Fate and Free Will: The Mystery of Rectilinear Propagation and Constant Speed of Light

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Abstract

Abstract should be on one page. It should summarise the project objectives, the work carried out, methods used, the main research findings arising from the work and conclusions reached.

Contents

1 Introduction

The initial motivation for this essay was a book by one of my favorite authors. I originally learned about Hesse through Siddhartha and found his essays and novels philosophical. So in the summer of 2023, I read another of his novels of a prose nature called KLINGSOR’S LAST SUMMER, one of which I particularly liked called ”The Music of Doom”. One of the lines reads ”Have not the stars set, are not the stars doomed too?” Tu Fu cried. ”For us, for our eyes.”

I was instantly intrigued, as I’ve always thought of so-called magic as being more physical beyond our human empiricism. Add to that the fact that I had just finished watching Oppenheimer

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directed by Nolan around that time, and one of the clubs I ran at school happened to be talking about quantum mechanics and general relativity. I suddenly realized that physics seemed to have a wonderful connection with philosophy - they seemed to be one and the same, advancing slowly in tandem. Inspiration came quickly, and it took me just one afternoon to complete the mind map for this paper. The paper will be an iteration of the perception of physics, centered specifically around light, and will conclude with a discussion of the ideas of physics and philosophy.

The topic of ”light” is actually very interesting because a friend of mine who is interested in theology happened to be discussing the Bible-Genesis with me and came across the phrase, ”God only said, ”Let there be light,” and there was light. I began to think about this mysterious light that mankind seems to have been arguing about for so long, as far back as Newton’s time, when the dispersion of white light was observed through a prism, and more recently in quantum optics, when scientists have successfully utilized individual photons to achieve experiments such as quantum entanglement and quantum invisible state transmission.

Light is really interesting, and I want to understand the theory about it systematically, so it is also a big argument for my thesis.

Many people think that physics and philosophy are two completely unrelated disciplines, however, in this thesis I will start from the famous Maxwell's four equations, derive the objective fact that the speed of light is invariant from the theories of physics, and introduce the discussion part with the impact of quantum mechanics on classical mechanics. With the unsolved mystery of light in physics so far, I will introduce several examples of "non-linear propagation" of light, and then correct them through theoretical physics, such as the well-known refraction and diffraction. This phenomenon was eventually corrected by Einstein's view of space-time. However, there are still many difficult problems in present-day physics; after all, a view of the world based on fitting it to the world is always subject to modification by the development of observational tools.

The next section will focus on a different worldview from that of physics, and will criticize and uncover the narrow problems that still arise in theoretical physics from a philosophical point of view. (Also to be discussed in relation to concrete positivism, etc.)

2 Literature Review

2.1 Maxwell Equation

Maxwell's equation, also known as Maxwell-Heaviside equations,was first proposed by James Clerk Maxwell in the 19th century. These equations describe electromagnetic phenomena by relating the behavior of electric and magnet fields together. The Maxwell's equations have four parts. In the first equation which known as Gauss' Law for Electric Field, Maxwell described the relationship between the total electric flux through a closed surface and the amount of charge within that closed surface.

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \tag{2.1}$$

(The symbol of a deloperator called nabla, in which here the dot product of it represents the divergence of the vector field. And the cross product of it represents the curl of the vector field.)

It can also be written in the form of

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$$\oint_S E \cdot dS = \frac{Q}{\varepsilon_0} \tag{2.2}$$

It shows the electric flux through a closed surface, and it is proportional to the charge Q, and the coefficient is exactly $\frac{1}{\varepsilon_0}$.

The surface of the electric field is a ball, and the charge inside the surface is in the center of the ball. Assuming the radius is R, then the electric field on the sphere is everywhere $k\frac{Q}{R^2}$.

总觉得这里不能直接写，better assume**可能更好（？ 高斯哥哥大概率就是猜的**

The surface area of the sphere is equal to $4\pi R^2$. Then, the magnetic flux $\phi = E \cdot S = 4\pi kQ$. Besides, $k = \frac{1}{4\pi\varepsilon_0}$ so $4\pi k = \frac{1}{\varepsilon_0}$, $\phi_E = \frac{Q}{\varepsilon_0}$. ~~In fact, you can~~ imagine that as long as the surface is closed, no matter what the surface looks like, the number of electric field lines passing through the surface is constant, that is, the electric flux is constant, and it's independent of the position of the charge inside the surface, so you get this equation $\oint_S E \cdot dS = \frac{Q}{\varepsilon_0}$

我用的是第一人称we you**可能不礼貌（？ 戳**

Regarding Maxwell's second equation, Gauss's theorem for magnetic fields, since no magnetic monopoles have been found, i.e. that is to say, if there is an N-pole, there must be an S-pole, which ~~can be interpreted to mean~~ s that the "magnetic charge" is always equal to zero. Or it can be said that since the magnetic field is a spinning passive field, if there is a line of magnetic susceptibility out of the closed surface, then it must be into the closed surface, and once in and once out, the magnetic flux will always be equal to zero. In short, the magnetic flux through the closed surface is always equal to zero, which is this equation 这一段字数多啦~

$$\oint_S B \, dS = 0 \tag{2.3}$$

Ctrl B

~~The equation can also be written in the form of~~

In differential form,

$$\nabla \cdot \mathbf{B} = 0 \tag{2.4}$$

The relationship between electricity and magnetism is primarily described in Maxwell's third

这是第三个，**没有第四个提到**

and fourth equations, which are known as Faraday's Law of Electromagnetic Induction - "When the magnetic flux through the area enclosed by a loop varies, the induced electromotive force generated in the loop is proportional to the rate of change of the flux with respect to time. " Thus there is the equation that $\oint_l E \cdot dl = -\frac{d}{dt}\int_S B \cdot dS$. The equation can also be written in the form of

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$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{2.5}$$

我记得在正式的论文里，要用特殊字体表示表面积，\mathbb{S}，
问问你的老师？不过我们这种第一次写的应该不会纠结这种东西

R.H.S

The right-hand side uses a surface integral $\int_S B \cdot dS$ to represent the magnetic flux. The $\frac{d}{dt}$ here is the derivative with respect to time, which represents the rate of change of the magnetic flux.

