Analysis of Irreversible Phenomena via τ-Manifold: A Formal τ-Analysis Approach

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Section 0 – Introduction:

Irreversibility is a fundamental topic in both pure and applied sciences, including mathematics, mathematical physics, and complex systems. Despite extensive efforts by leading researchers, traditional methods often rely on approximations or computationally intensive algorithms. Consequently, many irreversible phenomena — such as entropy evolution or complex economic fluctuations — remain only partially understood.
In this preprint I will introduce a novel formalism for treating irreversibility not merely as a unavoidable loss of information, but as a structured domain – a τ manifold, systematically designed to contain and control information dissipation.

To formalize an irreversible process, we introduce a unit τ satisfying:

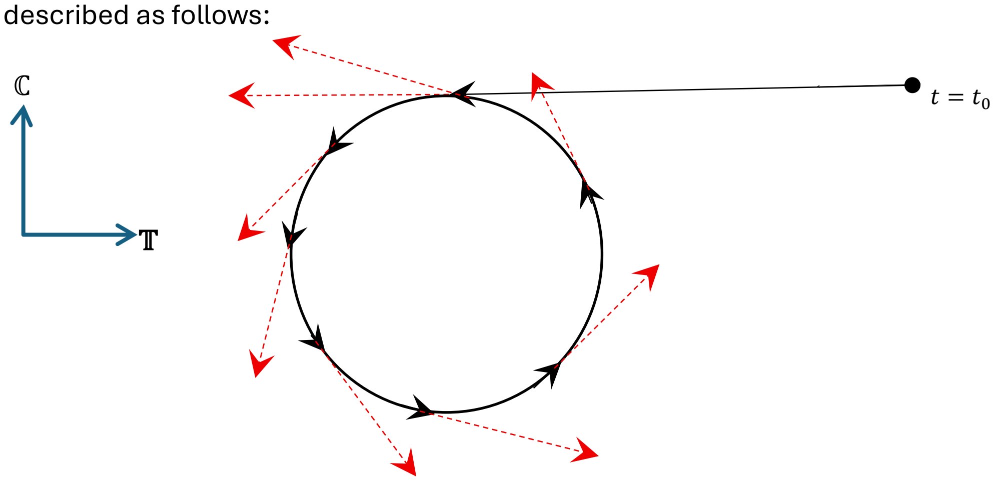
$$\sqrt{\tau} = -1$$

Squaring both sides yields $\tau = 1$, however the original negative sign is lost in the squaring process, indicating an intrinsic loss of information. This property exemplifies the irreversible nature encoded in τ and motivates its use as a foundational unit within the τ-manifold.

Section 1 – The τ-Sphere :

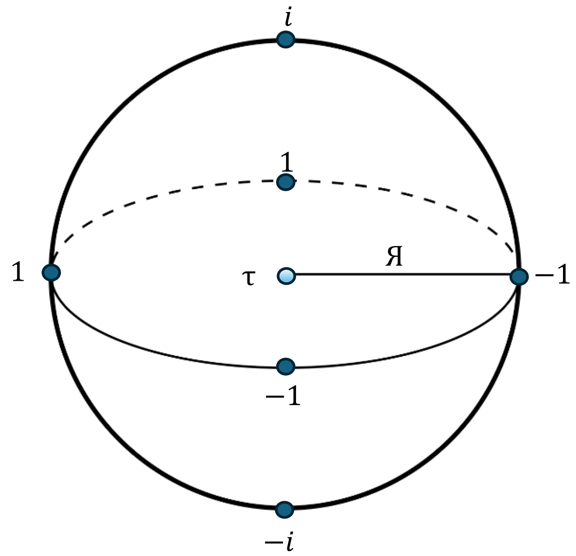
To follow the chronological sequence of the theory, for an advance on mathematical abstraction I shall introduce the idea of time-current. The time is one of the most logical and direct ways to identify irreversibility, in the sight that, a change in some parameter in some point in a given time position, may affect future events chaotically.

The interpretation of time-current is directly connected with the definition of circulation - described as follows:



Once a perturbation at $t_0$is done, the time current takes the path towards a point t; the path walked by the current passes along a circumference, which represents geometrically the τ space. According to the degree of reversibility of the analyzed system, the current scapes by an angle ξ compared with the original route, and such an angle describes the degree of irreversibility of the system. By convention, because the degree of irreversibility is not periodic the angle ξ is a hyperbolic angle, $-\infty < \xi < \infty$, such that, when $\xi = 0$, there is the absence of deviation, and when $\xi \to \infty$ the complete irreversibility happens (in hyperbolic coordinates it's similar to affirm orthogonality).

The τ-sphere - S_τ, is a remarkable way to interpret the τ-space: It consists of six poles representing the supremum of S_τ ($\sup(S_\tau)$): (-1,1); (-i, i); (-1,1). The previously seen circulation consists in a sub circumference of S_τ. Inside the sphere the pure τ domain is evident; the center of the sphere is the τ-unit, far from a distance Я of the vertexes (that changes according to the chosen direction).



- *Theorem 1: The τ-unit is a basis for S_τ and $\mathbb{C}$ concomitantly, but not for $\mathbb{R}$.*

Let $\sqrt{\tau} = -1$, then:
1) $\sqrt[4]{\tau} \equiv i \in \mathbb{C}$

2) $\tau^2 \neq 1$, otherwise, information dispersion occurs.

Therefore, rational powers of the τ-unit are represented as complex numbers, but the same is not true for real numbers.

Section 2 – Mathematical Framework: