PHYSICS, MATHEMATICS, AND THE THEORY OF SOMETHING

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Abstract

Physics seeks to model the entire observed physical universe. Mathematical physics, however, can only model what can be quantified. A key feature of the physical universe, the observed Arrow of Time, cannot be quantified. Mathematical physics therefore cannot model the Arrow of Time. As a consequence, a theory of mathematical physics is only ever a Theory of Something – never a Theory of Everything in the broadest sense, since it cannot model the observed Arrow of Time. This means that a single unified theory that models the entire observed physical universe cannot be a theory of mathematical physics. Instead, if it exists, it must be a more general theory of qualitative physics.

1. Introduction

We may be approaching an important milestone in the history of scientific knowledge. We are on the precipice of synthesizing all scientific knowledge into a single unified theory, if it exists. The discovery of such a theory may occur only once, if at all. This once-in-millennia opportunity is galvanising some of the best minds to seek the single unified theory. The person or group who discover the theory, if it exists, will join some of the greatest thinkers of all time.

We can trace the systematic development of knowledge back to the philosopher Thales of Miletus (624-546BC) who proposed the first recorded unified theory – everything was ultimately made of water. Since that time, science and philosophy has pursued two approaches – analysis which breaks our understanding of nature into smaller and smaller parts, and synthesis which combines these parts back into a more general theory of nature. Almost all scientists pursue analysis – which provides the backbone of facts and theories that underlies all of science. However, the great scientists have pursued synthesis. Isaac Newton (1642-1727) showed that terrestrial gravity and the motions of the planets were all explained by the one force: gravity. Charles Darwin (1809-1882) showed that biological diversity could be explained by the theory of biological evolution. James Maxwell (1831-1879) showed that electricity and magnetism were parts of one force: electromagnetism. Albert Einstein (1879-1955) showed that space and time combined into one entity: spacetime; and that the curvature of spacetime is gravity. Max Born (1882-1970), Erwin Schrödinger (1887-1961), Werner Heisenberg (1901-1976), and others showed that the underlying structure of energy/matter in space and time is explained by quantum mechanics. An army of physicists over the middle half of last century showed that our observed particles of nature could be explained by the Standard Model of Particle Physics. What awaits us is a scientist/philosopher or a group of them that can synthesis our understanding of nature into a single unified theory, if it exists. It appears that we have collected sufficient scientific knowledge to complete the unification. What awaits is the crowning glory of bringing it all together, if this is possible.

Physicists, in general, believe that the single unified theory must be a mathematical theory. In this paper we show that a theory of mathematical physics is only every a Theory of Something, never a theory of the entire observed physical universe. As a consequence, the single unified theory that models the entire observed physical universe cannot be a mathematical theory. Instead, if it exists, it must be a more general theory of qualitative physics.

2. The Observed Arrow of Time

The Arrow of Time represents the empirical observation that time flows from the present to the future and not from the present to the past. There are many ways we may observe the Arrow of Time (see Table A).

Table A
Empirical Arrow of Time

Observations of the Arrow of Time	**Description**
Cosmological arrow	Expansion of the universe
Causal arrow	Effects follow causes
Measurement arrow	Quantum collapse of the wave function
Uncertainty arrow	Whilst possible to know past exactly, not possible to know future exactly
Particle arrow	Kaon decay
Radioactive arrow	Radioactive decay
Electromagnetic arrow	Outward flow of electromagnetic radiation
Thermodynamic arrow	Increasing entropy
Biological arrow	Biological evolution
Ageing arrow	Death comes after conception
Record arrow	Records of past (e.g. fossils), not future
Psychological arrow	Remember past (e.g. memories), not future
Knowledge arrow	Know things in past, not future
Intervention arrow	Bring about things in future, not past
Symmetry breaking arrow	Increasing symmetry breaking (in general)
Complexification arrow	Increasing biological, ecological, sociological, and economic complexity (in general)

These different qualitative observations provide the empirical evidence for the existence of the Arrow of Time. For example, the observation that effects follow causes provides empirical support for the

Arrow of Time. Whilst for many lay people the Arrow of Time appears to be a common sense observation, some physicists and philosophers argue that it must be an illusion since the theories of mathematical physics do not model the Arrow of Time [1-2]. However, there is a simpler explanation consistent with empirical evidence for why mathematical physics cannot model the Arrow of Time: mathematical physics cannot model something that cannot be quantified – and the Arrow of Time cannot be quantified. This brings us to the very question of how we quantify time.