L.H.S.

主观色彩有点多？ 理论推导我喜欢装高冷 :-)

And on the left, $\oint_l E \cdot dl$, the field point multiplied by a displacement, seems to be the familiar potential difference (voltage), which ~~in this case is~~ called the induced electromotive force. The integral symbol has a circle added to it, indicating that this is an induced electromotive force on a closed curve. So the equation above means: the induced electromotive force is equal to the rate of change of magnetic flux.

And as for the negative sign on the right side of the equation, it's the mathematical embodiment of Corrugator's Law. So this equation tells us that a changing magnetic flux (changing magnetic field) can produce a vortex electric field (changing electric field).

The fourth equation: electricity generates magnetism. This equation is the most complex of all, and it is modeled after the Ampere's Loop Theorem. A loop-shaped magnetic field is generated around an energized wire, and the direction can be determined from the right-hand spiral rule, so what is its magnitude? Ampere tells us this equation
gives the

$$\oint_l B \cdot dl = \mu_0 I \tag{2.6}$$

This shows that the strength of the magnetic field of this loop multiplied by its length is proportional to the magnitude of the current.

However, we find that the third equation, which states that a varying magnetic field produces an electric field, now becomes that a current produces a magnetic field, which lacks a symmetry. Maxwell was convinced that the laws of physics were perfect and symmetrical, so he proposed
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that by replacing the changing electric field with an imaginary current, a displacement current, he could bring it into the Ampere's Loop Theorem. So he proposed the displacement current hypothesis.

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After complex derivation, he arrived at the displacement current $I_D = \varepsilon_0 \cdot \frac{d}{dt} \oint_S E \cdot dS$, i.e.: the vacuum dielectric constant multiplied by the rate of change of electric flux. That is, the changing electric field can be equated to a current. Then, the previous equation is modified into

$$\oint_l B \cdot dl = \mu_0 (I + I_D) = \mu_0 \left(I + \varepsilon_0 \frac{d}{dt} \oint_S E \cdot dS \right) \tag{2.7}$$

This is the fourth equation, also known as the Ampere-Maxwell law, which describes how an electric current and a varying electric field can produce a magnetic field.

It can be seen that if there is no current, it is

$$\oint_l B \cdot dl = \mu_0 \varepsilon_0 \frac{d}{dt} \oint_S E \cdot dS \tag{2.8}$$

which is very symmetrical to the third equation.

In differential form

When written this equation in the form of nabla, the equation look like

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{2.9}$$

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2.1.1 Constant speed of electromagnetic waves

Brief introduction of electromagnetic wave

Electromagnetic waves are a fluctuating phenomenon consisting of electric and magnetic fields that propagate energy and momentum through space at the speed of light. Electromagnetic waves do not require a medium to support their existence; they can propagate freely in a vacuum. The generation and propagation of electromagnetic waves can be described and explained by a system of Maxwell's equations.

What are waves? Waves are a form of energy transfer that involves the periodic change of a physical quantity over time and space. Waves can be categorized into mechanical and non-mechanical waves. Mechanical waves are those that require a medium to propagate, such as sound waves and water waves. Non-mechanical waves are waves that do not require a medium to propagate, such as electromagnetic waves, gravitational waves, etc.

Electromagnetic waves are non-mechanical waves that consist of an electric field and a magnetic field. An electric field is a force field that exists in space and can exert a force on charged particles. Magnetic field is the existence of another force field in space, which can produce force on the movement of charged particles or magnetic material. There is a close connection between electric and magnetic fields; when a varying electric field is produced, it causes a varying magnetic field; when a varying magnetic field is produced, it also causes a varying electric field. Thus, an oscillating electric field produces an oscillating magnetic field, and vice versa. These two oscillating fields are perpendicular to each other and perpendicular to the direction of propagation, creating a transverse wave, known as an electromagnetic wave.

Theoretical derivation of the constant speed of light

As I mentioned on the previous section that the Maxwell's equation include four part,

From previous derivations, we have

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \tag{2.10}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{2.11}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{2.12}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{2.13}$$

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To calculate the speed of the electromagnetic wave in the vacuum, it is necessary to know some physical property about the vacuum. Firstly, as there's no charge in the vacuum, so $\rho = 0$. Thus the first formula of Maxwell's equation $\nabla \cdot \mathbf{E} = 0$ In addition, it is not possible for induced current exist as the condition for the formation of induced current is that the magnetic flux through the closed conductor loop changes, then there is an induced current in the closed conductor loop. But in the vacuum, there's no conductor, let alone the closed conductor loop. So $\mathbf{J} = 0$. Thus, the forth formula of Maxwell's equation $\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$.

impossible /(ㄒoㄒ)/~~

After recompiling all the formula, it is gained that

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \tag{2.14}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{2.15}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{2.16}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{2.17}$$

The vector field formulation of the nabla operator proposed by Hamiltonian shows that

这里是不是多写了啥 2.18应该靠右的来着

$$\bigtriangledown \times \bigtriangledown \times E = \bigtriangledown \cdot (\bigtriangledown \cdot E) - \bigtriangledown^2 \cdot E(2.18)$$

which is a formula that describe the relationship between the divergence and curl of a vector we have

field. Bringing known quantities into this formula, it is gained that

$$\bigtriangledown \times (-\frac{\partial \mathbf{B}}{\partial t}) = \bigtriangledown \cdot 0 - \bigtriangledown^2 \cdot E \quad (2.19)$$

