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Killing Laplace's Demon

Disclaimer

The information in this article is derived from knowledge I acquired from various Wikipedia articles and YouTube videos. Therefore, there is a high probability of errors in the explanations. This article is only meant to test my ability to explain complex scientific concepts. If you find any wrong descriptions or misleading arguments please let me know.

Introduction

What are we really doing with this science thing?

To answer this question let's see a very quick summary of the method we use to create science, **The Scientific Method**.

When we observe a previously unknown phenomenon, we try to explain it using assumptions from our previous knowledge. Then, we transform our initial interpretation into a testable hypothesis. We then test our hypothesis using an experiment. If it passes the test, it is considered a model of the phenomenon. Over time as we ask more questions, our model gets increasingly complicated as some things are added, replaced, and removed from our model. Or maybe we discover that the phenomenon is just a side effect of a larger process taking place in the background.

The scientific method is the most effective and reliable method we have for acquiring new knowledge. Using the scientific method, we can understand some parts of the universe independently. We can then incrementally build upon this understanding to further our knowledge even more until we finally understand the whole universe as a single system. Living in this universe is like being locked in a room while being blind and crippled. Not knowing how we got here, we are just trying to make sense of our situation. One of the ways we try to make sense of our situation is by making a model of the room we’re in. We can do this by throwing a bunch of balls in every direction. We can then look at which ones bounce and come back and use this data to construct a map of the room we are in. But this can go wrong in many ways. Maybe we don't throw the balls far enough to bounce off the wall, maybe we forget to throw one in one specific direction.

In case it wasn’t clear the room is the universe, and the balls are logical questions that help us model our universe.

The scientific method is not infallible. For example, we can't be sure how much our mode of existence affects our observations. We can't be sure that the true nature of reality is captured in our

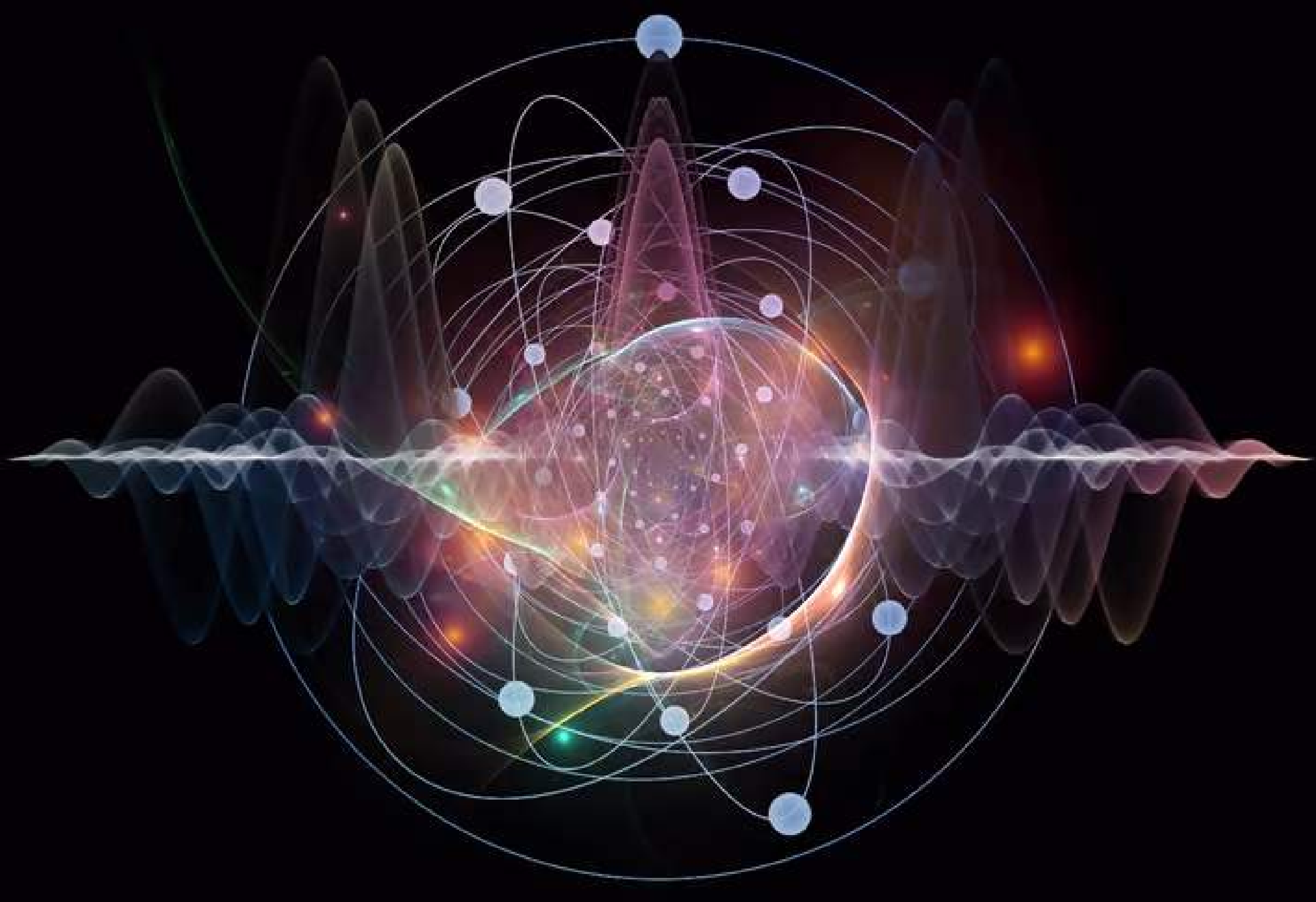
observations. Some scientists question the objectivity of our model of our universe. They ask, **Are these models we have developed really defining the objective reality of the universe or are they simply describing our view of the universe?** For example, Niels Bohr insisted that what we actually model is our observations, not the world itself.