3. The Quantification of Time – and Space

Let us begin with a simple example that distinguishes between measurement and quantification. Consider an object that is moving at 10 metres per second. Let us define our first measurement of this object to be at time t = 0 seconds and position s = 0 metres. This measurement is quantified in our terminology by the pair of quantities (0,0). Similarly, we can measure the position of the object in the direction of its motion at the later times t = 1, t = 2, and t = 3 seconds as shown in Table B.

Table B
Measurement and Quantification
of Times and Positions

Temporal Measurement (in the direction of the Arrow of Time)	**Spatial Measurement** (in the direction of the object's motion)	**Quantification**
t = 0 seconds	s = 0 metres	(0,0)
t = 1 second	s = 10 metres	(1,10)
t = 2 seconds	s = 20 metres	(2,20)
t = 3 seconds	S = 30 metres	(3,30)

These three measurements are quantified by the corresponding pairs of quantities (1,10), (2,20), and (3,30). Mathematics works with these pairs of quantities. In this example, the simplest mathematical equation modelling the relation between each pair of quantities is:

$$s = 10t$$

However, in the process of quantifying the temporal and spatial measurements, the units of measure (i.e. seconds and metres) are lost. The units of measure are not encoded into the each pair of quantities and, therefore, not into the corresponding mathematical equation. Instead, we need to impose the units of measure from the outside on each pair of quantities and the corresponding mathematical equation.

Similarly, the physical location corresponding to the first measurement is not encoded into each pair of quantities nor the corresponding mathematical equation. Instead, from the outside we need to impose the mapping from the pair of quantities (0,0) to the observed physical position of the first measurement – or to the physical location corresponding to another of the quantity pairs.

Now, the direction of measurement of spatial distance does not have to be in the direction that the object is moving. Instead, it could be in the opposite direction. In that case, our measurements could be those shown in Table C.

Table C
Measurement and Quantification
of Times and Positions

Temporal Measurement (in the direction of the Arrow of Time)	**Spatial Measurement** (in the opposite direction to the object's motion)	**Quantification**
t = 0 seconds	s = 0 metres	(0,0)
t = 1 second	s = -10 metres	(1,-10)
t = 2 seconds	s = -20 metres	(2,-20)
t = 3 seconds	S = -30 metres	(3,-30)

In this case, the simplest mathematical equation representing the relation between each pair of quantities is:

$$s = -10t$$

The direction of spatial measurement is not encoded into each pair of quantities nor the corresponding mathematical equation. Instead, we need to impose the direction of spatial measurement from the outside on each pair of quantities and the corresponding mathematical equation.

Importantly for this discussion, the direction of measurement of temporal distance does not have to be in the direction of the observed Arrow of Time either. Instead, it could be in the opposite direction. The measurement could be of how long *before* the time t=0 rather than how long *since* the time t=0. In that case, our measurements could be those shown in Table D.

Table D

Measurement and Quantification
of Times and Positions

Temporal Measurement (in the opposite direction to the Arrow of Time)	**Spatial Measurement** (in the direction of the object's motion)	**Quantification**
t = 0 seconds	s = 0 metres	(0,0)
t = -1 second	s = 10 metres	(-1,10)
t = -2 seconds	s = 20 metres	(-2,20)
t = -3 seconds	S = 30 metres	(-3,30)

In this case, the simplest mathematical equation representing the relation between each pair of quantities is:

$$s = -10t$$

The direction of temporal measurement is not encoded into each pair of quantities nor the corresponding mathematical equation. Instead, we need to impose the direction of temporal measurement from the outside on each pair of quantities and the corresponding mathematical equation.

In summary, when we make temporal and spatial measurements we record the measurements together with five physical attributes associated with the act of measurement:

1. The unit of time (i.e. seconds).
2. The unit of space (i.e. metres).
3. The physical location corresponding to the quantity pair (0,0) – or the physical location corresponding to another of the quantity pairs.
4. The direction of measurement of space.
5. The direction of measurement of time.

However, when we quantify the measurements – which we represent by quantity pairs – we lose the above five physical attributes which are not encoded into the quantity pairs. The mathematics of mathematical physics models quantity pairs, without knowledge of these five physical attributes. Instead, we need to retain this information outside of the mathematics and then impose it back on the mathematical solutions. In our example, the direction of measurement of time is not encoded into the quantities nor the mathematical equations. But what about more generally?