Using the commutative law of multiplication, get the $\partial \mathbf{B}$ term is multiplied by nabla.

$$-\frac{\partial}{\partial t}(\bigtriangledown \times \mathbf{B}) = -\bigtriangledown^2 \cdot E \quad (2.20)$$

Substitute

Then put the term of

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \quad (2.21)$$

into the formula,

$-\frac{\partial}{\partial t}(\mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}) = -\bigtriangledown^2 \cdot E$

Partial differentiate $\frac{\partial \mathbf{E}}{\partial t}$

咋靠左了 好可爱

$\mu_0 \varepsilon_0 \frac{\partial E^2}{\partial t^2} = \bigtriangledown^2 \cdot E$

Because $\nabla \cdot \mathbf{E} = 0$, so $\bigtriangledown^2 \cdot E = \frac{\partial E^2}{\partial t^2}$. Then put this term into $\mu_0 \varepsilon_0 \frac{\partial E^2}{\partial t^2} = \bigtriangledown^2 \cdot E$

$\mu_0 \varepsilon_0 \frac{\partial E^2}{\partial t^2} = \frac{\partial E^2}{\partial t^2}$

欸 二阶导？是不是应该写成 delta^2E

Divide both sides of ∂E^2 in this equation, and make a transposition of term,

$\mu_0 \varepsilon_0 = \frac{\partial t^2}{\partial x^2}$

By simple partial differentiate and evaluate half power of $\mu_0\varepsilon_0$

$$v = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

Since $\mu_0\varepsilon_0$ are all constant, so the speed of electromagnetic wave in vacuum is a constant as well. It is getatable to get the value of it by put in the actual value of $\mu_0\varepsilon_0$

$$v = \frac{1}{\sqrt{(8.9\times10^{12})\times(4\pi\times10^{-7})}}$$

$v = 299019881.2$, which is close to the experimental tested speed of light.

2.1.2 Constant speed of light

The Michelson-Morley experiment

The Michelson-Morley experiment aims to quantify Earth's velocity in relation to the optical ether, a substance that permeates space and is considered to be a light wave carrier. American physicists Edward W. Morley and Albert A. Michelson experimented at Case Western Reserve University in Cleveland, Ohio, between April and July of 1887.

The experiment attempted to measure the relative mobility of matter through the blazing ether (the "ether wind") by comparing the speed of light in a vertical direction. However, Michelson and Morley discovered that there was no discernible difference between light's speed in the correct direction and its apparent travel through the aether, which means the aether theory is wrong. This experiment eventually led to the development of special relativity. The aether experiment also proved in reverse that the speed of light does not change as the results of the experiment show that the speed of light remains constant regardless of the position of the Earth in its orbit. This is consistent with the fact that the speed of light is not affected by the observer's state of motion.

Particle accelerator experiment

There is also an interesting experiment that can proof in disguised that the speed of light is always a constant value. In the 1930s, scientists invented particle accelerators to explore the deep microscopic structure of matter. In the experiment of acceleration, scientists found that no matter how to increase the power of particle accelerators, the speed of particles that be accelerated by the accelerator can never be up to the speed of light. This is because in particle accelerators, Newton's second law still holds. The change in particle velocity still depends on the ration of force (f) and mass (m). $f(v) = f/m$

Now that the particle can no longer accelerate, it is obvious that

$f/m = 0$

There are two cases: one is $m = \infty$; the other is $f = 0$. Both theories could account for the fact that particles cannot travel faster than light. But the point is whether the claim itself makes sense.

哈哈哈infinity

Assume that $m = 0$, in which very mysterious and antilogical, no one has ever seen, has always been questioned. Besides any theory related to "infinity" should be avoided, here is no exception. So turnd to the assumption of $f = 0$, which very grounded, anytime, anywhere visible, anytime verifiable. That's the more hopeful way of putting it. Of course, the next question is: When does $f = 0$? Here is a statement: electromagnetic force for particle acceleration, because the electromagnetic interaction propagation speed is the speed of light, when the particle speed increases, the efficiency of the interaction will decrease; When particles reach the speed of light, the efficiency of the interaction drops to zero, which means the rate of intersection can no longer catch up the motion of particles. In this case, $f = 0$.

It is better to say "the force decreases with increasing velocity" than to say "mass increases with increasing velocity." Because the "mass" is an inherent property of the particle, it has no necessary connection with the external speed, and the force is not the particle itself, but the interaction caused by the interaction, and the relative speed affects the interaction is obviously reasonable. So when a particle reaches the speed of light, the force drops to zero, so it can't accelerate anymore; Therefore, particles cannot travel faster than light.

2.2 Rectilinear Propagation of light

2.3 The background of Quantum Mechanics

Quantum mechanics is a subject connected to quantum, as its name implies. As a result, we can start by addressing the definition of quantum. The smallest quantity of any physical entity participating in an interaction is known as a quantum in physics. According to my understanding, it is a microcosmic quantity that shows the energy's degree of dispersion. Phonons, for instance, are the basic excitations of elastic fields.

The bold assumption that the energy of vibrating charged particles may only be an integer multiple of a minimum energy value was made by the German physician Plunk in late 1900. For example, the energy of a vibrating charged particle can be 2ε or 2ε, but it cannot be 1.5ε . He called this energy quantum (ε) the undivided minimum energy value.