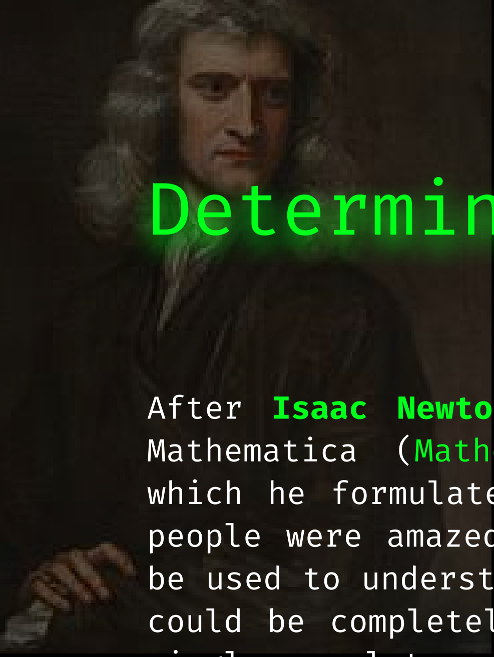
> “It is wrong to think that the task of physics is to find out how Nature is. Physics concerns what we can say about Nature”
> – **Niels Bohr**

No matter how many times a theory or model is proven to be right it can't be considered completely true. This is because only one negative result is needed to render the whole model incorrect. This is a consequence of a principle of probability called **Bayes' Theorem**. This theorem describes the probability of an event, based on prior knowledge of conditions that might be related to the event. Bayes' Theorem is commonly explained using the analogy of coming out of a cave and observing the sunrise. If it is your first time seeing the sunrise you would have no way of knowing that the sun would rise again tomorrow. Over time, however, as you see the sun rise every day, you will become more and more confident that it will rise again tomorrow. Bayes' Theorem tells us that the probability of any prediction never reaches 100% but it keeps asymptotically increasing to 100% as the predictions are continuously proven to be right. This raises the question of the objectivity of our models of the universe. Because if these models don’t really describe reality then we have no reason to believe the predictions generated using these models. We have no way of believing that these predictions would in any way be analogous to what is observed in reality. Some scientists question the objectivity of reality, but others are confident of the fact that the universe is objective. They say that the universe is just a state that evolves over time using the laws of physics.

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

Our laws of nature are just models of the real thing. But we test these models based on how well they predict the next state of the phenomenon they are describing. So if we tested these models of reality based on how well they predict the future. Then what we get at the end is an optimized way of telling the objective future. The final destination of our epic quest for knowledge in science is a single model of the universe that describes everything in the universe. It will describe the evolution of the state of everything in the universe. In the face of such knowledge, even time ceases to be a barrier. If we know the connection between every cause and effect in the universe, nothing can be random, since each event would be triggered by a cause that preceded it.





Determinism

After **Isaac Newton** had published Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy) in which he formulated the laws of motion and universal gravitation, people were amazed at the level of accuracy that this model could be used to understand nature. People started to realize that nature could be completely understood. They also realized that one day a single complete model of the universe could be used to calculate the evolution of the position of every particle in the universe. One of the people that came to this realization was **Pierre-Simon Laplace** who introduced a thought experiment to the world in his book **A Philosophical Essay on Probabilities** by stating the following:

> “We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes”
> - **Pierre-Simon Laplace**

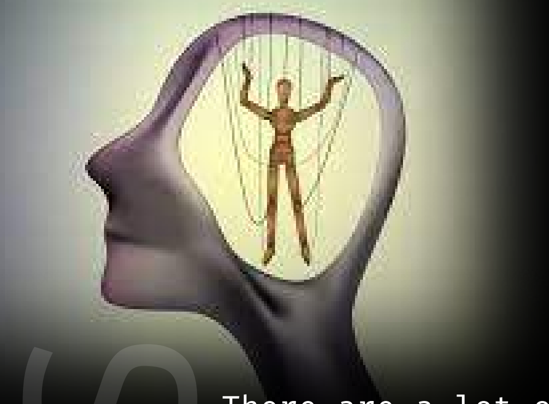
The intellect described in this thought experiment is known as **Laplace’s Demon**.

The idea Laplace is trying to convey is that according to the physics of his day, which was classical physics, if you could collect the state of every particle in the universe and if you had enough computation power to analyze the data you collected then the past, the future, and everything in between is no longer uncertain. You can turn the dials of time to the extent of your will to see **what has happened in the past** or **what is going to happen in the future**. If you were able to achieve this, time will no longer be a restriction. It would simply be another variable in your equation.

