not progressing towards a greater truth, rather digging an intellectual hole and jumping head-first in it. Therefore, we can say that truth is not decided by democratic principles, needs to distance itself from any bias, aiming to uncover the pure facts. What if, unbeknownst to us, universities are wielding similar power on academic-led researchers nowadays?

To some extent, one could argue that this is already the case, subjective theories are being taught all the time. In courses on modern physics and quantum mechanics, undergraduates are taught the widely used Copenhagen interpretation, a theory which has neither been proven nor wields any experimental proof. David Mermin elegantly portrayed the theory which seemingly tells us to: "shut up and calculate" [6]. Of course, in this instance the implications are not dramatic since our mathematical understanding allow for some freedom in interpretations. The liberal nature of universities also entails more dramatic scenarios, leading to a groupwide think where students are taught and to conform and are discouraged from expressing ideas or viewpoints that challenge the dominant narrative. They might then grow up to become more dismissive of new or different views that challenge the status quo. This is only one instance of subjectivity being used in institutions, while it is convenient to understand the real world, it must be known that hypotheses are not absolute. They can also be very detrimental to the research field, leading it into years of unnecessary research. We must not, however discredit academia, it is perhaps the best we have, and progress in physics will almost certainly come from there, but it is important to recognize that we might want to engage into more varied research.

2.2 Science: a Social Construct

Philosopher Bruno Latour's early book "*Nous n'avons jamais été modernes* (1991) later translated as "*We Have Never Been Modern*" asks where our most prestigious institutions are leading us. Latour challenged the extent to which truth can be discovered by these institutions through their scientific work. The root cause of this questioning comes to light when one realises that scientific knowledge is a construction of various social, political, and economic interactions. The question then does not regard the facts themselves, but where they come from, and the factors from which they emerged, involving a more complicated story than "just waiting to be discovered." As a consequence, science can be regarded as subtly distinct from pure facts, it is deeply rooted on an array of non-scientific causes: experimental instruments, debates, ideas, curiosity, legal battles, biases, and culture.

It is not just negative, but we are and will always be under the spell of our own cultures, sometimes constrained by it, other times it is a the best way to study a subject. In a wider context, this leaks to the rest of society, where the difference in ideology results in significantly different concerns and understanding, regarding different policy issues that are at the intersection of science and politics. Different populations and cultures have different approaches, due to the diversity of the cultures, impacting how citizens comprehend information. I believe that the Covid-19 pandemic has consequently led to a shift in how we understand scientific information, the reliability of its sources, and the ones we decide to trust. As an example, people all around the world view climate change differently, even the ways to understand and interpret results is different, influenced by the ideology they are subject to [7]. Since different people understand hypotheses, theories and ideas differently, how can science transmit information bypassing the cultural and political barrier, focusing on transmitting the facts, while promoting transparency?

Understanding science as a social construct entails that diversity has to play a major role in bringing more cultures, and more views to study the matter. Diversity comes in the people exercising the discipline, students, teachers, journalists, etc. And it also has a role in the medium used to perform such experiments: university, private companies, alone in a basement, etc. I believe the private sector, and people outside of universities should have full access to the resources: academic papers, textbooks, etc. This would promote the democratization of the knowledge, and lead to greater collaborations between actors of all different places, and backgrounds. When papers are made freely available, they can be more easily shared and cited, leading to greater exposure for the research and potentially more funding and support for further research in the field.

3 Go Crazy with Experiments

The politics in the field of research science often makes it difficult for ideas to spring into existence, it democratizes finding a direct application from the get-go. I believe a scientific exploration and revision of many theories, coming from more angles will be necessary to make significant progress to the standard model. To overcome this, I believe we need to embrace a scientific method known as

"Blue-skies research." This approach was incredibly successful during the Cold War when the United States and the Soviet Union invested heavily in scientific research without imposing restrictions. The vast sums of money poured into the space programs led to remarkable advancements in physics and engineering, culminating in the historic feat of landing a man on the moon in less than two decades. In this relatively short span of time, huge advances were made in physics and engineering. In the 1970s, once these efforts had died-down and came to an end, financial strains forced governments to scale-down their investments in science. This approach resulted in groundbreaking advancements in physics and engineering that fundamentally transformed human society. This is why it is essential to prioritize the culture of openness, curiosity, and creativity to promote innovative ideas and enable science to reach its full potential.

