

**THE ASSOCIATION BETWEEN TIME REVERSIBILITY AND THE INCREASE OF ENTROPY*****Lie Chun Pong****Received 19th November 2025; Accepted 24th December 2025; Published online 30th January 2026**

Abstract

Entropy is a fundamental thermodynamic phenomenon centered on the concept of randomness and irreversibility. Its connection to time suggests that the flow of time is also inherently irreversible. However, if we consider a hypothetical scenario, such as an hourglass, time could appear to achieve a certain balance between disorder and order. In this context, time could be reversible, though not as a continuous process of entropy. For instance, placing an hourglass in a bottle and flipping it causes the sand to flow in the opposite direction when overturned. This demonstrates that, under certain spatial conditions, the process can be reversible. Imagining the universe as a bottle, the perceived flow of time from different viewpoints may vary, appearing to rise or fall depending on the observer's perspective. Altering the curvature of space implies that time could indeed be reversible. This article explores the idea of time's reversibility from various perspectives and specific "state" conditions.

Keywords: Entropy, Reversibility of Time, Cold Dark Matter, Sand-like-Time Matter, Time reversibly.

INTRODUCTION

Thermodynamics was formally established as a branch of physics in 1824 by the French engineer and physicist Sadi Carnot, often regarded as the founder of thermodynamics. Carnot's pioneering work introduced the concept of the Carnot cycle and laid the groundwork for the second law of thermodynamics. The notion of an absolute zero temperature point was later proposed, serving as a fundamental reference in thermodynamic systems. According to the zeroth law of thermodynamics, thermal equilibrium implies that heat spontaneously flows from a hotter to a colder body until equilibrium is reached. Applying this principle to the vacuum of space, it implies that thermal energy will continuously dissipate into the cosmic void, resulting in heat transfer over astronomical timescales. This behavior can be analogized to pouring milk into a cup of coffee; the milk's molecules diffuse and disperse throughout the liquid until uniform temperature is achieved. Building upon these concepts, the second law of thermodynamics was formulated, encapsulating the principle of entropy increase the measure of system disorder which states that in isolated systems, entropy tends to increase over time, dictating the direction of spontaneous processes and energy dispersal [1][2]. Entropy is a fundamental concept in thermodynamics [1][2], representing the measure of disorder or randomness within a system. It is intrinsically associated with irreversible processes, reflecting the unidirectional nature of entropy increase according to the Second Law of Thermodynamics. When considering the arrow of time, entropy's irreversibility underpins the temporal asymmetry observed in macroscopic phenomena. However, if we introduce a hypothetical scenario involving a reversible interpretation of time, such as within a controlled, modeled environment, certain conditions can be conceived where temporal processes exhibit reversibility. For instance, imagine an idealized hourglass contained within a closed, rigid vessel. If we invert the vessel, the granular sand particles, which normally flow from the upper chamber to the lower, could, in a theoretical framework where friction, air resistance, gravitation, and other dissipative effects are eliminated, flow back may happen in the opposite direction.

This reversal implies that, under specific spatial and boundary conditions such as certain curvature of spacetime or engineered environments time could theoretically be modeled as reversible. In such a context, the temporally asymmetric process of entropy increase might appear symmetric, revealing that entropy-driven irreversibility is contingent upon particular conditions. In a broader cosmological perspective, if our universe is conceptualized as a closed system analogous to a sealed container, then observations of temporal directionality could depend heavily on the observer's frame of reference and the geometric properties of spacetime. Different vantage points or spacetime curvatures can lead to contrasting interpretations of whether processes are forward or backward in time what appears as entropy increase from one frame might be perceived as entropy decrease from another. This suggests that the apparent arrow of time is, at least in part, relational and dependent on the spacetime manifold's geometry. Therefore, by modifying the curvature of spacetime or shifting the observational perspective, the fundamental irreversibility attributed to entropy may, in principle, be rendered reversible within specific moment. The exploration of such scenarios involves analyzing how spacetime geometry, boundary conditions, and initial states influence the directional flow of time and the associated thermodynamic processes. This discourse aims to rigorously examine the conditions under which time can be perceived as reversible and these conditions relate to the underlying physical principles governing entropy and spacetime structure.