Note that I said, “**what is going to happen**". You might have sensed a bit of certainty in that statement. In this model of the universe, the universe is void of any uncertainty. If you consider a particle moving through the vacuum of space, its position and its momentum are always known at any point in time. (This is not true if we consider the effects of Heisenberg's Uncertainty Principle, which we will see in the following sections).

When you combine this with the law of the conservation of mass and the law of the conservation of energy, the universe can be considered a completely **closed system**. This is because nothing happening outside it can influence what happens inside it. Anything that exists now has existed in some form since the beginning of the universe. For example, every atom in your body, the carbon, nitrogen, oxygen, and so on, were fromed from the corpse of a dying star.

This view of the universe is called **determinism**. This can also be considered as a **clockwork universe**. In such a universe, the universe is considered a completely deteministic machine much like a mechanical clock whose gears are governed by the laws of physics. This makes every part of the system predictable. Although Laplace referred to a being when he described his thought experiment, in modern day physics Laplace's Demon is thought of as a computer capable of simulating the universe.



IMPLICATIONS

There are a lot of interesting questions that arise when discussing this topic.

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Can you fit all of the information in the universe into a region smaller than the universe?

Can you make a computer that can compute the universe while simultaneously being a part of it?

How much energy would this computer need?

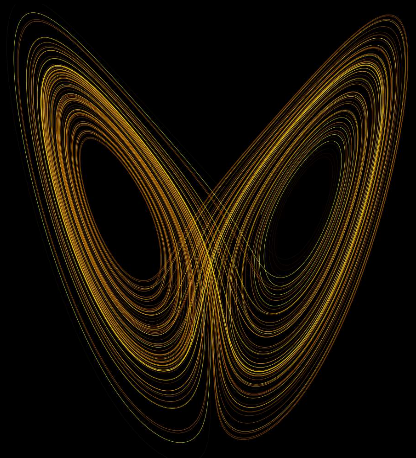
We will not discuss these questions here, but we will look at the physical models of reality we have today. Then we will find out if they allow the existence of such a computer or being. We will explore the question **Can Laplace’s Demon Exist?**.

The harshest and possibly the most dangerous implication of determinism is that anything we humans do in this life doesn't matter. We aren't independent actors writing our own stories. We are all actors playing the roles nature wrote for us. The things that happen in life are meant to happen, and we can't stop them. Murderers cannot be guilty of their crimes because they were always meant to kill because they cannot oppose the laws of physics. People cannot be responsible for their actions under determinism. Oedipus was always supposed to kill his father and marry his mother. It is imperative to remember that you yourself are part of the physical universe. This implies that you, your body, and everything else in the universe follow the same mechanics of the universe that everything else follows. Shortly, you are not immune to the laws of physics. A deterministic universe has no place for **Free Will**. Now that we know what's on the line if Laplace's Demon exists, the proposition of **Killing Laplace's Demon** becomes very appealing. Laplace's Demon is a product of a thought experiment. To kill it, we need arguments that contradict its existence.

The Beasts

Laplace's Demon will face the following **three beasts of reason** to defend its existence.

Chaos Theory



The Uncertainty Principle

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

Black Hole Evaporation

These are not all of the arguments against determinism. They are just the ones that are covered here.

Chaos Theory

One of the many arguments against the existence of Laplace’s Demon is **Chaos Theory**.

Chaos Theory deals with the changes in the final state that result from minor changes in the initial state of a deterministic system. One example is the **Butterfly Effect** which states that a butterfly flapping its wings in Brazil could cause a tornado in Texas. Everything in the world is connected. Because of this, one could never know the full effects of even the tiniest of forces or lack thereof. Even the small force from a butterfly flapping its wings in Brazil might affect the molecules around the butterfly. This might start a chain reaction that eventually causes a tornado in Texas. This theory states that tiny differences in initial conditions, such as those caused by errors in measurement or calculation, can yield widely diverging results in the final state.

Measurement is always limited by the measuring device. For example, any measurement made with a regular ruler is limited by the ruler's scale, which is commonly 1 mm. When using a ruler with a scale of 1 mm, there is an implicit uncertainty of 0.5 mm in your measurements. The actual value of a measurement such as 2.1 cm is somewhere between 2.05 cm and 2.15 cm. Even if you use a laser beam for your measurement, you would be restricted by the wavelength of the laser and a host of other factors. Although we can never get rid of it, we can always minimize the uncertainty in our measurement with a more accurate measuring device.