3.1 Blue-Skies Research

"Blue-skies" research in the 1960s marked a fundamental change in how research was conducted: governments invested in science a clear goal. Although economically unpopular, and very controversial, something like "blue-skies" research is necessary to make advancements in high-level fundamental theoretical physics. We need to explore many roads to find the correct path. Paul Dirac also believed in this method, in a 1963 paper, he infamously stated that "we can hope to make a guess at the kind of mathematics that will come into the physics of the future"[7]. Dirac then explains how Schrödinger stumbled upon his equations by "pure thought." Later developing the formalism associated with it, forming the core components of quantum mechanics. Of course, this wasn't part of a blue-skies research project, but it goes to show that not every discovery passes the lengthy process of the scientific method to become rigorous and viable, facts, while not being absolute, can be stumbled upon even by studying beauty, a concept seemingly opposed to science itself as it is purely subjective.

It's needless to say that science and creativity are hugely intertwined. At a higher level, science becomes more than just pure and rigorous calculations, it's a new way of modeling the world, a beautiful symphony of Greek letters, and numbers all with huge implications on our world. Simply thinking about inventions that were stumbled upon by accident should be a great motivator for an open type of research. In fact, one could argue that this thought process is how most, if not all important scientific discoveries happen: by asking creative questions, then coming up with interpretations and a new formalism. In February 2009, 20 United Kingdom scientists, including one Nobel laureate launched an attack on the U.K.'s seven research councils for trying to make this subtly change, now requiring grant applications to include a 2-page statement on the economic impact of the proposed work [9]. With this agenda being pushed, the funding that goes into curiosity-driven science could greatly be decreased. Research councils should not be disadvantaging blue-skies research, nor silencing creativity. The reason why something like blue-sky research is necessary is because it acts as a barrier to the cultural pressure on science to invest in purely biased research and to interpret results in one way above another.

3.2 Peer Review

The early 1970s marked the end of large scale research and significant improvement in our views of the nature of the universe. Simultaneously, the "peer-review" became the norm for all scientific publishing. Peer-reviewing allows for the publication of papers under strict criteria, where a panel of blind reviewers determine if the article in question fulfills the criteria. In the medical field, and public health sector, where information is highly sensitive, this is a great way to ensure the reliable publishing of information, although it might be partially hindering its access. But in theoretical research physics, implementations of discoveries are not direct, and the peer-review process becomes more detrimental. Robert Maxwell, Elsevier and other people and businesses grew this into a lucrative business, where universities had to subscribe to his empire. Nowadays, fellow researchers and independent scientists cannot freely access articles, and discoveries discredited [10]. The number of open access articles is growing, but the change isn't radical enough. Applicants for research grants usually budget for the cost of presenting results at conferences, but not for open access publication. It should be a condition of any government research grant that a full report of the findings be made publicly available on completion of the research.

I believe peer-review to be a major contributor to the slow progress of physics. Apart from bringing a lack of transparency and standardization, it makes the physics community seem more like a cult than a rigorous scientific discipline. With this black box of a system, creativity is limited, and theories dismissed. This is how string theory has stayed as the main focus for scientists, and why only recently, have scientists been questioning it. Now we don't know whether or not it has even answered the questions for which it has been put forward. To stray away from this culture, we need a more exploratory community and to be forgiving when observing results that don't pan out. We should not so easily discard string theory, simply focus on the bigger picture, and tackling the problem from more standpoints. To foster a more exploratory community, I believe we should adopt a more forgiving approach towards results that do not conform to expectations and focus on the bigger picture.

4 Question Every Result

Scientific knowledge is an ever-evolving and dynamic process that is continuously subject to revisions and updates. The reason for this is that the world is incredibly complex, and our understanding of it is limited by the information we have at any given moment. Therefore, it is vital to continuously question and re-examine our theories, concepts, and hypotheses in light of new evidence and observations. This process of questioning and revising our ideas ensures that our understanding of the universe is as accurate and comprehensive as possible. There are often multiple explanations for the same phenomenon, and our ability to distinguish between them depends on the quality and rigor of our scientific inquiry. By continually questioning our results and hypotheses, we can identify and explore alternative explanations, which can lead to new insights and discoveries. This process is fundamental to scientific progress and is a testament to the importance of scientific inquiry as a tool for understanding the world around us.

