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The Arrow Of Time In Quantum Measurement

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Abstract:
The irreversible process of 'wave packet collapse' in quantum measurement contradicts the reversible characteristics of the Schrödinger equation and the entire quantum mechanics. This contradiction is actually the origin of measurement problems in quantum mechanics. How to resolve this contradiction is related to the understanding of some philosophical concepts. The Copenhagen School embraces the reversible/irreversible contradictions in quantum measurement through the principle of complementarity. Both von Neumann's measurement hypothesis and Everett's many world explanation adhere to the 'universal position of the Schrödinger equation', but due to their detachment from the thermodynamic mechanism analysis of quantum measurement processes, they fall into the dilemma of subjectivism or possible state materialization in ontology. Decoherence theory is a natural extension of dissipative structure theory in quantum mechanics, which helps to solve quantum measurement problems by combining the study of classical conversion mechanisms between reversibility and irreversibility in statistical mechanics. Due to the common statistical roots of the time arrow problem in classical mechanics and quantum mechanics, decoherence theory cannot be seen as a measurement theory that fully implements the 'universal Schrödinger position'. Many contradictions in quantum mechanics may need to be cleverly resolved through various contradictions in classical physics.

Keywords: *quantum measurement, irreversibility, time arrow*

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I. Introduction

As is well known, quantum mechanics described by the Schrö dinger equation is reversible. However, the measurement process of quantum mechanics is essentially irreversible. In von Neumann's measurement hypothesis, the usual measurement is described by an irreversible process called 'wave function collapse', which leads to a clear contradiction with the Schrödinger equation and the reversible characteristics of quantum mechanics as a whole. This contradiction is actually the origin of measurement problems in quantum mechanics. How to resolve this contradiction is related to the understanding of some philosophical concepts, especially the understanding of the ancient problem about arrow of time.

1.The reversible evolution of quantum wave functions and the irreversibility of measurements

According to von Neumann's measurement hypothesis, quantum mechanical systems are represented by the Schrödinger equation, which is time reversible or is entropic. If system I is regarded as a quantum system represented by the Schrödinger equation, and measurement system II is also regarded as a quantum system represented by the Schr ö dinger equation, then they both satisfy the reversible or is entropic characteristics of quantum mechanics. This assumption can be continued indefinitely, as all measuring instruments are represented by the reversible Schrödinger equation, including the final measuring instrument being is entropic. This leads to the persistent coherence of the entire quantum system, which is difficult to eliminate. Von Neumann hoped to derive this 'measurement hypothesis' purely from quantum mechanics without introducing any other requirements. However, as the fundamental equation for describing the motion of microscopic particles, the Schrö dinger equation has a characteristic of invariance under time inversion transformation, making it time inversion symmetric. In the measurement process of quantum mechanics, the transition from pure state to mixed state is irreversible due to time inversion, which means that the quantum measurement process is essentially a process of entropy increase. The Schrödinger equation satisfies the 'reversibility' of time inversion, which is a process of entropy conservation. In principle, it is impossible to 'derive' the irreversible result of time inversion, that is, the process of entropy increase cannot be derived from the equation of entropy conservation. To derive the 'wave packet collapse' hypothesis of quantum measurement process from the Schrödinger equation, or to make the Schr ödinger equation uniformly describe the quantum measurement process without introducing other special assumptions, it is necessary to emphasize the macroscopic or classical characteristics of the instrument, rather than simply obtaining it from the Schrödinger equation. In fact, any measuring instrument is both a quantum system and must have corresponding macroscopic variables. If the instrument does not have these dual characteristics, it cannot reflect the eigenvalues of the microscopic particle system with some macroscopic variables. Therefore, the measuring system cannot be simply represented by the Schrödinger equation.