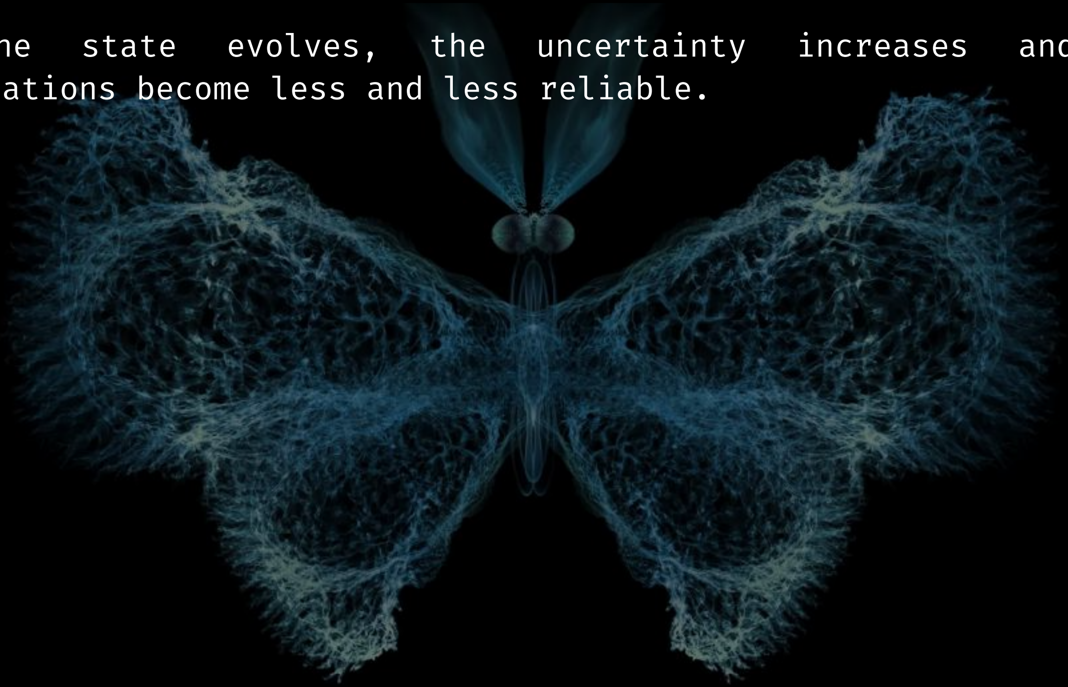
Laplace’s Demon needs to be able to collect the position and momentum of every particle in the universe to infinite precision. This is not possible due to the limits set by chaos theory. Even if the universe is deterministic, Laplace's Demon cannot know the future until the end of time. Alternatively, it can't look back to the past until the beginning of time. Due to the butterfly effect, even small changes in inputs can result in wild variations of outputs. Therefore, any measurement of the initial state (position and momentum of every particle in the universe) is insufficient for looking into the future to infinity or back into the past to the beginning of time. What Laplace's demon can do is predict small segments of the universe and the past. Laplace's Demon's ability to predict the future becomes less and less certain after some steps in the simulation of the universe.

Chaos theory doesn’t completely rule out the possibility of the existence of Laplace’s Demon. It simply limits the demon's ability to view the future and the past. Chaos theory is like a fog that sets in when one looks too far into the future or too far back to the past. Chaos theory tells us that even if the universe is deterministic we can’t look at all of time at the same time.

The effects of chaos theory are quite obvious when you consider the inherent inaccuracy of all measurements. For example, if we are continuously squaring a number, our uncertainty gets broader and more pronounced with each evolution until our measurements are no longer useful. When measured with a ruler of uncertainty 0.5 mm, our initial state is 2.0 cm. So, our actual value is somewhere between 1.95 cm and 2.05 cm. If we square this number continuously, we will get the following.

initial state = 2.0 ± 0.05 cm = 2.4 ± 2.5%
1st evolution = (2.0 ± 2.5%) * 2 = 4.0 ± 5.0%
2nd evolution = (4.0 ± 5.0%) * 2 = 16.0 ± 10.0%
3rd evolution = (16.0 ± 10.0%) * 2 = 256.0 ± 20.0%
4th evolution = (256.0 ± 20.0%) * 2 = 65,536.0 ± 40.0%

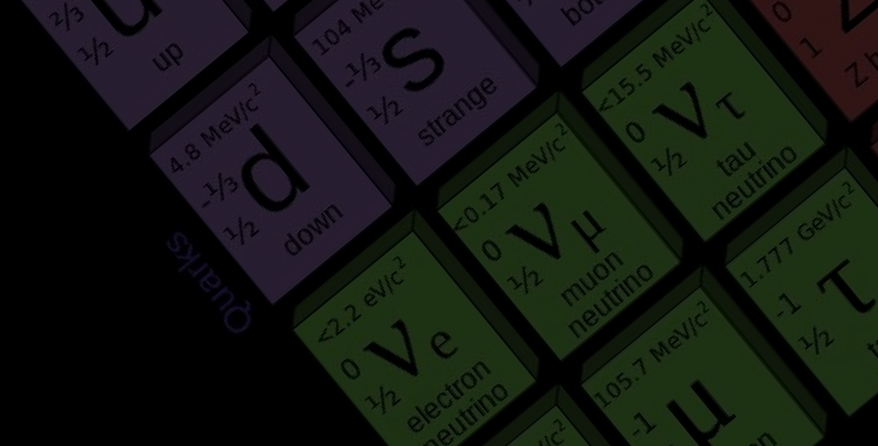
As the state evolves, the uncertainty increases and our calculations become less and less reliable.



The Uncertainty Principle

The next beast Laplace's Demon has to face is the beast of **Heisenberg's Uncertainty Principle**, which states that you can't measure both the position and momentum (velocity) of a particle exactly at the same time.