This theory defies logic because energy fluctuates continuously in our reality which is the macro universe (similar to what happens in a vertically vibrating oscillator; this small device's gravitational potential energy varies continuously, without interval). Nevertheless, Plunk thought that either the energy of microscopic particles is discontinuous or quantized in his hypothesis. The Planck constant, h, has a value of h= 6.62607015×10-34 J·s. Using v as the electromagnetic
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wave wavelength and h as the Planck constant, one can compute the quantum energy magnitude.

如果写h就加斜体或者公式吧 最好

Depending on Plunk's quantization hypothesis, Einstein published four of his famous theses in 1905 (On a Heuristic Viewpoint Concerning the Production and Transformation of Light, On the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat, On the Electrodynamics of Moving Bodies, and Does the Inertia of a Body Depend Upon Its Energy Content? So we named this year Annus Mirabilis).

文章标题用斜体？ **也不用全写？**敬重伟人不需要扒着他们的裤子哈哈哈

He used the terms "energy quanta" and "light quanta" in his thesis On a Heuristic Viewpoint Concerning the Production and Transformation of Light. He also held the view that since the electromagnetic field is originally discontinuous, light is made up of indivisible quanta of energy. With frequency v, the energy quantum of light is h, where h is the Planck constant.

我记得这个不是简单的v，**好像是希腊文**

Afterwards, this particle of energy were dubbed photons.

2.4 The background of Relativity

Albert Einstein published his theory of relativity at the beginning of the 20th century. This well-known theory primarily explains how motion, space, and time are related to one another. The first publication of special relativity was made by Einstein in 1905. Two postulates underlie this theory: the invarince of the speed of light and the relativity principle. It was noted by Einstein that the physical theory was the same in all inertial references (the reference in which there is no acceleration). Furthermore, regardless of the source of light or the motion of observers, the speed of light in a vacuum is always the same. Because of Maxwell's equation, he is able to deduce that light is invariant. Using the equation, Maxwell was able to determine the wave speed of electromagnetic waves by taking the second derivative with regard to the magnetic field's time.

Since u0 and 30 in this equation are constants, the speed of an electromagnetic wave in a vacuum is independent of its external surroundings. This equation can be solved simply for the value of 3*108 m/s, which is the same as the speed of light as determined by Jean-Baptiste Foucault's experiment. Consequently, scientists daringly assumed that light is an electromagnetic wave in a vacuum with an unchanging speed.

The theory of special relativity has led to some fascinating phenomena in reality. Take the ideas of length construction and time dilation, for instance. Picture a man with two flashlights in the middle of a spaceship, pointing them left and right, respectively. Next, turn on all of the flashlights at once so that the light beam interacts with the wall simultaneously. The speed of light is constant, but the spaceship is traveling in the same direction as the right-hand flashlight, so the left-side beam will appear to be moving more quickly than the right-side beam if the spaceship is moving and a ground observer sees the man. This will create a paradox. In order to rectify it, scientists proposed that time will slow down, causing the spaceship's left side to be in the future and its right side to be in the past. Since the left side's time was a little bit faster than the right, it appeared that the ship was completed. The observation of particle u landing on Earth can also be explained by these occurrences.

In order to rectify it, scientists proposed that time will slow down, causing the spaceship's left side to be in the future and its right side to be in the past. Between 1907 and 1915, Albert Einstein devised the theory of general relativity, which describes gravity. Einstein proposed that the influence of mass will cause space to bend under this theory. The entire area has the properties of an extensible cloth that will be stretched and warped by the mass. The gravitational potential force has this as its root source. Many riddles can be solved by applying the theory of general relativity. Mercury's orbit, for instance, processes more than predicted by Newton's law of gravity yet behaves exactly as predicted by general relativity because of the sun's enormous mass and its proximity to the planet.Since the left side's time was a little bit faster than the right, it appeared that the ship was completed. The observation of particle u landing on Earth can also be explained by these occurrences.

中微子？

哦对这里开始基本上我就没提什么东西了
写的真的很好 至少我基本上看懂了
画出来的都是笔记而已。。。

但是我还有点问题 **我都能看懂是不是会有一点写的太通俗 像科普文章而不是论文（？**

3 Discussion

3.1 Non-straight Propagation of Light

Light travels in a straight line in the same homogeneous medium. Imaging of small holes, shadows, solar and lunar eclipses can be evidence to prove it. However, if you put two pencils together and look at a fluorescent light from the slit in the middle of the pencil, it is surprising that you can see colorful streaks, and the pencil slit surprisingly makes white light dispersion. This is completely contradictory to the usual phenomenon of imaging through a small hole. From this small phenomenon can be guessed that perhaps the width of the slit or hole is adjusted to a very small, light in the passage of the phenomenon, it will produce different phenomena. The experiment found that when the slit width is relatively large, the light propagates along a straight line, and constantly reduce the width of the slit, when the slit width is approximately equal to the wavelength of the light, the experiment saw that the light deviated from the straight line track, around the edges of the obstacle, and passed to the back of the obstacle, and formed a bright and dark light intensity distribution pattern on the light screen. This is the phenomenon of diffraction of light, which also proves that light is a wave. In fact, light is essentially an electromagnetic wave. Therefore, we usually say that light travels in a straight line is only a special case, light in a uniform medium without obstacles is along the straight line, in the case of obstacles in the size than the wavelength of light is much larger than the case of diffraction phenomenon is not obvious, you can also think that the light is along the straight line of propagation. However, in the size of the obstacle can be compared with the wavelength of light, or even longer than the wavelength of light, diffraction phenomenon is obvious, it can not be said
cannot

that the light along the straight line. There is a very common phenomenon in life, such as why sound can penetrate walls and other obstacles, but not light? The human ear can hear the sound frequency range is 20HZ to 20000HZ, so the sound wavelength range of 0.017-17 meters. The wavelength of sound waves can be compared with the general size of the obstacle, so the sound waves can bypass the general obstacle, so that we hear the sound on the other side of the obstacle. The wavelength of visible light waves is about 0.4-0.7um, compared with the size of the general obstacles is very small, so the light can not bypass the general obstacles, generally do not see the diffraction phenomenon of light, said light along the straight line propagation.

explain why light sometimes seen as travel in straight line

3.1.1 Refraction and Diffraction

As we all know from high school physics textbook that the speed of light in vaccum is the higher than that in other materials. But this conclusion seems to go against the invariance of speed of light as the formula of theoriotical speed of light is $\mu \cdot \varepsilon = \sqrt{\frac{1}{v^2}}$, From high school knowledge, it is easy to calculate the speed of light in a given material since the speed of light is altered with different atoms, crystal lattices, and other substructures, it has a significant impact on the type of material. An index of refraction (n) is a constant that can be utilized to determine the speed of light in a certain material.