The debate on quantum mechanics measurement has long been in a purely speculative state. However, pure philosophical debates are difficult to convince people, and the best solution is to seek help from scientific experiments. In 1996, a research group in Paris conducted experiments using microcavity quantum electrodynamics (QED) to superimpose coherent states of radiation fields in cavities. The results showed that the disappearance of the 'interference term' in quantum measurements is a dynamic decoherence process that is completely unrelated to whether the human observer is present or not, and is purely caused by the inevitable entanglement between the photon field and the external environment. Even an isolated system cannot exclude photons because thermal radiation always exists in nature. [1] It is necessary to distinguish between 'observation' and 'measurement'. Observation usually relies on people, and the observation of a drawing or a reading on a dashboard requires 'subjective intervention'. The purpose of this 'subjective intervention' is to record the drawing or read the count. However, measurements can be taken in their natural state without anyone present. Mario Bunge believed that quantum measurements can be automatically conducted under computer control, and that nature may evolve devices similar to measuring instruments to cause quantum phenomena to occur. Therefore, measurement can be purely objective, and it can be the automatic decoherence of the system's collective body caused by the inevitable interaction between the system and its environment. Indeed, natural or purely objective measurement information has not been utilized by humans, but the collapse of the wave function is independent of whether the measurement information has been utilized or not. For quantum measurement, we can remove the phrase 'when there is measurement involved'. Simply put, the measurement of quantum mechanics, that is, the collapse of the wave function, is an event that has always existed and occurred in nature, and is difficult to eliminate.

According to recent research progress on decoherence, in quantum measurements, the uniformly evolving Schrödinger equation can lead to discontinuity in measurement results, manifested as irreversible features of the measurement results, which is actually a problem related to the internal degrees of freedom of the object. The loss of coherence caused by the measured object can also be provided by a micro degree of freedom measuring device, and the decoherence that occurs in this case is reversible. Therefore, in terms of decoherence of the measured object during quantum measurement, irreversibility is not actually necessary. For the decoherence of the object or system being measured in the quantum measurement process, the macroscopic characteristics of the environment or the macroscopic characteristics of the measuring device are not necessary, only the orthogonality of the environmental states (such as $| E_1$ and $| E_2$) ($E_1 | E_2 =0$) is necessary. If the orthogonality of environmental states can be achieved in the absence of macroscopic properties, the disappearance of interference is sufficient. In fact, even in a microscopic environment without macroscopic degrees of freedom, this orthogonality can sometimes be provided. In this case, the decoherence of the system occurs as a result of entanglement or quantum correlation, and the decoherence that occurs in this case is reversible. [2]

Therefore, if decoherence is caused by entanglement between the system and the micro environment (such as an instrument of one degree of freedom), then this decoherence is actually reversible. If decoherence is caused by entanglement between the system and a macroscopic environment (such as a thermal reservoir with a large number of degrees of freedom or an instrument+thermal reservoir), decoherence can be considered reversible in principle. However, from a practical perspective, it is irreversible because the large number of degrees of freedom in a macroscopic thermal reservoir is difficult to control. As long as one pair of degrees of freedom is orthogonal, the coherence of the system will disappear in this irregularly moving thermal reservoir. This situation is exactly the same as the case of a broken teacup in classical mechanics: the motion of putting all the fragments of the teacup together, so it is theoretically possible to restore the broken teacup, but in reality, this motion is impossible to achieve. This explains why the macroscopic world we see is an irreversible world, even though quantum mechanics and the Schrödinger equation are reversible.

2. The Arrow of Time and the Possibility of Time Travel

If decoherence is caused by entanglement between the system and the macroscopic environment, it is a time-dependent effect that, like the accompanying dissipation effect, points towards an increase in entropy: evolving from an ordered state, i.e. a pure state, to a disordered state, i.e. a mixed state. Although reversible processes are mathematically meaningful, we can always consider the density operator that remains unchanged in time inversion transformation as an initial state, following the Schrödinger equation. As a result, this initial state evolves to the final state over time t and has the same form under unchanged time inversion transformation. However, it is worth noting that as a matter of principle, it is usually not possible to prepare such time inversion density operators. Because according to the sufficient laws of physics, this will make the instrument for preparing this time reversal state too large to function properly. This impossibility may lead us to a new understanding of the second law of thermodynamics. According to Ilya Prigogine, the profound message conveyed by the second law of thermodynamics is that there exists a time arrow in nature, and the breaking of time symmetry and irreversibility are constructive factors in nature. Time symmetry breaking implies the existence of an entropy barrier, which means there are states that do not allow time inversion to remain unchanged. Just as in relativity, light barriers limit the speed of signal propagation. The infinite entropy barrier ensures the singularity of the time direction, guarantees the consistency between life and nature, and also makes understanding possible.