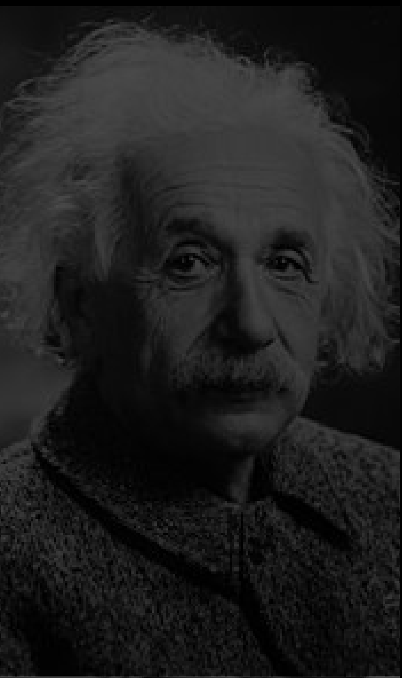
I realize that through out this essay I have been referring to **some particles** without specifying what they are. As the deterministic view of our universe evolved, scientists have been learning a lot about the underlying particles of nature. Because of this different scientists that worked on this problem used the word particle to mean different things. Science has historically used the term particle to describe indivisible small materials that make up everything in the universe. In modern science these particles are the particles of the standard model. The **Standard Model** is the theory describing **three of the four known fundamental forces** in the universe and **twelve elementary particles**. Gravity remains unexplained by this model. If you are talking about determinism in terms of the standard model, you are asking if the interactions between the fundamental forces and the elementary particles are random in anyway. Some say that even the standard model is not fundamental enough, pointing to its shortcomings in explaining gravity. The Laplace's Demon thought experiment implicitly assumes that the most fundamental thing that makes up the universe is some form of particle. However, there are other modern theories of everything or theories of determinism that consider other things as fundamental. For example in **string theory** the most fundamental things from which everything is made up are **infinitesimal vibrating strings**. There are also some theories that propose that the most fundamental thing in the universe is **binary information** (**1s** and **0s**). In this essay I have been using the word particle to mean the most fundamental thing in the theory we are discussing. In this instance, we are considering the elementary particles of the standard model.

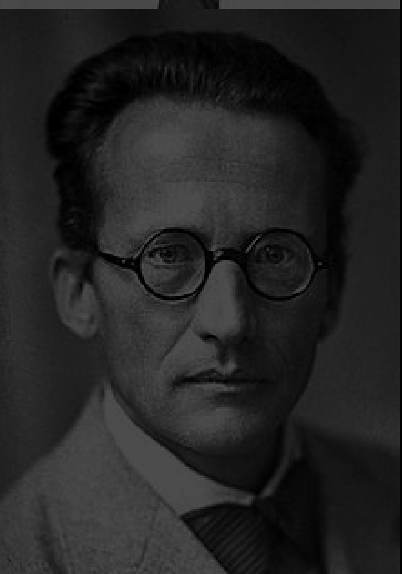


This beast tries to disadvantage Laplace’s Demon by affecting its power to observe. No matter what form of seeing is employed (light, radar, etc.), some wave or particle has to traverse the space between the observer and the subject, and then bounce off the surface of the subject to return to the observer, who can then identify which ones came back and use that information to form an image. It is imperative to realize that illumination does not necessarily have to begin with the observer. That is the particle or wave we are using doesn’t necessarily have to originate from the observer.

We often do not think about observation as a physical process, but it is and has side effects on the physical universe. Meaning that if the subject you are observing is small enough to be affected by the particle or the wave your observation mechanism is using then it will be. An observation is a snapshot of a subject before the effects of the observation take place. Observation alters the state of the subject. If we are using light waves to observe the position of an electron then that electron’s velocity will be affected by the observation. This is because a photon just collided with it. This means its observed state is out of sync with the state it is in the real world. If we had known the velocity of the electron before the collision, we wouldn't know it now. In order to observe something as small as an electron, we need light with a very short wavelength. When we decrease the wavelength of a light, we are inadvertently increasing its frequency. The higher your frequency the more energetic the wave is. Due to this our light will have more energy. This will cause the electron’s velocity to be even more greatly affected. The more accurately we try to observe the position of a particle (i.e. by decreasing the wavelength) the more the velocity of the particle is affected making our knowledge of its velocity less accurate.

Werner Heisenberg was able to realize this fundamental limit on observation set by nature. He found the limit for this inaccuracy to be plank’s constant divided by the mass of the particle. Laplace’s Demon needs knowledge of every particle’s position and momentum (i.e. mass times velocity) to make predictions, but Heisenberg’s Uncertainty Principle has taken that away. Heisenberg’s Uncertainty Principle has torn out Laplace’s Demon's eyes, rendering it incapable of total knowledge. Making it impossible to know the position and momentum of every particle in the universe.





In order to simulate a system one needs to know what the most fundamental pieces of that system that make it work are. For example in string theory the most fundamental things in the universe are infinitesimal vibrating strings. According to some scientists, the most fundamental thing in the universe is information. We will cover these ideas another time. There is a theory called **hidden variable theory** which asserts the uncertainty principle is the result of a hidden variable which has yet to be discovered. This hidden variable is the source of the uncertainty principle. The hidden variable theory states that there must be a more fundamental, underlying theory in which properties such as speed and position are defined without uncertainty. **Albert Einstein** famously said, "**God doesn't play dice with the universe**". Which illustrates the frustrations many scientists have with uncertainty. Einstein was a proponent of Laplacian determinism. Einstein thought that the uncertainty we observe is because of our view of the universe. He thought that the underlying reality of the universe as perceived through a power such as God (an omnipotent entity outside of the universe) would have no place for uncertainty. The hidden variable theory has since been proven to be wrong by British physicist, **John Bell**.

