**The Grand Design**

Stephen Hawking and Leonard Mlodinow’s latest work, *The Grand Design*, is a brief and reasonably easy-to-read account of some of the essential theories in quantum physics, culminating in a very broad-brush picture of where modern physics is currently at. In this commentary, I want to focus on a couple of points raised in the book that strike me as problematic. The first is the claim that philosophy is dead. The second is a broader problem physicists seem to be making concerning what Hawking/Mlodinow call *model-dependent realism*.

[I should issue a brief caveat here in advance. I am neither a scientist nor a mathematician. However, I believe the issues I discuss below don’t depend on a full understanding of the mathematics involved. In fact, I assume the mathematics is perfectly kosher. What I find interesting are the interpretations physicists let their formulas lead them to.]

*“[P]hilosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge.”*

This incredibly dismissive claim is typical of modern physics and in its strongest incarnation claims to sweep aside not just philosophy but even other “hard” sciences, such as chemistry and biology as well as the “soft” sciences, like sociology and psychology. I will discuss the strong version first before defending philosophy specifically.

The basic idea is that since physics deals with the fundamental building blocks of reality and the forces that govern their interactions, everything is ultimately reducible to physics and more importantly, *only physics is capable of capturing and describing reality as it truly is*. All other disciplines can only approach reality as it *appears* to be and their descriptions, while perhaps being useful, reflect only a crude and distorted picture of reality.

In one sense, this is of course, true. Since it specialises in the deepest levels of reality, physics deals with the fundamental “bits” that other disciplines can only describe in larger conglomerations. The problem however, is the claim that these descriptions of reality at the deepest level are somehow *truer* than other accounts.

Take the trivial claim that my phone is black. According to physics, my phone is made up of colourless atoms (ultimately quarks and electrons, and perhaps even “more ultimately” vibrating strings) so my phone *actually* isn’t any colour. What is *really* happening is that the atoms in my phone absorb all of the light hitting them except for light waves of a particular wavelength which get reflected off the surface. Then my eye detects these waves and my brain subsequently ‘sees’ them as black.

The argument is that ‘black’, as a colour humans perceive, doesn’t *really* exist in the physical world. It only manifests as a contingent consequence of the way our brains and sensory organs evolved. If we encounter intelligent aliens, we won’t be able to discuss the colours of things like we can with other humans but we *will* be able to talk about the wavelengths of light being reflected off different surfaces because that is what colour *really* is. The aliens, who may only see in infrared for example, will nevertheless be able to understand what we are talking about when we define black as light of a certain wavelength because they will have invented machines that can detect the visible (to us) part of the spectrum of light in the same way that we can detect X-rays, even though we can’t see them.

So the scientist (physicist) claims to be describing reality *as it really is*, not just as it appears to creatures of a certain physical constitution, thereby giving us a purely objective view on reality; that is, a view not dependent or contingent on a certain perspective. This reveals science’s ultimate goal; to remove the individual, perceiving subject from the universe in order to get at some imagined ‘objective’ truth.

The problem is that this is a fiction.

Taken to extremes, removing all traces of an observer with contingent perceiving apparatuses reveals a universe that is *really*… nothing. There are no phones, no tables, no air, no light waves of a certain wavelength… it’s all just atoms or strings or whatever the most fundamental, indivisible *things* are. Think about that for a second. If there is no specific subject applying a discerning perspective of some sort to the raw material of the universe (what the physicist claims to study) then *everything* is just vibrating strings. The universe is just a solid mass of vibrating strings. It’s at this point that we realise the idealised, *de*-perspectival truth of the scientist is, in fact, a universe completely stripped of meaning. This is why the notion of an “objective”, pristine truth is a fiction; because without a subjective perspective on the universe, there is no universe worthy of the name.

Another way to consider this is to think of a painting. What is the Mona Lisa? You might say it’s a picture of a woman. But then our scientist comes along and asserts that in actuality it is *really* just a collection of coloured dots. Now, of course it is true that the woman is *composed* of those little dots of colour and related to them in an uneven relationship; i.e. the dots don’t depend on the woman but the woman depends on the dots. However, it does not follow from this that the dots are somehow *truer* than the woman. They are more *fundamental* in that they constitute the woman while the woman does not constitute them but this does not give them any privileged claim to ‘objective’ truth because, as we have seen, ‘truth’ without a subjective perspective is an empty concept.

So, what about the slight directed at philosophy? Is philosophy dead because it hasn’t kept up with science? Absolutely not, although you might be forgiven for thinking this given the rate at which some philosophers are trying to quantify their discipline to show some form of progress and answer the critics who claim that philosophers are still discussing the same problems Plato and Aristotle were 2,500 years ago.

The mistake being made by Hawking/Mlodinow and others like them is to assume that everything valuable must be quantifiable and steadily progress from a position of ignorance to one of knowledge. This is indeed how science operates and is one of its strengths. We make hypotheses about the world and test them to determine their validity. On the basis of this we can reject, adopt or refine those hypotheses, steadily improving our understanding of the world around us as we do so.

Philosophy doesn’t progress towards certain knowledge like this precisely because it doesn’t deal with a constant, stable subject matter which we can formulate theories about and make observations on (a position filled by the external world in science). Instead, philosophy, broadly speaking, takes for its object the human subject and the human subject’s relation to the world it finds itself in. The problems philosophy concerns itself with do not therefore admit of certain proofs. The issues Plato raised are still relevant today because there are no fixed, immutable “laws” concerning human thought and the relations of conscious beings to the external world.

Granting that philosophy doesn’t bequeath absolute certitude on those who study it, of what use is it then? One might respond to this question with another question; “Must everything of use admit of absolute certainty?” Hopefully the answer to this is in the negative because if it isn’t, basically all of human life and certainly the truly important things are all useless. Human life, human thought and the complex cultures/societies we have constructed around us are anything but black and white and very seldom yield to anything even remotely resembling certain knowledge. And yet, most of us do not think of our lives or thoughts or interpersonal relationships as useless. It is a myth being foisted on us by scientists that certitude is the supreme value and if it can’t be reduced to an equation, it is worthless. Philosophy carries us beyond the clean, absolute world of mathematics and deposits us in the messy realm of judgement where, although you can support your claim with reasoned arguments and logic, very often at the end of the day all you can offer is an interpretation. Like it or not, that is just what human life is.

Ultimately then, as long as there are conscious, self-aware creatures in the universe, philosophy, as a discipline which considers that universe and one’s place in it, can never die.

*“According to model-dependent realism, it is pointless to ask whether a model is real, only whether it agrees with observation.”*

This refers back to the philosophical problem of realism vs. idealism. The former states that there is a mind-independent reality that corresponds more or less to the perceptions we have of it while the latter says that all objects of knowledge are dependent on the mind in some way. Model-dependent realism cuts this Gordian knot by saying it doesn’t matter and all we need to know is whether our model of the universe matches observations. (It is worth pointing out that this contradicts the earlier claim that scientists are the “bearers of the torch of discovery in our quest for knowledge” given that the ideal of certain knowledge is completely abandoned here)

As a stance towards reality this is fine. Philosophers can continue to think about realism/idealism and what this means for us as human beings, while scientists can get on with modelling the physical world and increasing our mastery over it. The problem is that scientists seem to have forgotten that they are talking about the models that describe reality, not reality itself and the deeper these models probe into the workings of the universe, the greater the potential for misunderstandings. We see this nowhere more clearly than in quantum physics where so-called “quantum weirdness” (which is a euphemism for “absolutely contradictory findings that don’t make any sense at all”) is just accepted as the norm under the auspices of ‘that’s what the mathematics of the most successful theory ever devised tell us.’[[1]](#footnote-1)

Hawking/Mlodinow start down the quantum path with the notion of wave/particle duality. Briefly, this principle states that particles appear to behave like both particles and waves. This has been demonstrated in the famous double-slit experiment. Imagine a light source, a light sensitive screen and a barrier with two vertical slits placed between the two. Turning the light source on produces an interference pattern on the screen (alternating bands of light and shadow) because light is a wave and the waves interfere with each other after passing through the slits in the barrier. Where two troughs or two peaks in the wave meet they combine to produce a light patch but if a trough and a peak meet they cancel each other out and leave a shadow.

However, when this experiment is reproduced with individual particles, such as electrons, as opposed to light (which is an electromagnetic wave) we still get an interference pattern. This holds even if the particles are fired so slowly that they are passing through the slits just one at a time. This is extraordinarily bizarre because it means that even if the particles could somehow interfere with each other like waves do, there aren’t any other particles around to interfere with!

Richard Feynman suggested a solution to this called the “sum over histories” model which supposes that a particle does not in fact only follow a straight path from the light source through one slit and to the screen; rather it takes *all paths* and what’s more *takes them all simultaneously*. Note that Feynman wasn’t suggesting that the particle only takes paths that coincide with our classical understanding of the world; i.e. straight lines, but that it also takes paths that go through one slit and circle back around to go through the other slit, paths that see it launch itself out to Jupiter and back, even paths that take it to the edge of the universe and back, etc. In short, the particle goes from the source to the screen across an infinite number of paths, simultaneously. On those paths where the particle goes through both slits, it interferes with itself and creates the interference pattern.