In the current situation, the most important thing is that the logical direction of time must be consistent with the direction of thermodynamics. In thermodynamics, if a unique projection describes the initial state, several projections must be used to describe possible final states. The irreversibility of thermodynamics arises from an ordered preparation of the initial state, resulting in a disordered final state. The irreversibility of quantum measurements also stems from the macroscopic characteristics of disordered degrees of freedom in instruments or environments.

The arrow of time objectively exists, not just human perception, which does not mean that time is absolutely irreversible. In the quantum field, irreversibility does not have absoluteness for decoherence. Time travel does occur at the microscale, but we are not aware of it. If someone applies Feynman's histories summation idea to a particle, they must include the history of the particle traveling faster than light or even traveling back to the past through time. Therefore, quantum theory appears to allow for time travel at the microscopic scale. However, this is not very useful for science fiction, such as going back in time to achieve a certain goal. Because time travel doesn't happen everywhere. According to Stephen Hawking's ‘the Chronology Protection Conjecture’, physical theorems work together to prevent macroscopic objects from traveling in time. Although histories summation allows for a time cycle, its probability is extremely small. Therefore, the so-called grandfather paradox: what would happen if you went back in time and killed your grandfather before your father was conceived? Only when you believe that when you return to the past of time, you have free will to do whatever you want, does this become a fallacy. Based on Hawking's duality argument, the probability of someone going back in time and killing their grandfather is less than $1/10^{10^{60}}$. That's a very small probability. The possibility of a villain returning from the future and killing their grandfather is extremely slim. So, reversible events or time travel that occur in quantum particles do not occur in the macroscopic world, and the arrow of time is consistent with our macroscopic perception, generally pointing towards the future [3].

In Schrödinger wave dynamics, for negative ‘energy eigenvalues’, only discrete solutions exist, leading to the characteristic spectra of chemical elements. For all positive energy values, a continuous solution consisting of eigenfunctions and eigenvalues is given, representing the free motion of electrons outside the atom. It is a linear superposition of a series of intrinsic oscillations, with probability amplitudes that trigger various orbital transitions inside the atom, and is modeled in a quantum pure state manner. During the measurement process, the Hamiltonian of the instrument only involves the macroscopic potential energy of the particle before triggering the internal orbital transition of the atom. When particles enter the instrument and trigger orbital transitions of certain atoms, ultimately giving an eigenvalue for measuring a certain physical quantity, the particles enter a negative energy eigenvalue, and the potential energy difference of the atomic internal orbitals guides the particle's motion in a quantum potential manner, just like David Bohm said when considering the single particle problem in a non-stationary state: ‘A particle is precisely subjected to a 'quantum mechanical potential' U=$(-h^2/2m)\nabla^2 R/R$, which fluctuates at an angular frequency ω=$(E_1-E_2)/h$, and the energy E=$-\partial S/\partial t$ and momentum p=∇S of the particle also fluctuate at the same angular velocity.’ [4, p352] This passage suggests that the source of the quantum potential that a particle is subjected to is when the particle interacts with the atoms of the measuring instrument, and the energy eigenvalue undergoes a non-stationary change from the continuous spectrum to the discrete spectrum, triggering the instrument atoms to undergo orbital transitions and enter the evolution of the quantum mixed state. The probability of atomic orbital transitions in instruments, M. Born uses the atomic collision process to understand: ‘A cluster of electrons from infinite distance, which can be represented by an incident wave of known intensity (i.e. $|\psi|^2$), collides with an obstacle, such as a heavy atom, just like the water waves generated by a ship will produce secondary circular waves when encountering a wooden stake. Some of the incident electron waves will also be converted into secondary spherical waves, and their amplitudes ψ are different in different directions. At places far from the scattering center, the square of the amplitude of this wave determines the relative scattering probability as a directional function. Moreover, if the scattering atom itself can be in different steady states, the Schrödinger equation automatically gives the excitation probabilities of these states, and the scattered electrons will... Losing energy, that is to say, what happens is what is called inelastic scattering.’ [4, p315]