The refraction of light is essentially a force phenomenon of light. This force is what we often call gravitation, which in classical mechanics is the ability of matter to attract each other, and the greater the mass of objects, the greater the force between them. From Einstein's theoretical perspective, the concept of light refraction is more metaphysical: light refraction is because space-time is curved. If you look at the direction of light refraction, it is easy to find that the light must be biased towards the direction of high density, and the light path is vice versa. The reason for refraction is that although light has zero rest mass, it also has a very small dynamic mass. When a photon crosses the interface between two different materials, the high-density side of the material has a higher mass than the low-density side, and the gravity is greater. When the photon passes through the interface of two different substances, it will suffer a slight imbalance force to form a force difference, and the stable force will cause the direction of the light to change, and refraction will be produced. This force difference is actually very weak and has no effect on common particles, only those near zero mass photons can effectively deflect them, and the outside world appears to have refracted the light.

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For example, the prism shows the application of light refraction, where the refraction Angle of light is different because the dynamic quality of different colors of light is different, the mass of color light force is larger than other color light, so the refraction Angle of violet light is the largest.

There are a lot of interesting refraction implications from this point of view.

Due to the difference in material density caused by light refraction, then the continuous density difference will cause continuous light refraction, this light uniform continuous refraction of the outside world looks like a rare "bending light." However, the continuous density difference in daily life is actually difficult to see, so the lensing phenomenon of bending light in daily life is relatively rare, but at the level of black holes, this continuous density difference is more obvious, so the black hole can obviously observe the bending refraction phenomenon of light.

引力透镜效应 usually in large mass bodies

For example, Einstein once published the prediction of "gravitational lensing effect", referring to the fact that light passing through a massive object will cause space-time to be bent by gravity, forming a phenomenon of "gravitational lensing", and the light will be bent before reaching the eye of the observer. This can be seen as a specific application of light refraction bending under the force of the huge mass of the planet.

If we can precisely control the enormous mass and gravity, we can design an experiment in which all light moves around an object at the speed of light. The light moves just like everyday Earth satellites, which the nature of the experiment is refraction.

When the light passes through the black hole, because of the huge force, the light will be biased to the black hole due to the huge gravity, when the gravity is too large that the refracted light can never return (the minimum escape velocity is even bigger than the speed of light), the black hole event horizon phenomenon is formed. The light refracted toward the black hole is broken down into various colors like a prism, and then disappears into the black hole forever.

will light be seperated into various col? due to the lens?like refractipon?

There is no mass in light as a result Newton's laws do not hold true. This is due to the fact that light always takes the quickest route when it moves. The theory of refraction states that things differ in their refractive indices, which alters the path taken by light. What then is the diffraction principle? Regarding diffraction, light behaves like a wave in a river, and as such, it causes the river to continue flowing around the stone. Obstacles can be avoided by waves. According to Huygen's Principle, which describes how light bends around barriers, can be used to explain diffraction. Each wave crest is made up of source points that generate wavelets, which then spread outward to create new wave fronts.

3.1.2 Spacetime curvature

Free fall can be clarified through the action of a force, which is also referred to as gravity, as we all learned in middle or senior high school. Because gravity represents the attraction between two mass items, it enables humans to forecast how objects will move. Nevertheless, F=Gm1m2/r2 only serves as an approximation, and it breaks down when an object's mass is too great. For instance, Mercury's orbit around the sun defies the application of the law of universal gravity. The mystery remained unresolved until 1915, when Albert Einstein's publication of General Relativity offered a fresh perspective on the structure of the cosmos. According to Einstein's theory, there are four dimensions in the universe: three for space and one for time. From his perspective, he made the observation that space-time is like an elastic web that may be distorted by heavy objects. Marbles in a bowl can be used to illustrate the effect of draping objects into a fall. This clarifies centripetal force's cause and effect.

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Apart from that, the curved path that light took can be explained by Einstein's theory of space and time. It is difficult to explain why light will travel in a curving path through a massive object when, as we all know, light is an item without mass. General relativity's advancement marked a significant turning point. Albert Einstein, the creator of general relativity, postulated that space is what is bent, not the path of light, which is essentially straight. When we witness a curved phenomenon, it is because we have various reference frames. If someone can "stand" on light, then the light path that he viewed is an extremely straight line.

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An illustration of this hypothesis was conducted on May 29, 1919, in Edinburgh, United Kingdom. It is referred to as the "Eddington experiment" or the "1919 solar eclipse expedition." That day, British astronomer Sir Arthur Eddington traveled to Sobral, Brazil, and Principe Island, off the coast of West Africa, to measure the positions of stars near the sun. This experiment's primary goal is to verify a general theory of relativity prediction made by Albert Einstein, namely the idea that the gravitational effect bends light. Eddington and his colleagues measured the apparent positions of stars that are incredibly close to the sun's edge by observing the positions of stars near the Sun during the complete solar eclipse. This was made possible by the eclipse's dark sky. Comparing these positions to their typical locations in the night sky without the sun is the goal.