This certainly seems to be nonsense but if scientists make this assumption and crunch the numbers, they are able to predict the results of experiments with incredible accuracy. However, what they get is not a specific, certain result; rather, since we are talking about an infinite number of potential paths, the results come in the form of probabilities. Hence, the oft-cited quantum claim that the universe is fundamentally probabilistic in nature.

Now imagine we repeat the double-slit experiment but this time we place transparent detectors across each slit so that we can choose to observe (or not observe) a particle at the slit before it reaches the screen. If we choose to observe the particle as it goes through one slit, this means that it couldn’t have taken any of those alternative paths which saw it travel through *both* slits to interfere with itself. The result? We no longer see the interference pattern on the back screen; i.e. the particle behaves like a particle… but, the really crazy thing is that if we choose NOT to observe the particle at the slit, it will then go on to produce the familiar interference pattern. Somehow, merely observing the particle seems to influence its behaviour.

So, what conclusions do scientists draw from all of this? Do they say, their *models* of the universe show particles acting like waves sometimes and like particles other times? That the sum over histories *model* makes the assumption that in going from point A to point B, a particle takes every single path imaginable… simultaneously? That the universe *appears* to be probabilistic in nature because they are viewing it through the lens of *models* which assume that particles take every conceivable path between two points? That their *models* cannot resolve a discrepancy whereby mere observation appears to influence the behaviour of matter? No. They tell us that particles *are* waves… and waves *are* particles; that particles really do take every possible path from A to B so there is a real, although vanishingly tiny probability that the atoms of which you are constituted might suddenly end up on Jupiter; that probability *is* a fundamental feature of the universe and that mere observation of inert matter affects what it does.

But all of this is backed up by mathematics, isn’t it? And mathematics doesn’t lie. True, on both counts, but the physical world and mathematics are not the same. Mathematics is only a *description*, a *model*, of the world. It doesn’t necessarily reflect the world as it really is, as the quote at the beginning of this section makes clear.

On page 51, Hawking/Mlodinow specify four things that a good model must have. It must:

1. Be elegant
2. Contain few arbitrary elements
3. Agree with and explain all observations
4. Make falsifiable predictions about future observations

The early Ptolemaic model of the solar system with the Earth at the centre failed on the third point so ‘epicycles’ were added to the orbits of the heavenly bodies (along with a couple of other features) to make the theory agree with observations. Although definitely unwieldy, inelegant and (as we now know) patently wrong, it closely agreed with observations for around a thousand years, fulfilling the demands of model-dependent realism. The moral of the story is that aligning with observations and predicting the outcome of future experiments does not necessarily make a model an accurate account of reality. You could use the Ptolemaic model to (reasonably) accurately predict where the moon would be at some point in the future and explain all of this with recourse to epicycles, deferents and equants, while at the same time having a wildly inaccurate understanding of the solar system.

And what do we see scientists doing today? Explaining, to unprecedented degrees of accuracy, experimental observations with recourse to notions like particles *actually* taking every single, possible path between A and B, simultaneously! If we challenge this, they tell us that we must stop thinking according to a classical understanding of reality. In other words, quantum physics is weird and doesn’t care about our classical sensibilities, our human, macro-experience of reality. Get over it.

Delayed-choice experiments lead to even more bizarre ideas than ‘sum over histories’ that cry out to be explained but seem to be accepted by physicists as something we just have to get used to. In a delayed-choice experiment the choice about whether to observe the particle or not is delayed until the moment just before the particle hits the screen (as opposed to the ‘regular’ double-slit experiment where we could choose whether or not to observe the particle only as it passed through one of the slits).

The amazing thing in these delayed-choice experiments is that the results scientists get are identical to those derived from experiments where the observation takes place at the slits; i.e. if they choose to observe the particle (just in front of the back screen), it hits the back screen without creating the interference pattern (i.e. like a particle) but if they elect *not* to observe it, it creates the interference pattern (like a wave). This is shocking because the measurement, which was carried out *after* the particle had presumably gone down every possible path simultaneously (and should therefore have already interfered with itself, just about to create an interference pattern), effectively seems to be reaching back in time to cancel out that subset of paths which saw it go through both slits, also cancelling the interference pattern we might have expected. The unlikely conclusion scientists draw from this is that observations in the present somehow affect the path the particle took in the past.