Probability in quantum field theory involves not only atomic orbital transitions, but also the interconversion between particles. Once the positive energy level reaches the relativistic energy corresponding to the rest mass of a certain type of particle, the generation annihilation process of such particles will begin, which means that the eigenvalues of positive energy also exhibit a discrete particle mass spectrum. In the Feynman diagram of quantum field theory, there are not only particles with space-like world lines, but also the time reversal world lines of particles are interpreted as world lines of antiparticles. However, as early as 1959, Canadian physicist and philosopher of Mario Bunge believed that we needed to seek a real self-organizing interaction mechanism to replace the teleological mechanism, where the closed spacetime loop that breaks causality in quantum mechanics could be naturally eliminated. Mario Bunge pointed out that the interaction mechanism between Feynman's 'future' and 'past' may be as follows. In a series of similar events, such as continuous scattering of particles of the same class in a given scatterer, the result is a reaction to the cause; The result is not caused by the same reason (unless instantaneous actions at a distance are allowed). Therefore, if a beam of electrons hits the target, the field generated in the scattering region will in turn correct the field of the electron gun. So, after the initial transition phase is completed, the entire process will manifest as a feedback system, where the result (scattered electrons) corrects the initial conditions, forming a stationary system in this way. In this case, the variable t cannot be simply seen as a definition of anything closely connected to the individual event process: just as in quantum theory, time t is a c number, as a coordinate, and does not belong to the quantum system involved, unlike spatial coordinates corresponding to a Hermitian operator in Hilbert space [5]. We found that it is the lack of a clear energy time uncertainty relationship in quantum mechanics and the issue of whether there is an operator for time t that triggers the purposive interaction between the 'past' and 'future' in the Feynman diagrams of quantum field theory. In the scattering process of electron impact on the target, the eigenstate in quantum mechanics can be regarded as a resonance state where the electron radiation and the recoil radiation in the scattering region reach a force equilibrium.

Further analysis of the time arrow in quantum mechanics reveals that the spontaneous emission of excited atoms is an irreversible process and a microscopic mechanism of thermodynamic irreversibility. Generally speaking, the irreversible factors of quantum measurement are deeply involved in thermodynamics. However, even if the measuring instrument does not have an irreversible recording process, the transition from quantum pure state to mixed state that occurs in negative result measurements is a typical microscopic irreversible process. On the other hand, most scholars believe that the Schrödinger equation is time symmetric, thus suggesting the existence of reversibility issues. In fact, the Schr ö dinger equation can only be written in a steady state form when the potential energy U is a conservative potential, and is related to the equation $\psi^*(-t)=\psi(t)$. At this point, the probability of the forward process of the quantum process is the same as that of the time inversion process, so the process remains invariant to time inversion. Only under this condition can we consider the Schrödinger equation time invariant and reversible. But in general, such as in an isolated system in a non-equilibrium state, U is related to the momentum of the particles; For systems that are in a non steady state, such as the spontaneous emission process of atoms, there is a case where the probability of the forward process is not equal to that of the inversion process, and the process is irreversible. Therefore, the Schrödinger equation cannot be invariant to time inversion. The Schrödinger equation cannot provide a specific form of the interaction energy U, and currently in quantum mechanics, the form of U is actually determined according to classical mechanics.