DISCUSSION

While the presumption of entropy increase as a fundamental aspect of the second law of thermodynamics is widely accepted, the robustness of the entropy increase paradigm is not absolute. It is important to recognize that the process of entropy increment can, under certain conditions, exhibit non-continuous behavior, thereby challenging the traditional notion of a strictly monotonic increase. If we conceptualize time as a granular, discrete substrate akin to a grain of sand, then the perception and measurement of temporal flow can vary significantly depending on the observational frame and the specific thermodynamic or quantum states involved. Such

perspectives highlight the nuanced and context-dependent nature of entropy evolution within complex thermodynamic systems. This research paper rigorously analyzes whether the second law of thermodynamics, specifically the principle of monotonically increasing entropy, universally applies across all specific thermodynamic and non-equilibrium conditions. It seeks to critically examine the fundamental nature of time through a novel theoretical framework, questioning the conventional interpretation of entropy as invariably increasing. Our study aims to determine whether the entropy production process is inherently irreversible or if certain conditions permit reversibility within the thermodynamic domain. By employing advanced concepts from artificial mechanics and non-equilibrium thermodynamics, this work attempts to provide a comprehensive reinterpretation of time's arrow and assess the universality of the entropy increase hypothesis.

The second law of thermodynamics asserts that, within an isolated system of the universe, the entropy defined as a measure of the system's disorder tends to increase spontaneously and irreversibly, indicating a unidirectional progression. This principle implies that in an isolated system, the entropy will never decrease, reflecting an inherent arrow of time. In the physics community, many theorists interpret this entropy increase as underpinning the arrow of time, establishing a fundamental link between thermodynamic irreversibility and temporal directionality. However, if we consider time as a non-fundamental construct emerging from more basic temporal and spatial dimensional manifolds, then the classical categorization of time as unidirectional may not be universally applicable. Although the increase of entropy appears continuous and statistically probable, it remains valid only under particular boundary and initial conditions, and its applicability may vary when considering quantum gravity or multiversal frameworks that challenge traditional conceptions of temporality. Applying the hourglass analogy to the nature of time introduces a fundamentally different perspective. In this framework, time appears to be reversible because the granular material analogous to sand can settle back into its original configuration, suggesting a reversible process under specific conditions involving matter states and spatial arrangements. This implies that, within certain contexts, the arrow of time could be bidirectional, contingent on the reversibility of the underlying physical processes.

Consequently, since thermodynamics is typically assumed from a restrictive, non-generalized conceptualization of time. That means the entropy increase concept does not apply across all physical conditions. If our new assumption is right. Incorporating a fundamentally reversible concept of time into thermodynamic frameworks would necessitate a reevaluation of the second law of thermodynamics. This paper proposes a conceptual experiment to explore the hypothesis that time does not exist as an independent, fundamental dimension. Instead, it suggests that temporal phenomena emerge from the interaction of multiple, intersecting spatial-temporal manifolds within a higher-dimensional framework. Under this model, traditional notions of a unidirectional thermodynamic arrow of time lose their validity, as the concept of temporal flow becomes context-dependent. While entropy, as described by the Second Law of Thermodynamics, generally exhibits monotonic increase, this behavior is only guaranteed under specific boundary conditions and assumptions about initial low-entropy states, which may not hold in a universe where time is emergent rather than fundamental. If we apply the concept of