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Observations conducted during the eclipse revealed that the star's location was different from what was predicted. This change confirms Einstein's theory that light is bent by the sun's gravity, which causes distortions in the positions of stars that are viewed close to the sun.

3.2 Introduction of Free will

Whether a human authentic have the free will is always a controversial topic in varies subject like philosophy, neuroscience and psychology as this simple question directly related to the nature of human behavior, self-awareness and how the universe works. An in-depth dissection of this issue requires consideration of different perspectives and evidence, and an understanding of the definition of free will and its practical application to human behavior.

The definition of free will is: the idea that humans have the ability to make their own choices and determine their own fates. Sounding very abstract, here is an example of free will. Suppose there are two boxes for a person to choose from, in which ten and one hundred dollars are placed. If the person chooses the box with the more money, can he be judged to have free will? Not really, because we can also design a machine and program it with the box with the most money. Here, if the person is more rebellious and he insists on taking the box with less money, can he be judged to have free will? Not really, because one can likewise design a box and set its program to be: that box with less money. So where does free will go, it seems?

In fact, whether or not one has free will is not the result of the choice, but the process of the choice. It is in the process, ”Even though I took the box on the left, I could have taken the one on the right,” that free will is manifested. Free will is the ability to make the ”possible” into the ”real”. The end result depends on ”my choice”, in other words, my choice and my unrestricted consciousness (which, however, is really only a relative concept, as I will mention in the following paragraphs).

3.2.1 Laplace’s determinism

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Laplace’s demon is a scientific hypothesis proposed by French mathematician Pierre-Simon Laplace in 1814. This ”demon” knows the exact position and momentum of every atom in the universe, and can use Newton’s laws to show the entire course of cosmic events, past and future. So in Laplace’s determination, there is no free will exist as every concepts and motions seems to be determined at the beginning of universe.

The notion of determination is also be approved by Albert Einstein. He once wrote to Tagore a letter and came up that the moon can also have free will like us. Because it may assume that the act of completing its eternal way around the earth is the gifted with self-consciousness. So he consider that it is possible for a being, endowed with higher insight and more perfect intelligence, watching man and his doings, smile about man's illusion that he was acting according to his own free will. In the end of the letter Einstein wrote: "This is my tenet."

Albert Einstein is a deeply causationist in which he deemed that everything in the universe must based on a strict logic. So there is no free will and the consciousness of free will is actually an illusion to human. The strict logic make Einstein a great theoretical physicists but in the reality human logic does not always work. Here's an example.

Marconi, an Italian engineer, came up with the idea of using electromagnetic waves to send messages across the Pacific Ocean. When he issued this view, he immediately attracted a large number of scientists ridicule, because according to scientific theory and logic, electromagnetic waves will only shoot into space after being emitted, and it is impossible to cross the Pacific Ocean. But Marconi didn't give up until the experiment was successful, and he punched the scientists in the face. Later, scientists began to study this, and discovered that the existence of the ionosphere in the atmosphere made radio possible, without the ionosphere, electromagnetic waves would only shoot out into space as scientists predicted.

3.2.2 Robert Kane's libertarianism

The philosophical question of whether human beings have genuine free will has been the subject of continuous debate among philosophers. Especially in the light of traditional physics, where determinism is highly touted, much of the focus in the study of free will has long been directed toward the idea that determinism is compatible with free will, while ignoring the possibility of non-deterministic free will. Robert Kane is a representative figure who advocates non-deterministic free will. He recognizes the existence of determinism, but opposes free will in its one-to-one binding of causation. At the level of physical development, non-deterministic free will became possible after modern quantum mechanics introduced non-determinism and chance into the physical world.

Kane argues that the debate over free will has always centered around four central questions: first, the question of coherence: is free will coherent with determinism? Second, the question of meaning: why do people need a free will that is not compatible with determinism? Third, the problem of intelligibility: do we make non-deterministic free will logical and intelligible? Fourth, the existence question: does such free will exist in nature?

3.2.3 Frankfurt's compatibilism

决定论与自由意志不违背

Frankfurt proposed compatibilism, which argues that determinism and free will are compatible, i.e., behavior remains free even if it is causally determined. The rough relationship between freedom and responsibility is that if your actions do not stem from free will, then you are not responsible for the actions. Here's an example, imagine a puppet on strings, if the knife in his hand kills someone, we would hardly hold the puppet responsible for that because he has no spontaneous agency. Frankfurt argues that freedom depends on the structure of your own will, rather than being determined by external causation, meaning that even if there were no other possibilities available, your actions could still be free, and therefore you would still be responsible. He uses the Frankfurt counter-example to illustrate the situation: suppose there are two dishes in the cafeteria, one is pizza and the other is fried rice, and now you have a chip in your brain that will activate and force you to choose the fried rice if you choose the pizza, but since you only like fried rice, you've never chosen pizza, and the chip has never activated to force you to choose fried rice. you. So, even though you only have one choice, you can still be free.

He argues that freedom does not depend on whether one has a choice or not, but on the structure of one's will, which is similar to an inner mental capacity. There are first-order desires and second-order desires in the structure of the human will. They can both be expressed as "A wants X", but for first-order desires X is some action or thing; for second-order desires X is the first-order desire itself, which can be expressed as ”A wants to want X”.

According to Frankfurt, ”Because a person has second-order determination, he is based on the possibility of enjoying freedom of will and the possibility of lacking it. The concept of a person, therefore, is not only the concept of an entity with first-order desires but also with second-order determinations.”