4. Mathematical Time versus Real Time

Consider any equation of mathematical physics with a time variable t. We think of the variable t as being real time – the time we experience day-to-day. However, the variable t is not real time. Instead the variable is mathematical time, which is a model of real time. The key difference between real time and mathematical time is that real time has the observed Arrow of Time whereas mathematical time most definitely does not. And it is mathematical time that is used in the equations of mathematical physics. To understand why, consider how a quantity is substituted for the time variable in an equation of mathematical physics.

When we substitute for the time variable, what we do is enter a quantity representing the position of one instant of time into the equation. May be with some additional substitutions for other variables, we get an output quantity from the equation. We can repeat this exercise by substituting other quantities representing different positions of instants of time into the equation one after the other. And may be with further variable substitutions corresponding to each instant of time, we get additional output quantities from the equation one after the other.

In total, we have an infinite collection of quantities representing the position of different instants of time that we can substitute for the time variable. However, this infinite collection of instants of time is mathematical time, not real time for two reasons.

1. Each instant of time is static – each instant only has a position and is not moving in any direction, so there is no movement in mathematical time to provide the Arrow of Time.

2. Each instant of time is a mathematical point with no parts. So there is no part of an instant of time that comes slightly before another part of the same instant of time, so to provide a compass needle for the instant of time pointing from the past to the future.

While the above two reasons refer to individual instants of time, the infinite collection of instants of time does not introduce an Arrow of Time over and above each instant of time. This is because each instant of time is independent of each other instant of time – other than their relative position. The very mathematical structure of mathematical time cannot encode the Arrow of Time. This does not mean there is not an observed Arrow of Time – rather it means that mathematical physics is limited to the use of mathematical time, which cannot model the observed Arrow of Time. This is a fundamental hidden subtlety in the use of mathematics in physics – mathematics cannot model the observed Arrow of Time, which is a fundamental component of the physical universe.

Real time is a continuous qualitative temporal medium with an observed Arrow of Time. On the other hand, mathematical time is a mathematically continuous, quantitative, static, undirected model of qualitative real time.

Just like in the earlier example where upon quantification we lost the five physical attributes associated with the act of measurement, so when real time is quantified – by breaking it into an infinite collection of instants of time – the Arrow of Time is lost. Any mathematics that uses quantified mathematical time cannot model the qualitative Arrow of Time. As a consequences, the equations of mathematical physics are time symmetric – they do not model the Arrow of Time. Instead, we need to retain information about the Arrow of Time outside of the mathematics and then impose it back on the mathematical solutions.

5. The Observed Arrow of Time Cannot be Quantified

Mathematical physics can only model what can be quantified. The observed Arrow of Time cannot be quantified. Mathematical physics therefore cannot model the Arrow of Time. This deduction is supported by empirical examples of time-directed observations of nature that are not captured by mathematical physics.

The classic example is evolution, whether it be physical, chemical, biological, psychological, cultural, economic, or universal evolution. Evolution is a time directed process where the history of events impacts the current evolutionary state. In evolutionary time, the past is different to the future – there is an Arrow of Time. But since mathematical physics cannot model the Arrow of Time, our fundamental theories of evolution are more general qualitative theories – not mathematical theories.

The academic subjects with an underlying reliance on the Arrow of Time include biology, psychology, sociology and economics. Since the Arrow of Time cannot be quantified and modelled by mathematics, these fields are much less mathematical than physics. It is not that we do not have the right mathematics to treat these fields with the same power and rigor as physics, but rather that mathematics cannot in principle model the Arrow of Time which is a cornerstone of these fields.

But if mathematical physics cannot model the Arrow of Time, then can there conceivably be a single unified theory that models the entire observed physical universe – including the Arrow of Time? The answer is yes.

6. Need for a Single Unified Qualitative Theory of Physics

There are currently three fundamental theories of the observed physical universe. These theories are:

1. General theory of relativity.
2. Quantum theory.
3. Universal evolution theory.

The general theory of relativity and quantum theory are mathematical theories. However, universal evolution theory is a qualitative theory, not a mathematical theory. Since it is not a mathematical theory, it is not possible to combine the three theories into a single unified mathematical theory. However, since a mathematical theory is a subset of a more general qualitative theory (i.e. we can always qualitatively describe the mathematical theory), all the theories can be classified as qualitative theories. It is therefore conceivable that these three theories can be combined into a single unified qualitative theory that models the entire observed physical universe.

Put another way, theories of the physical universe can be classified into qualitative theories and mathematical theories (which are a subset of qualitative theories). We have deduced that the single unified theory cannot be a mathematical theory. So, if there is a single unified theory that models the entire observed physical universe, then this theory must be a more general qualitative theory of physics – not a mathematical theory.