Even though **Laplacian Determinism** saw its end when faced with the Uncertainty principle, determinism is not just the kind described by Laplace. A deterministic system is a system in which an input always produces the same output or set of outputs. Despite refuting laplacian determinism, quantum mechanics gives us another type of determinism.

There is a new kind of determinism born from quantum mechanics. A determinism born from a new kind of information about a particle, the **wave function**. The wave function is a property containing both the position and momentum of a particle in a single expression. The evolution of a wave function is calculated using the **Schrödinger Equation**. The wave function is a function that describes the state of a quantum system using two degrees of freedom, the particle's position and time. The most peculiar thing about the wave function is that it doesn't give a definite value for calculations instead it gives us a probability. However, in the real world we don't observe objects being in a space of probabilities. This is because when we actually measure the particle's position we get a definite value. At this point, the wave function is said to have collapsed from describing a space of probabilities to describing a single point. This led to the paradox of **Schrödinger's Cat**, which asks what causes the collapse of the wave function.

Schrödinger stated that if you place a cat and something that could kill the cat (a radioactive atom) in a box and sealed it, you would not know if the cat was dead or alive until you opened the box, so that until the box was opened, the cat was (in a sense) both "**dead and alive**". Schrödinger used this thought experiment to show the illogical conclusions of his own equation.

This surprisingly feline paradox has been the inspiration for the various **Interpretations of Qunatum Mechanics**. The **Copenhagen Interpretation** states that measurement collapses the wave function. In the case of Schrödinger's cat the copenhagen interperation tells us that the wave function describing the state of the cat collapses when measurement is done. Therefore, the cat is both dead and alive until the box is opened. One of the various other interpretations is the **many-worlds interpretation** which states that the wave function doesn't collapse into any specific state instead this interpretation states that the wave function collapses into every possible state. Using the many-worlds interperatation, the Schrödinger’s cat paradox can be understood as the world splitting into two branches, one which contains the dead cat, and another in which the cat lives. Depending on how you interpret quantum mechanics, it is either deterministic or random. As in the case of the Copenhagen interperation, the universe is not deterministic because there is no way to determine what point a wave function will collapse to, but in the many-words interperation, the wave function is considered to collapse to every possible point in the space of probability and the universe branches to universes that contain each and every probability. However, we can't know which branch we are on until we take the measurement because the branching hasn't happened yet.

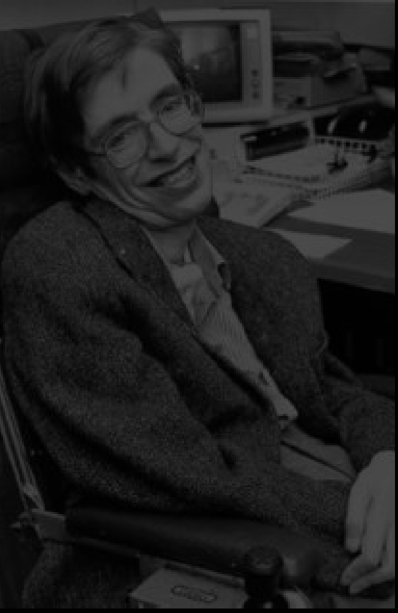
Chaos Theory and Heisenberg's Uncertainty Principle have badly wounded Laplace's Demon. Chaos Theory obscured Laplace's Demon's ability to see into the past and the future without bounds. And now Heisenberg’s Uncertainty Principle has made Laplace's Demon incapable of observing the position and momentum of every particle in the universe with any level of certainty. Determinism however lives to fight another day because even a quantum mechanical system allows for a kind of determinism to exist. Next we will see an argument that can be raised against quantum mechanical determinism.

Black Hole Evaporation

A black hole is a celestial structure with a strong gravitational field such that anything that descends into it would not be able to escape. Black holes are very dense. They have a large amount of mass and a small volume.

Laplace wrote a paper in 1799 describing a gravitational field that is so strong that light itself wouldn't escape its grasp. Before Laplace, a scientist called John Mitchell also wrote about this phenomenon. In Laplace's time light was considered to have been made up of particles called **corpuscles**. The corpuscles light was thought to have formed of, have a very small mass and move very fast. Therefore, in order to experience gravity they need to be in a very strong gravitational field. This will cause the corpuscles to slow down. In 1887 Michelson and Morley showed that light always traveled at a speed of **300,000 km/s** independent of its origins. This disproved the theory that light could be slowed down by a strong gravitational field. In 1915 Einstein published his revolutionary paper on the **General Theory of Relativity**. In this theory space and time are not separate entities. They are two directions in a single object called **space-time**. Space-time is curved and warped by the matter and energy in it. This curvature is what objects experience as the force of **Gravity**. The General Theory of Relativity also dictates that everything follows a straight line in the fabric of space-time. Therefore when an object of some mass curves space-time everything including light, moons, stars, planets, and other objects follow the curved path formed by the curvature of space-time. Therefore light can be curved (shifted from its original straight path) but not slowed down. In 1919 Einstein's theory was proved to be correct when the shift of light from distant stars, caused by the curved space-time around the sun, was measured during an eclipse in West Africa.