He expresses the difference between having a second-order will or not through the example of an addict. Suppose I am a reluctant addict, and my first-order desires include both a desire to smoke and a desire not to smoke, and my second-order desire is to want to restrain myself from smoking. Suppose I am a permissive addict, and my first-order desires have both the desire to smoke and the desire not to smoke in them equally, but I have no second-order will, and I don't care which of the two desires I actually want, and in terms of not caring, Frankfurt argues that permissives are not human beings and have no meaningful freedom of will.

There are different levels of responsibility for people with second-order desires, i.e., with free will; if your second-order desires are in line with your first-order desires, and there is no contradiction at all, then you should take full responsibility for your actions. If your second-order desires do not desire the actions of your first-order desires, but you act in accordance with your first-order desires nonetheless, then you are not fully responsible, only partially.

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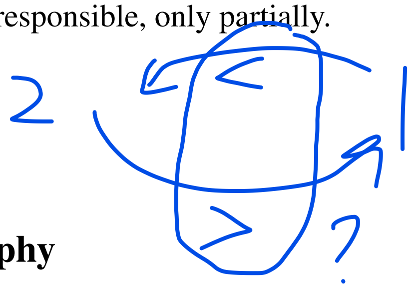

3.3 The relevance of physics and philosophy

3.3.1 The battle between determinism and nondeterminism

Throughout the history of mankind, there is the battle between determinism and nondeterminism, in which nondeterminism takes the high ground.

In the mechanical worldview, material behavior was predictable on the basis of prior conditions and experiences. Determinism, which ruled science in the 18th and 19th centuries, held that everything was linked by ”cause and effect”, that all movements in the world were determined by definite laws, and that if one knew the cause, one could surely know the effect. On this basis, science has developed enormously. Similarly, this ”Laplace’s creed” is reflected in the philosophy of destiny in the fatalistic view: ”Matter” is in motion - the motion is lawful –The laws are not subject to the will of man, and therefore ”the world is predestined”. Therefore, man’s predestination is also inevitable. Continuing to extrapolate further, the same is true of the materialist view of history: history is regular.

Yet with the advent of quantum mechanics sparking the famous Bohr-Einstein debate, Einstein’s letter to Bohr perhaps illustrates this philosophical confusion: ”I am by no means willing to be forced to abandon strict causality... I cannot at all tolerate the idea that the electron, when irradiated by radiation, chooses of its own free will not only the moment of its jump, but also its direction. If that were true, I would rather be a cobbler, or even an employee in a casino, than a physicist. I am in any case convinced that God does not roll the dice.”

With regard to the game of whether or not humans have free will, materialistic philosophy and science throughout the ages have put numerous nails in the coffin of will. And quantum mechanics came close to lifting the coffin boards. Indeed, even electrons have free will.

3.3.2 The loss of certainty

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3.3.3 realism

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The discussion of positivity stems from the physics of ghostly superlocation. The so-called superdistance effect is that tiny particles are born with an extra-sensory power (ESP), so that if one particle moves in a certain way (usually spinning up or spinning down), then its twin will immediately exhibit the same behavior, even if the two are separated by a great distance. Moreover, this information is transmitted faster than the speed of light. Since the two particles are identical, it was felt that it should be possible to use this information to predict the corresponding state of the second particle, having access to its complementary properties, such as speed. This would mean that we would know both the speed and the position of the second particle. However, measuring the activity of one particle has some kind of measurement effect on the other particle leading to the fact that no one can predict the corresponding state of the second particle (you can only get one or the other of velocity and momentum).

PS: It's not the Heisenberg principle of inability to measure that's being talked about here, it's the observer effect! The two get confused from time to time. The observer effect means that measurements of a system inevitably affect that system.

Until Bell's theorem came along in 1964, many people still insisted that the physical states and properties of an object existed before it was measured, and that these property states were independent of the observer. Einstein's insistence on definiteness is that nothing can affect other matter at the speed of light in excess of the speed of light. Quantum mechanics, however, proves that "a phenomenon is not really a phenomenon until it is observed." (John Wheeler)

So, philosophers aside, it's not hard to understand why Buddhism, teleology, and even more forests of metaphysics are particularly fond of quantum mechanics. Because quantum mechanics elevates the observer to the realm of the supreme.

”I know there is no contradiction in the matter, but it seems to me that the matter has a certain irrationality.” (Einstein)

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However, to say that the idea in philosophy that is most similar to the observer effect is phenomenology.Since it is impossible to have any grasp of things in themselves, or ”das Wesen,” to use the term favored by materialism and other ontological philosophies, and since the only objects of our reason are phenomena, the only phenomena we can or must study are phenomena. (Husserl)

3.3.4 continuity

The cause: the double slit experiment. The motion of microscopic particles is non-continuous, and this motion can be clearly shown by direct experimentation. The experiment tells us that in order for a single electron to produce interference fringes, it will pass through both slits non-continuously, not just one. Very abstract and poorly understood, quantum mechanics gives us the phenomenon, not the essence. As a result, people who believe in positivity have been asking, ”But how the hell does a particle pass through both slits at the same time?” Similarly, humans have never seen an object jump from A to B without passing through the space in between. To us, the existence of continuous motion seemed deterministic. Now here comes the quantum leap, a moment here, a moment there, a moment both here and there, a moment neither here nor there - and one wonders again about the fundamental law of material motion?

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Just as Zeno's paradox asked thousands of years ago: how on earth is the motion of objects possible? There are four Zeno's paradoxes, one of which is that flying vectors do not move. Major premise: no object can be in two positions at the same time. Minor premise: A flying ship can only be in one position at any given instant. (Since the ship is in only one position, it must stop immediately.) So, the essence of a flying vector is that the arrow appears sequentially in each position on a particular spot in succession, and does not itself move. Motion does not actually occur, but is a series of separate events, represented like a slide flipped at high speed. Motion is a projection of something discontinuous within us, a feature of thought.