What it means for something in the physical world (i.e. the Arrow of Time) to be NOT describable or model-able in terms of mathematics is that it needs to be modelled qualitatively instead. We are missing interesting physical theories because we are committed to particular mathematical frameworks – instead of recognising that not all of nature can be modelled by mathematics. If there is a single unified theory that models the entire observed physical universe, it cannot be a mathematical theory since it would not capture the observed Arrow of Time. Instead, it needs to be a more general qualitative theory.

7. Why we have not Discovered the Single Unified Theory

There are two cultural issues that are holding us back from discovering a single unified theory of the entire observed physical universe, if it exists. They are:

1. The cultural belief of the physics community that such a theory must be mathematical, even though mathematical physics cannot model the Arrow of Time.
2. The cultural practices of academic philosophy do not encourage the study of qualitative theories of nature deduced top-down from first principles, even though top down philosophical systems were at the heart of philosophy up until the beginning of last century.

It is not because we are not smart enough to discover the single unified theory nor that we do not have enough information to discovery the single unified theory. Rather, if it exists, the problem is that we are searching for the single unified theory in the wrong place.

One reason we may not have discovered the single unified theory of the physical universe, if it exists, is that most of our great minds operate within the scope of academia – but the solution is outside of this scope. The current scope of academia does not encourage the study and publication of single unified qualitative theories that model the entire observed physical universe. If and when the scope of academia is extended to include these theories, it is conceivable that a single unified theory of the physical universe may be discovered – if it exists. We cannot be sure it exists since it is conceivable that there are a few principles underlying the universe, but the principles do not allow us access to sufficient information to determine what they are.

8. Structure of the Single Unified Theory

One of the notable features of the fundamental mathematical theories of physics is that they are deduced from a small number of qualitative empirical principles. If we cannot unify our fundamental theories mathematically then, if it is possible, we need to unify our theories qualitatively. What this means is that, if possible, we need to deduce the principles that underlie our fundamental theories from as few qualitative empirical first principles as possible.

The structure of the single unified theory, if it exists, is a qualitative theory deduced top-down from qualitative empirical first principles that are consistent with the foundational theories – the general theory of relativity, quantum theory, and universal evolution theory. That is to say, the single unified theory needs to deduce the qualitative principles of the foundational theories from as few qualitative empirical first principles as possible. Whereas the foundational theories have synthesised their parts of science mathematically bottom up, the single unified theory – if it exists – synthesises science qualitatively top down from qualitative empirical first principles.

What is quite remarkable is that there is almost no one searching for the single unified theory in this way. Many physicists are focused on searching for a mathematical theory to unify the general theory of relativity and quantum theory – even though this does not unify all of science, since universal evolution theory is not included. On the other hand, philosophers are quickly losing the opportunity to develop a philosophical system whereby the principles of the three foundational principles can be deduced from empirical first principles – because their discipline does not approve of such research.

If we step outside of the constraints of academia, the solution space for solving this great unanswered problem is opened up. There is a qualitative land of opportunity in which to discover the single unified theory. This opportunity is analogous to the opening up of the Wild West. However, there are only a few pioneers who in recent times have entered the qualitative land (e.g. [3]). It may be time for more to follow their lead.

9. Conclusion

We need to move on from the current impasse in physics and philosophy. We need to give up the notion that the single unified theory that models the entire observed physical universe is a mathematical theory – since it cannot be. We need philosophy to open up and take-on its millennia-old principle-based approach to unifying knowledge. But unlike earlier times where many of philosophy's principles were non-empirical, it needs to avoid those errors by ensuring any first principles are empirically based.

We need to recognise that mathematics can only model what can be quantified – and the Arrow of Time cannot be quantified. We need to recognise that mathematical physics cannot model the Arrow of Time. We need to recognise that mathematical physics cannot model the entire observed physical universe. We need to open up more positively to qualitative theories, like evolution theory, since whilst qualitative theories do not make explicit predictions – they have the advantage of being more general.

We need to recognise that mathematics is an important modelling tool of physics – but it is not the only modelling tool. We need to recognise that mathematical physics is an important branch of physics – but not all branches of physics are mathematical.

We need to search for the qualitative empirical first principles of the single unified theory of physics. We may be close to finding the theory, if it exists – but we will only find it if we look in the right place.

References

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[3] Scoular, S.C., *Beyond the Mathematical Paradigm of Science*, 2014.