The General Theory of Realtivity is commonly explained using the following analogy. When a heavy mass is placed on a fabric sheet, the fabric will be curved around the mass. Any other mass we put on the fabric sheet will roll down to the heavy mass following a curved path. In relation to itself, the smaller mass still travels in a straight line. However, the medium it is travelling on is curved, so its path appears curved to any observer.



Black holes are formed when a massive star uses all its nuclear fuel, cools down, shrinks below its critical size, and collapses on itself due to its massive gravity. Even light can't escape the grasp of a black hole and since nothing can move faster than light, nothing can be able to escape a black hole.

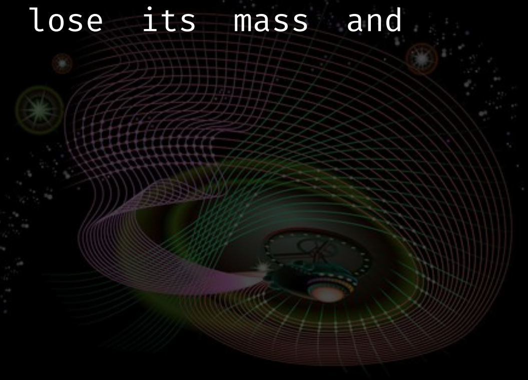
Black Holes sound cool, but how do they affect **Determinism**?

When a particle falls into a Black Hole, all its information is lost. The only two characteristics of a Black Hole that change after a particle falls into the black hole are the mass of the Black Hole and its state of rotation. Previously, it was thought that the information of a particle that falls into a Black Hole, such as its position and momentum, is not lost, but rather inaccessible. This is because the information is trapped in the Black Hole. This was presumed to be true because of the **Conservation of Quantum Information** (i.e. In the quantum world, information cannot be created nor destroyed).

Stephen Hawking said the following about this phenomenon.

"Out of Sight. Not only do the particles and unlucky astronauts that fall into a black hole, never come out again, but also the information that they carry, is lost forever, at least from our region of the universe."
- **Stephen Hawking**

Before the discovery of Black Hole Radiation, everybody thought Black Holes would exist forever. All that was changed when Stephen Hawking combined **Quantum Field Theory** (QFT) with the **General theory of Relativity**. He found that Black Holes send out radiation at a steady rate. The discovery of **Black Hole Radiation (Hawking Radiation)** showed that Black Holes leak their energy and evaporate by radiating particles. Hawking Radiation slowly drains the energy of the Black Hole due to the energy needed for radiation of particles. These will make the Black Hole lose its mass and disappear.



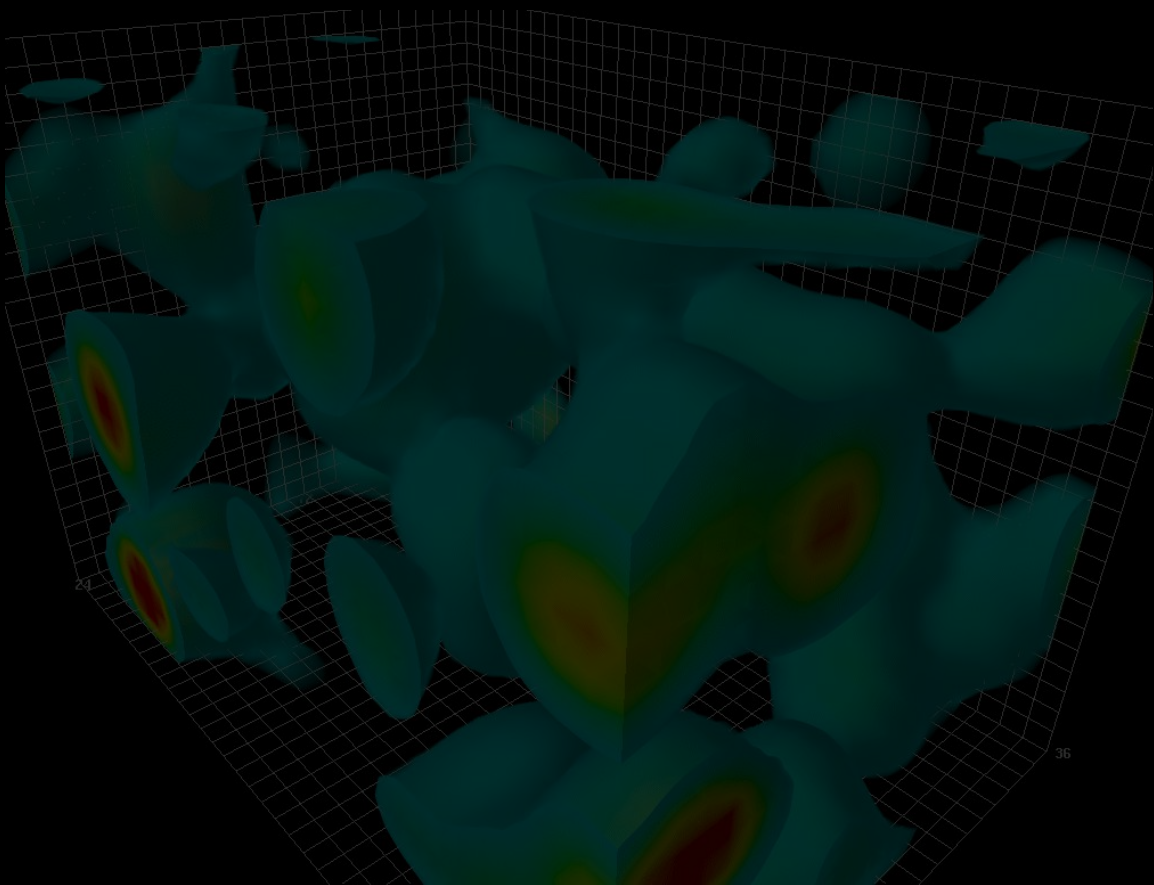
According to QFT empty space is not really empty. It is filled with particles and anti-particles that spontaneously appear and immediately collide and annihilate each other. This phenomenon is called **Vacuum Fluctuations**. These pairs of particles are virtual and appear for all elementary particles. They can't be directly measured using particle detectors. When Vacuum Fluctuations occur near a Black Hole, something peculiar happens. When a particle and an anti-particle simultaneously appear, one of them might be pulled into the Black Hole. The other particle would be left free because there is no particle to annihilate with it. These free particles will then move out into space. These free particles will appear to have been emitted by the Black Hole to a distant observer. This phenomenon is called **Black Hole (Hawking) Radiation**.