Motion is really an illusion, and time is a subjective feeling of the creature. For physicists, all models that work for entities, from Newton to Einstein, from relativity to quantum mechanics, do not require time. Time is not Planck's constant, the speed of light is. Positivity, continuity, no longer exists in quantum mechanics, and this is the loss of certainty in the physical sense. What is lost is man's grasp of the supremacy of reason and the absoluteness of cause and effect.

3.3.5 the death of Metaphysic

While mechanistic theory does seem to be long dead, physicists were still plagued by some basic metaphysical assumptions before the advent of quantum mechanics. Particularly assumptions related to time and space, what with form and mass, position and energy, continuity and discontinuity... it's all really metaphysical thinking that binds our minds. In fact, the challenge and dismantling of many of the fundamental concepts that make up our cognitive faculties has been transformative since the days of Einstein's theory of relativity-physics doesn't need these words and concepts. These concepts are more applicable to simply applying them in three-dimensional, Euclidean space.

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3.4 conclusion

Many people think of physics and philosophy as two disciplines that are not connected in any way; however, it turns out that physics and philosophy have many complementary aspects.

Developments in physics can help drive philosophical thought, such as quantum mechanics in recent years. There is a tendency to associate philosophy with quantum mechanics, but in reality there is still a fundamental difference between the two. The development of quantum mechanics has created a great impact and opportunity for philosophy, and its own direction has

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The convergence of physics and philosophy actually began in ancient Greece, and many early scientists were also philosophers, such as Descartes, Pascal, Helmholtz, Boltzmann, and others, including Newton Maxwell, who also had a distinct philosophical stance. Kant was also held in high esteem by people including Einstein and others. The British physicist Isaac Newton even titled his work italic ! ! ! Mathematical Principles of Natural Philosophy. In recent years, however, bigwigs such as Feynman and Weinberg are the ones who have been quite critical of philosophy. And philosophical greats like Wittgenstein have asserted that scientists are unlikely to get help from their philosophical theories.

Helmholtz described in 1862 how ”philosophers accuse scientists of being narrow-minded; scientists sneer back and say that philosophers are crazy. As a result, scientists began to emphasize to some extent the need to sweep away all philosophical influences from their own work, and some of them, including the keenest scientists, denigrated even the whole of philosophy, saying not only that it was useless, but that it was a harmful dream. ...... The proper requirements of philosophy, namely, a critique of the sources of knowledge and a definition of the functions of the intellect, are also left unattended.”

In quantum mechanics, the fact that observation or non-observation directly determines the form of existence of a particle is philosophically significant in the sense that anything we can experience is relevant to the behavior of our subject. A system that we are not experiencing has no defined reality. This unobserved system, which has no definite observable measurements, can only be described in terms of a ”quantum state” (which has a number of special properties, such as superposition, arbitrariness, multiplicity, amorphousness, etc.), which is undoubtedly very different from the traditional philosophical sense of ”reality”, i.e., a system in which there are no definite measurements. ”real” in the traditional philosophical sense. That is to say, there is no observed system in which positivity is suspect.

By positivity I mean that we directly observe the various objects that exist in this world through some sense organs, and recognize various features of them. For example, I use organs such as my eyes and nose to observe an apple and recognize its color, shape, smell, and so on. This idea is consistent with most people's common sense. However philosophers and scientists are often not satisfied with common sense. Hence the indirect positivism. Direct positivists believe that we observe the various objects in this world directly, without having to rely on some kind of intermediary. Indirect positivists, however, believe that we recognize the world through the intermediary of "mental representations". A mental representation is something like a photograph that details the difference between a "photograph" and an actual human figure, i.e., the observation is not the same as the object itself. For example, when I look at an apple, what I see is a mental representation, not the apple itself. Indirect positivism holds that I am first observing the mental representation of this apple. I then draw on the mental representation to recognize this apple. The images of the apple, the smells, and the sounds it makes under certain conditions are all mental representations.

This is also how science can be understood: science is not a description of objective reality, but a description of observed phenomena, and the results of the observations depend on how you observe them, not on "objective reality". Poe once said: "Reality without observation is not reality". According to this statement, physics is not about "what the physical world is" but only about "what phenomena I see".

Physics and philosophy are in fact two different approaches to the world. We tend to think of physics as objective only because it is a discipline whose main logic is summarization, yet everything is based on observation, which is reality. Some philosophers once mocked physics as a dangerous building built on high ground, because the fundamental logic of physics is the result of a few researchers reading the scale of a laboratory instrument.

Physics is arguably the least ”humanistic” philosophical outlook, and while it does require a great deal of logical thinking, the general framework of thought is well established, which is why physics is the more easily disproved discipline. Physics has been in development since more than a decade ago, and its theories have been in constant iteration up to the present day. From Aristotle’s view of physics, to the famous Newtonian classical mechanics, to Maxwell’s four laws of electromagnetism, Einstein’s view of space-time, quantum mechanics, etc... Physical theories have always gone through iterations. This is because the essence of physics lies in the creation of a theory of the digital word that summarizes things, and this fundamental characteristic directly determines the total magnitude of the influence of the tools of observation on it. As the tools of observation continue to evolve, there is a gradual realization that some of the previous conclusions were not entirely correct or accurate. However, according to indirect positivism, we can never directly know the nature of anything, and this directly leads to the continuous follow-up nature of physics.

Unlike physics, philosophical worldviews tend to be more difficult to disprove. This is because philosophers tend to build a worldview that is self-justifying before fitting the real world to it. This is the exact opposite of physics, and makes the combination of the two disciplines a very interesting topic to look forward to. phy批评的有点多（其实是我心疼我的老婆
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References

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