After analyzing the irreversibility of the U-process in quantum theory, we believe that under CPT symmetry, as long as the external potential in the Schrödinger equation is non conservative, the U-process will give different probability amplitudes in the two directions of time, leading to the irreversibility of the R-process. In the debate about whether quantum gravity is reversible, Hawking ignored the possibility that gravitational potential energy could affect the reversibility of quantum processes; Penrose did not thoroughly clarify how the influence of gravitational potential on quantum processes ultimately leads to macroscopic irreversibility when dealing with this issue. We believe that the essence of the Weyl curvature hypothesis is the asymmetry of gravitational potential in the past and future time directions. Hawking mistakenly believed that CPT symmetry naturally leads to time reversal symmetry in quantum processes, especially quantum gravity processes. The irreversibility of quantum measurements comes from the incompleteness of information related to thermodynamics, black holes, and the event horizon of the universe. As Bohr said, 'irreversibility is the result of introducing ignorance into the fundamental laws of physics'; In fact, in different gravitational fields, especially near black holes of different sizes, the probability of matter or radiation being absorbed or emitted is not equal. However, the unequal probability of matter or radiation being absorbed or emitted in a gravitational field, as well as the irreversibility of the R process in quantum measurements, do not require microscopic physical laws to break CPT symmetry as envisioned by Penrose. Instead, they only require some non conservative potential (whether gravitational or electromagnetic) to result in different probabilities of quantum process evolution in both time directions. Further analysis reveals that the different evolution probabilities of quantum processes caused by non conservative potentials are related to the different stability distributions of non conservative potentials at both ends of time. Probability is related to information incompleteness, but both the differences in probability and the degree of information incompleteness have objective reasons; Only in the process related to human intervention, subjectivity serves as a conditional difference that leads to differences in probability and information.

3.The classical origin of irreversibility in quantum measurement processes

We know that in quantum measurement problems, the Copenhagen School adheres to the philosophical position that the Schrödinger equation is not universal. They believe that applying quantum mechanics to macroscopic aggregates composed of a large number of atoms - experimental instruments - is ineffective. The 'wave packet collapse' in quantum measurement is the process in which the measuring instrument intervenes in the quantum system, causing the interference term to disappear. The Copenhagen interpretation relies on the principle of complementarity to argue that quantum measurement must rely on the binary coexistence of quantum concepts and classical concepts. Although the mutually exclusive and complementary use of classical concepts is not contradictory, the logical dependence of quantum mechanics on classical concepts inevitably leads to the impossibility of quantum mechanics being a logically autonomous system that completely updates classical concepts. In the framework of the Copenhagen interpretation, the self proclaimed quantum revolution cannot be compared to the physics revolution in which relativity completely updated the concept of spacetime in Newtonian mechanics. Peter Atkins believes that the attitude of the Copenhagen School seems like a desperate struggle of the losers, as it is difficult to see how quantum mechanics mixes or completely transforms into another theory as the number of atoms in the system continues to increase. Von Neumann attempted to adhere to the 'universal Schrödinger equation', but lacked analysis of the thermodynamic statistical mechanics mechanism of quantum measurement processes, falling into the trap of subjectivism. [6]The theory of non local hidden variables uses the Newtonian mechanical analogy of quantum potential to understand the quantum non locality caused by the Hermitian operator of spatial variables, but conceptually blurs the thermodynamic properties of quantum measurements.

The many worlds interpretation proposed by Everett et al. considers the various probability distributions of quantum states expressed by quantum wave functions as real physical states, but once measurements occur and are detected, the universe will be split into countless parallel universes. Essentially, it is the interaction between the measuring instrument and the observer's brain that selects a branch of the universe that will exist next. Every observer is splitting the universe, and as the brain follows different paths, there will be an increasing number of parallel universes. Decoherence holds that classical states are the internally stable eigenstates that strongly resist decoherence. Decoherence can be experimentally measured in various situations. Since decoherence can actually have the effect of wave function collapse, people have lost the motivation to study non unitary quantum mechanics, which has also made Everett's many world interpretation increasingly popular. If the time evolution of the wave function is unitary, then there exists a quantum parallel universe, and physicists are working very hard to test this key hypothesis. At present, no deviation from singularity has been found. In terms of theory, an important debate against singularity involves the possible loss of information when black holes evaporate, which means that quantum gravity effects are non unitary, leading to the collapse of wave functions. But a recent breakthrough in string theory, called AdS/CFT, suggests that quantum gravity is also unitary, mathematically equivalent to a low dimensional gravity free quantum field theory [7].