The pursuit of scientific knowledge is a continuous journey, and it is through our willingness to question, revise, and explore that we can achieve a deeper understanding of the world in which we live. This exploration is not limited to the path we have paved, therefore it might involve violating previous "no-go" theorems, sometimes based on assumptions, or with clear limitations. For example, the Bell's inequality theorem was thought to fiercely hold its ground, as a consequence the theories regarding the predictions of quantum mechanics such that it could not be explained by any local theory. However, this theorem was later violated through experiments, which led to the discovery of quantum entanglement. In this way, science could uncover and explore more avenues, opening new fields of research, leading to the development of new technologies. While science is often driven by beauty itself, one may have to sacrifice it temporarily to uncover the deeper mysteries of our reality.

Experimentalists play a critical role in scientific research by developing and conducting experiments to test and verify theoretical hypotheses. They recognize that scientific knowledge is not static and that advances in technology and theoretical frameworks can expand our understanding of the world. To achieve this, experimentalists employ various methods such as conducting more precise experiments, developing new theoretical frameworks, or using new technologies.

These approaches can serve several purposes. Firstly, they may be used to validate or refute existing theoretical models or thought experiments. In doing so, experimentalists can confirm the accuracy of established theories and identify areas where additional work is needed. Secondly, experimentalists can use these methods to challenge or disprove existing hypotheses, revealing flaws or limitations in current understanding. By identifying gaps in knowledge or revealing discrepancies in existing theories, they can drive scientific progress forward. Finally, experimentalists may employ these methods without a specific goal in mind, hoping to uncover something unexpected in the process (Similar to the blue-skies process). These exploratory approaches can lead to the discovery of entirely new phenomena or the development of innovative technologies that can advance scientific research in unforeseen ways. It's important that science, disregards personal opinion and continues to explore every road possible, experimentation, observational studies, theoretical analysis, simulations, historical analysis, etc.

5 No Theories Dismissed

The underlying reason why science has reached a point of stagnation may be attributed to the evolving field of physics, but we as scientists have not been able to adapt to the new physics field. Many physicists argue that we are still using 20^{th}-century methods with 21^{st}-century equipment and that we are scared to leave our comfort zone and develop new theories. This is easier to say than to solve. I believe that for science to evolve, it must step away from political pressure and detach itself from the cultural and historical baggage it carries. One example takes place at MIT, where graduate students still learn and research the field of supersymmetry in quantum field theories (QFT), keeping them in the cultural dogma [11]. Introducing QFT is necessary to explain the standard model, but it does not delve into subjects like neutrino physics. That is not to say that string theory should be entirely discarded. Some elements of it may be relevant in a grand unifying theory, but its failures cannot be denied, hinting that we should stray away from it.

Science is a battle of ideas and theories which hopes to find the ultimate view of nature, to undergo such a task, humans will need to develop new ideas, methods, and platforms in order to increase the common brainpower at hand. Scientists must also remove the prejudice they hold towards new theories. This culture demotivates scientists most of whom often prefer to stick to the masses, without deviating from this group think. As it currently stands, there is often too much risk associated with tackling subjects from a different angle. Going against the status quo is neither worth a career, nor a life, there is already so much pressure for scientists and few are ready to tackle these huge problems.

6 New, More Debates

In every section of this essay, we've defined science as a new notion, this time we'll discuss how it can be regarded as a common ground for intense debates. Science is a dynamic field, and it requires a constant influx of new ideas to evolve and progress. Engaging in debates is an effective way to introduce fresh perspectives, challenge existing theories, and stimulate discussions among scientists. Through debates, researchers can expose their ideas to a diverse audience and receive constructive feedback, which can refine their theories and improve their communication skills, welcoming more people to the table and making it accessible to a wider audience. Debates can help remove the stigma around being wrong and encourage researchers to be more open to feedback and criticism. The scientific community must get comfortable being uncomfortable.

The complexity of scientific theories, such as quantum mechanics, can often lead to a disconnect between scientists and the general public. While these theories have been proven, their consequences are not always clear and can be difficult to understand. This has led to criticism of quantum physicists for presenting their work in an overly complicated and inaccessible manner. Simply recall the famous Feynman quote: "Nobody understands Quantum mechanics". It is however the responsibility of scientists to communicate their findings in a clear and accurate way to the wider public. The truth of scientific discoveries is ultimately decided upon by common agreement, but if only a small group of individuals understand or accept these ideas, their value is limited. Therefore, engaging in more debates with the outside world can help to bridge the gap between scientists and the public and promote a better understanding and appreciation of scientific progress.

6.1 Discussions

Over the course of centuries, philosophers have thought of the best form of oral communication for humans. Each has a specific set of goals which it aims to accomplish, this is why the format we choose to employ when communicating is so crucial. For example, in an interview, the interviewer hopes to learn more about his/her subject, it is often more formal and respectful than a discussion, sometimes even challenging the ideas presented. A speech on the other hand is a completely different way to transmit a message: it is delivered to an audience for a specific purpose, such as to inform, persuade, or inspire. Speeches can take different forms, including motivational speeches, political speeches, and commemorative speeches. So what is the most effective way of transmitting a scientific message?