Hawking radiation destroys information. The radiation produced by a Black Hole is independent of the particles that have fallen into the Black Hole. One of the basic laws of physics is the **conservation of information**. This conservation rule states that information might be mixed up or hidden, but can't be destroyed. The theory of Hawking radiation violates this rule. A Black Hole loses mass due to Hawking Radiation. However, the radiations produced by the Black Hole contain no information about the particles that had fallen into the Black Hole. Where do the particles that had fallen into the Black Hole end up when the Black Hole disappears? This is widely considered one of the most complex unsolved paradoxes of Physics. Stephen Hawking was able to use **Quantum Field Theory (QFT)** which clearly states that quantum information can't be destroyed, to conclude that information can be destroyed under extreme conditions such as the **Death of a Black Hole**.

The destruction of information is a threat to determinism. In determinism cause and effect must be related to each other. An effect cannot happen without a cause. In the theory of Hawking Radiation, the cause (a particle falling into a Black Hole) is not related to the effect (radiation produced from the Black Hole).

In mathematical terms, for an inverse of a function to be itself a function the original function has to be **one-to-one**. A one-to-one function is a function in which one specific input produces one specific output. The Hawking radiation paradox prevents the universe's mechanics from being one-to-one because the output (the radiation emitted) is not specific to the input (the particle). Many different particles with different initial states fall into the Black Hole, but the radiation produced is the same for all of them. As a result, determinism cannot exist since the radiations emitted by the Black Hole cannot provide information about what fell into it.

Hawking Radiation disproves the idea of a deterministic universe by showing that in extreme conditions such as the beginning of the universe and the death of a black hole information can be lost. Even in a quantum mechanical deterministic universe, there are blind spots left by the loss of information.



Conclusion

In the introduction, I mentioned that science is dependent on the universe being objective. When viewed under the assumption of determinism, our universe is analogous to a black box that produces a different output or set of outputs for different inputs. From this, it follows that experimental knowledge is acquired primarily by providing input to the black box and recording the output. The experimenter does this again and again until she has enough data to reverse engineer the process that takes place inside the black box. If determinism is proven to be false, we can no longer be certain that the universe doesn't produce the same outputs for the different inputs. This will render all the knowledge we have acquired from experimentation false. The patterns we see in nature will all have been illusions of order in a random process. If we can't test that a specific input gives a specific output then we can't check if our hypothesis is right. Determinism is not about the dream of simulating the universe. It is about the hope that our quest for knowledge can bring us closer to the truth. It is about the belief that the universe is objective. Knowing how it works will allow us to comprehend the **circumstances of our existence**.

The idea of determinism has been regarded as an emotional attachment to control and order in the universe. I don't think that is true because determinism is the natural side effect of the way we conduct science. A random universe is much scarier than a deterministic universe. I don't think people realize that. The main reason people fear determinism is that under it people wouldn't be responsible for their actions. It would mean that we are all puppets controlled by the grand calculus of the universe. It would imply that we have no control over our fates. It would mean that we are not active actors in our lives but passive observers of what has already been decided. On the other hand, determinism allows us to see the strings that bound us. In determinism, we can make models of the universe and test their validity, and trust the results of our experiments. Randomness, while giving us freedom and the burden of responsibility, takes a tremendous sacrifice. We must sacrifice our belief that there is a direct relation between cause and effect. Randomness would mean that what happens before is not in any way able to affect what happens after. Theories produced using the scientific method would be no more truthful than their religious or cultural counterparts. We can't definitively know anything about a random universe. A random universe would mean that, we can't light the torch of knowledge in this cave of delusion.

Looking forward to the day when we finally understand this room we are stuck in. This has been Killing Laplace's Demon.