Weinberg believed that the many world theory is like radio. In our universe, we have tuned to the corresponding frequency, but there are infinitely many parallel universes coexisting with us in the same room, even though we cannot tune to their frequencies. The frequencies of other parallel universes have become decoherent and are no longer in phase with the frequencies of our universe, making them unobservable. Bohr's wave function 'disappearance' is mathematically equivalent to environmental interference, which in quantum measurement is decoherence. The decoherence theory holds that ordinary quantum mechanics is only applicable to closed systems, but the external environment with countless degrees of freedom will inevitably couple with the system through noise or measurement, thereby establishing entanglement between the system and the external environment. If we detect the degrees of freedom of the external environment, the coherence of the system will decrease, or in other words, the pure state of the closed system will gradually evolve into a mixed state. Given the known coupling strength of the environment, decoherence theory can effectively calculate the dissipation of quantum systems, but this theory clearly does not solve the problem of quantum measurement. Saying that decoherence solves the measurement problem is equivalent to believing that Newton's law of universal gravitation explains the source of gravity[8].

In decoherence theory, the essential characteristic of a measuring instrument is a macroscopic quantum device embedded in its environment. The strange thing about quantum mechanics is the combination of micro and macro, because our measurements seem to indicate that quantum mechanics is entirely a probability theory and far from determinism. However, the wave function evolves deterministically completely according to the Schrödinger equation, and the reason why determinism does not work is in predicting the measurement results. The decoherence theory holds that the Schrödinger equation is universal, but the measurement process must consider the subtle effects caused by the participation of the environment on the random selection of various eigenstates in quantum pure states. This selection leads to irreversible transformation from quantum pure states to mixed states when the environmental states are orthogonal. When a certain eigenstate of the wave function enters the real world, the eigenvectors of eigenstates in other worlds become orthogonal to it and unobservable, transforming into a possible state of reality that causes other possible states to irreversibly disappear. The decoherence mechanism in quantum mechanics corresponds to the dissipative mechanism of the transition from intrinsic randomness to intrinsic irreversibility in open thermodynamic systems, as described by Prigogine. The decoherence theory returns to the thermodynamic consideration of irreversible processes, attempting to solve quantum measurement problems from the thermodynamic source of irreversible processes. Microscopic systems may be explicitly endowed with thermodynamic characteristics. In the multi world interpretation, these possible states that cannot be achieved during the measurement process due to decoherence are abstractly set to exist in other unobservable and non communicable universes to ensure the persistence of quantum information and achieve the unitary evolution of wave functions.

In fact, discussing the irreversibility of quantum measurements has a simpler and more profound classical analogy mechanism compared to discussing quantum non locality. This is because in quantum mechanics, time t does not have the Hermitian operator like spatial coordinates, which involves the physical debate of whether time is reversible or irreversible. The result will not change because Newtonian mechanics transforms from the Hermitian operator of mechanical quantities to quantum mechanics, because the time coordinate maintains a continuous and differentiable topological homeomorphism transformation in both Newtonian mechanics and quantum mechanics. On the contrary, when the spatial coordinates in Newtonian mechanics are transformed into Hermitian operators of positional variables in quantum mechanics, quantum nonlocality arises due to the special properties of spatial Hermitian operators, and with the uncertainty of positional momentum, it is impossible to fully rely on classical mechanisms for understanding. The classical distinction between reversible and irreversible phenomena was first clarified in thermodynamics, and Boltzmann's theory of molecular motion transferred reversible and irreversible phenomena to the microscopic level: in molecular motion theory, the part of the change in velocity distribution caused by free motion corresponds to the reversible part, while the part caused by collision corresponds to the irreversible part. The molecular chaos assumption required for Boltzmann's proof of the H theorem essentially requires the system to be subjected to environmental effects, which have the following characteristics: macroscopic equilibrium conditions (symmetry) and microscopic randomness in system motion caused by interactions with the system. The collision of the system itself without the influence of the environment does not necessarily lead to the system reaching an equilibrium state, as revealed by Poincaré and Loschmidt. The understanding of wave packet collapse by decoherence theory actually relies on the random selection of a certain eigenstate in quantum superposition states by environmental factors, but many mathematicians regard this randomness as the inherent randomness of the wave function.