an hourglass, then sand scattered into a cup of extremely hot water initially disperses innocuously, but over time, it settles and sinks in an orderly fashion; it is not a random diffusion. Similarly, after being heated and dispersed, the cooled sand doesn't disperse randomly but sinks in an orderly fashion. Therefore, under this new assumption, time in the isolated system of a cup of water disperse randomly initially but eventually coalesces in an orderly fashion. Applying the conceptual framework of an hourglass, the dispersion of granular particles analogous to sand into an aqueous medium at elevated temperatures initially appears to occur in a seemingly random, ballistic manner. However, over time, granular matter undergoes a progressive settling process characterized by thermodynamically driven, orderly stratification, rather than stochastic diffusion. When the heated granular material cools and is dispersed again, it does not revert to random diffusion; instead, it follows a systematic sedimentation pattern governed by gravity and interparticle interactions within the fluid. Consequently, within this isolated thermodynamic system represented by a cup of water the temporal evolution of particle distribution does not entail initial randomness. Instead, it exhibits a transition towards a macroscopic state of organized, entropy-driven coalescence, aligning with principles of kinetic theory of granular flows.

This phenomenon exemplifies a reversible thermodynamic process rather than a unidirectional increase in entropy. Consider a vessel of hot water into which sand particles are initially introduced; at high temperature, the thermal agitation causes the sand to disperse chaotically, increasing the system's entropy. But when the system undergoes cooling, the kinetic energy diminishes, and the sand particles transition from a dispersed, disordered state to an aggregated, ordered configuration. This process reflects a spontaneous reorganization driven by thermodynamic equilibrium, fundamentally contrasting with the classical portrayal of entropy as an irreversible increase. It illustrates that entropy is not solely an agent of irreversibility but can exhibit reversibility under specific thermal and energetic conditions.

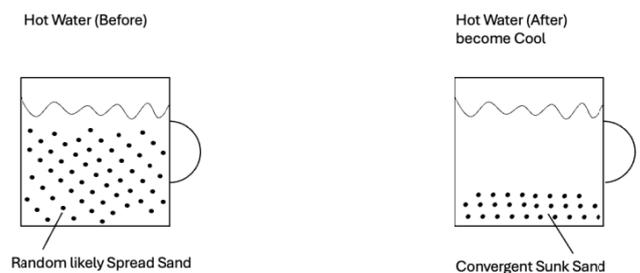


Figure 1. Random likelihood Spread Sand & Convergent Sunk Sand

When sand is initially introduced into a container of hot water, the particles exhibit a dispersed and random distribution, primarily driven by thermal agitation. As the water gradually cools, the kinetic energy of the particles decreases, leading to a transition from random dispersion to an organized aggregation. This organized, downward settling of sand particles suggests a transition from stochastic behavior to a semi-ordered state, resembling a systematic, cohesive structure.

Extrapolating this phenomenon into the fabric of spacetime, one can hypothesize that such continuous and orderly aggregate phenomena might serve as an analogy for a novel classification of matter or energy. Specifically, this concept could be mapped onto a new form of matter that exhibits temporal coherence what we might term "sand-like-time

matter" which potentially diverges from traditional entropy-driven frameworks. This hypothetical construct might provide insights into the nature of dark matter, offering an alternative explanation rooted in the organized, non-entropy-dominant behavior of particles that follow an orderly, persistent downward aggregation pattern within a cosmic spacetime continuum.

This phenomenon can be attributed to the fact that various substances, each in distinct independent states, can be applied to different physical systems, such as the fabric of spacetime. Variations in spacetime geometry, dimensionality, and the intrinsic properties of these substances can significantly influence the perception and measurement of time. Such influences emerge from the interplay between the substance's quantum state, the curvature of spacetime, and the dimensional framework within which these systems operate. Applying a one-way process to the coffee example results in an effectively irreversible transformation, due to entropy increase in thermodynamic terms. If we consider the system as comprising separate, isolated subsystems such as warm water, hot water, or hot milk and introduce additives of varying masses such as sand the final state of each system may differ significantly. This variation depends on the physicochemical properties of the additives, including their specific heats, densities, and interactions with the base liquids.