Yes, such a theory *does* explain the experimental observations and taking this as the physical model the mathematics is built on allows scientists to predict precisely what will happen through their equations (at least in a probabilistic framework, anyhow), but as Ptolemy would have realised if he had lived another millennium and a half, explanatory power is no guarantee that a theory accurately describes the reality it explains.

Hawking/Mlodinow now have recourse to the idea captured in quotes at the head of this section; namely, “These mental concepts are the only reality we can know. There is no model-independent test of reality.” What this amounts to is a disclaimer that says, in effect, “Well, we *can’t* know for sure what reality is *really* like so let’s not bother wondering. Let’s just agree that it is like this model we have devised which *explains* that reality near perfectly.” Now, there are three reasons I am unconvinced by this. First, it goes against the supposed prime directive of science to be the “bearers of the torch of discovery in our quest for knowledge”. The narrative physicists typically outline and one of the main reasons science is superior to other disciplines (like philosophy) is that it is supposed to deliver certain knowledge, not mere supposition about a reality we can never know. Secondly, such an attitude would be fine *if* physicists actually held to it, but, as I have pointed out, that is not what they typically tell us. They don’t say that it is their models that contain these bizarre elements and we can’t actually know what reality is really like; rather they say that quantum reality *is* stranger than we can imagine, particles really *can* act like waves and vice versa, depending on the experiment we devise, and so on. Third, even if this is true and all we can know for certain are our models, some models reflect reality more accurately than others. So even though Ptolemy’s model of the solar system did a decent job of explaining the observed motions of the heavenly bodies (to the level of precision capable at the time), it was still completely wrong and anybody who defended it by appealing to the “no model-independent test of reality” argument would have been wrong too.

The core of my argument here is that no experiment I am aware of has ever *proven* that a particle traverses an infinite number of paths between two points or that present actions determine a merely probable past suspended between different states of being. The double slit experiment proves that observed particles impact a screen like particles but when unobserved, impact like waves. That’s all. The postulate that particles are behaving like both particles and waves is an *interpretation*, created to *explain* the observation. It is not what we observe directly. So while these postulates/interpretations *explain* the experimental observations extremely well and form the underlying assumptions for the mathematical models of reality we have devised, they don’t necessarily reflect what is really, physically going on.

The problem we have is that the quantum model which has risen to prominence requires us to believe all manner of contradictory things which we just cannot make any sense of. Again, this is not to dispute the fact that the mathematics of the model work exceptionally well and many modern technologies depend on these quantum models of the world – they clearly do. But we aren’t talking about minor discrepancies here between observations and understanding, we’re talking about blatant logical contradictions. It is categorically impossible for a particle to simultaneously travel an *infinite* number of paths in a *finite* amount of time. Mathematically, you might be able to deal with this, but physically (at least by any definition of the word that makes sense) it is clearly impossible. What we have here is a mathematical description of reality we are able to manipulate through various (and *valid*; I am not disputing this) techniques to get the correct answer. But we must not assume that these mathematical flourishes or explanatory assumptions describe reality. The notions of faster than light travel (to the edge of the universe and back, no less) and the present determining the past are the modern day equivalents of Ptolemy’s “epicycles” and “deferents”.

The obvious rebuttle is to point out that that is what everybody said to Copernicus regarding his theory of the sun-centred solar system. “We can’t be orbiting the sun. We would feel it if we were! Physically impossible!” Well, we all know how that turned out. It was their physical intuitions that were wrong, not the theory. However, it is also what people could have said of Ptolemy’s sun-centred model. “Epicycles?! Deferents?! Come over here and I’ll give you equants!” And in that case, they would have been dead right to question these unlikely postulates.

Let me stress that, despite what it may sound like, I am not “physics-bashing” nor am I “anti-physics” in any way. I love physics and lap up new discoveries/findings as eagerly as anyone. However, physics, like all disciplines, is not without limits. When those limits are reached we need to turn to other disciplines like the soft sciences; psychology, sociology, etc., and, yes, philosophy, which is still breathing despite taking some serious hits in a modernity that has no use for a thing if it can’t be converted to money or certitude (preferably a certitude that leads to money).

Also, as I have argued for here, physicists have forgotten that their models, no matter how completely they explain a past observation or predict a future one, do not necessarily accurately describe reality. And even if all we can have certain knowledge of are models (as opposed to the reality they describe), that is hardly a compelling argument in favour of just pretending that the model, with all of its epicycles and deferents, is real. When our best mathematical models tell us that particles are also waves at the same time, that a particle going from point A to point B passes through an infinite number of different paths simultaneously and that present observations affect past histories, these seem to me to be strong reasons to concede that our models haven’t fully illuminated the reality they describe.

1. This is not a quote from the book [↑](#footnote-ref-1)