The decoherence theory reproduces the classical conflict between the dynamic reversibility and thermodynamic irreversibility of molecular motion theory at the level of quantum mechanics. Can this conflict be resolved by revealing that the reversibility of the dynamic system is an illusion? It is believed that the reversibility of dynamic processes is based on the time inversion invariance of dynamic equations, that is, the existence of inversion processes. However, the inversion process and the reverse process are two fundamentally different concepts, and the process of inversion may not necessarily be the process of reverse. Firstly, since the inversion process and the original process generally belong to spontaneous motion of different orbits, the inversion state from the final state can only return to the inversion state of the initial state and cannot return to the initial state. Therefore, the inversion process does not constitute the reverse process of the original process. The invariance of time inversion does not imply the existence of a reverse process of a process, and the proof of time inversion invariance cannot be used as proof of the reversibility of a dynamical system; Prigogine also noticed that the ultra weak interaction that causes K meson decay violates time reversal invariance, but it does not lead to the second law, as it can still be incorporated into Hamiltonian modes or unitary dynamical systems. Secondly, time inversion is equivalent to transitioning from a motion state to a motion state that is completely opposite to all its motion direction vectors, which requires the environment to exert a precise effect on the system and simultaneously cause external changes. Therefore, the two processes that are mutually inverted in dynamics cannot spontaneously transform. Again, both the dynamic process and its inversion process are dynamic deterministic processes, and the dynamic spontaneous process is not necessarily a homogenization process of certain physical quantities (i.e. not necessarily an equilibrium process). Similarly, the dynamic inversion process does not necessarily mean a thermodynamic non-equilibrium process. So, the process of dynamic inversion and the reverse process of thermodynamics have different meanings, and the dynamic process and its inversion process are not necessarily related to the homogenization equilibrium process and its non-uniform reverse equilibrium process in thermodynamics. This is like a stock falling from 10 yuan to 9 yuan, and then rebounding to 10 yuan through an inversion process. The future trend when rebounding to 10 yuan is likely to be very different from the initial 10 yuan trend. Tsung Dao Lee pointed out in ‘Symmetry and Asymmetry’ that there is a fundamental difference between the microscopic reversibility related to time inversion and the macroscopic reversibility similar to thermodynamic reversibility processes: just like there are planes flying back and forth between Chengde and Beijing, but there is only one possibility to fly from Chengde to Beijing, while there are various possibilities to fly from Beijing to other cities, so the possibility of returning to Chengde becomes very small; Microscopic reversibility cannot guarantee macroscopic reversibility, as the microscopic information that ensures macroscopic reversibility is dissipated in random collisions [9].

The systems studied in all equilibrium problems in thermodynamics are subject to environmental effects, and their motion is non spontaneous. Therefore, thermodynamic laws can only be regarded as process evolution laws summarized from experience when a quasi equilibrium environment imposes constraints on a system. It is necessary to further explore whether they are applicable to highly non-equilibrium dynamic systems and the entire universe without an external environment. The irreversibility of thermodynamic processes does not have absolute universal significance. In the framework of general relativity, thermodynamic problems are discussed, and in systems with non orthogonal time axes, clock speed synchronization cannot be transmitted, resulting in the inability to transfer the thermal equilibrium temperature determined by the frequency of the blackbody radiation spectrum, leading to the dilemma of breaking the zeroth law of thermodynamics [10]. To solve this dilemma, there seem to be two philosophical positions: either follow Prigogine and regard the laws of thermodynamics as the fundamental laws of the real physical world, acknowledging that irreversibility is true at all levels, and that the reversibility of dynamics is only an idealized description of time oriented polarization that has not yet considered the initial conditions. Starting from thermodynamics, limit the spacetime of general relativity to a ‘clock speed synchronous’ reference frame, and modify general relativity in conjunction with the study of quantum gravity; Either follow Einstein and declare that ‘the difference between the past, present, and future is just an illusion we stubbornly insist on’, acknowledging the existence of spacetime where thermal equilibrium does not have transitivity, breaking through the framework of existing thermodynamic laws through the development of relativity thermodynamics, and ultimately modifying quantum mechanics based on Planck's blackbody radiation law of thermal equilibrium. Just as Hawking's black hole radiation principle can test the curved spacetime quantum field theory, we can also test the transitivity of thermal equilibrium on a rotating disk reference frame with non orthogonal time axes, and experimentally test the philosophical positions of Prigogine and Einstein.

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