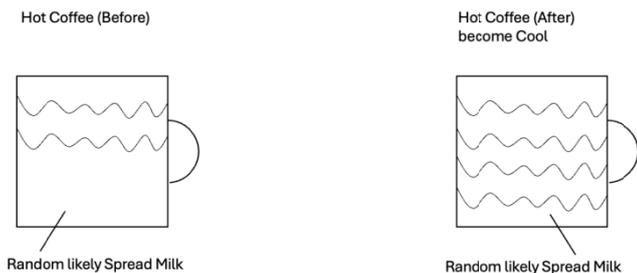


Figure 2. Random likely Spread Milk in the Coffee Pot

Consequently, the outcome of entropy increase is not universally consistent; it depends solely on the nature of the substances added. If the conditions change, it will lead to different equilibrium states due to the different characteristics of the substances involved. Applying the principle of unidirectional entropy increase to the thermodynamic example of a coffee system demonstrates that the entropy change is fundamentally irreversible within this context.

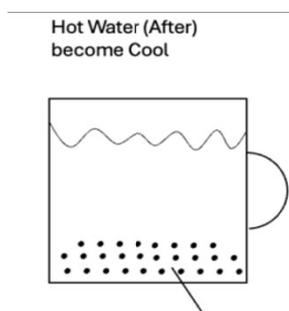


Figure 3. Convergent Sunk Sand

But, when considering isolated, independent thermodynamic systems such as systems comprising sand and hot water, the apparent irreversibility of entropy increase will not be applicable. It can depend on parameters such as the system's mass and the observation time scale, which can make the process potentially reversible under certain conditions.

Therefore, recognizing different experimental or theoretical perspectives that show varying outcomes challenges the idea that is often linked to entropy increase in the unidirectional arrow of time. This discussion aims to demonstrate that the flow of time in thermodynamic systems is not necessarily diffusive; it is influenced by the specific variables and boundary conditions of the system.

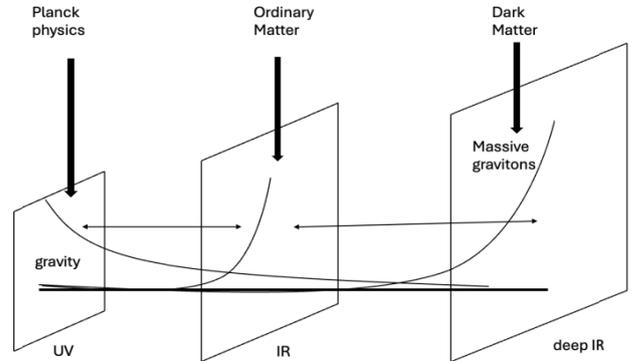


Figure 4. Dark Matter Massive gravitons in Deep IR

Provided that the boundary conditions differ appropriately, it becomes theoretically feasible to induce a reversal of spacetime dynamics. Crucially, the framework articulated within this manuscript maintains full compatibility with the Cold Dark Matter paradigm. If the dark matter component assumes the characteristics of an hourglass-shaped distribution, then the proposed hourglass mechanism aligns with the foundational assumptions and theoretical constructs of Cold Dark Matter theory, potentially offering a quantum field theoretic interpretation of dark matter interactions within a curved spacetime manifold.

Conclusion

In conclusion, entropy remains a core principle in thermodynamics, representing the degree of disorder or randomness within a system. Its inherently irreversible nature aligns with the unidirectional flow of time, but we find it does not apply well in all situations. In our research paper, we believed that when considering spacetime curvature and specific boundary conditions, scenarios such as the hypothetical reversal of an hourglass "sand" suggest that the perceived arrow of time may not be absolute, in the condition under the "sand-bottle." Under certain geometric and topological configurations of the universe, what appears as an irreversible process could, in theory, be reversible, like "Time". Therefore, in this research paper, we believe that it is plausible that by manipulating spacetime geometry, the fundamental irreversibility associated with entropy and temporal evolution might be circumvented, implying that cosmic anisotropies and curvature could influence the true nature of temporal asymmetry, which means "time" can have the possibility that it is reversibly. Hope my research paper can contribute to the world and the mankind.

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