Recently podcasts, Talks, and short form of video content have greatly increased in popularity, sometimes as interviews, speeches or discussions, or simply clips introducing an idea, a concept or a method. Through this form of content, many scientific fields are left behind, not being accessible enough. As a result, many pseudo scientific theories have gained traction. Science may need to develop and adapt to these mediums in order to become more attractive, increasing diversity as a byproduct. From an outsider's perspective concepts may seem out of reach, and restricted, sometimes gatekept by the scientific community.

6.2 Better Formats

Bohmian dialogue is a form of discussion first invented by David Bohm, a famous physicist, known for his works and interpretation of Quantum mechanics. It would best be described as a supervised version of a Socratic dialogue. In Bohmian Dialogue participants are encouraged to suspend their own personal beliefs and assumptions to engage in collective thinking to arrive at a shared understanding of a concept or idea. This approach allows for a deeper exploration of complex ideas by encouraging individuals to listen deeply to one another and build on each other's ideas. To set up a Bohmian Dialogue, a facilitator is needed who guides the process and helps to create a safe and respectful environment for participants to engage in open and honest conversation. The facilitator begins by presenting a topic or question for discussion and invites participants to share their initial thoughts and feelings on the subject. The facilitator then encourages participants to listen deeply to one another and to build on each other's ideas through open-ended questioning and reflection.

The discussion is structured around four key elements: listening, inquiry, reflection, and dialogue. Listening involves paying attention to what others are saying without judgment or interruption, and trying to understand their perspective. Inquiry involves asking open-ended questions to explore the topic in greater depth and to challenge assumptions. Reflection involves taking a step back to think about what has been said and to consider new perspectives. Finally, dialogue involves engaging in a collective exploration of the topic, building on each other's ideas and working towards a shared understanding. Bohmian Dialogue can be particularly useful in scientific discourse because it encourages individuals to engage in open and honest conversation about complex and controversial ideas. By suspending personal beliefs and assumptions, participants are able to explore new and innovative ways of thinking about a subject, which can lead to new insights and discoveries. By listening deeply to one another and building on each other's ideas, participants are able to create a more nuanced and comprehensive understanding of the topic, which can help to inform future research and scientific inquiry.

Another method of discussion that is gaining popularity is the fishbowl method, in which a small group of participants sits in a circle in the center of the room while the rest of the audience sits around them. The participants in the fishbowl are encouraged to engage in a respectful and open discussion of the topic at hand, while the audience listens and observes. This method allows for a more intimate and collaborative approach to debate, and encourages participants to listen actively and consider multiple perspectives. It is similar to the 3-2-1 method because it also involves the participants sharing takeaways from a discussion. As the name suggests, the 3-2-1 format involves sharing three things they learned or found interesting, two questions they have, and one thing they would like to explore further. This method encourages participants to reflect on what they have learned and to identify areas where they may need more information.

7 Conclusion

In this paper we discussed some of the reasons why science has been slowing down, with the field of physics is facing significant challenges that have led to a slowdown in progress. Peer review, politics, lack of funding, and a failure to adapt to modern communication methods are just some of the factors contributing to this issue. However, there are solutions that can help address these challenges, including promoting diversity and inclusion in science, engaging in open and honest discussions, and redefining progress in the field. It is important to continue striving for progress and to always challenge our assumptions and beliefs in order to advance our understanding of the natural world. By doing so, we can hope to push the boundaries of what we know and make new discoveries that will benefit society as a whole.

Of course, even after having implemented solutions, excluding politics from physics as much as possible, reinvesting in research, questioning every theory possible, and engaging in debates, it's still possible physics stagnates. No doubts there will be other options than those I have proposed here that people will explore, since solving fundamental questions require drastic change in our physical interpretation. I suggest a reorganisation on how we study the fundamentals of nature: mathematically, physically, or experimentally. My belief is that this will breath in fresh air and people might, as many did, discover better equations, and be able to peak behind the curtains which limit our understanding. This is why we must diversify our involvement as we don't know where progress might come from. I'm confident that sooner or later, we will make progress whether or not we stay on the current course of affairs, but I believe redefining progress should offer a significant shortcut, removing the nonsense from physics. Science is not absolute, it absolutely can become better.

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