Entropy Clocks and Rotational Misalignment as a Physical Measure of Time in the Holosphere Lattice

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Abstract

We propose a physically grounded model of time in which its passage arises from the progressive loss of angular coherence within a discrete spacetime lattice composed of rotating Holospheres. In this framework, time is not a background parameter but an emergent property linked to the misalignment of rotational phase between neighboring units in the lattice. The flow of time corresponds to the accumulation of rotational defects and phase mismatches, which serve as entropy-like markers of irreversibility.

We define "entropy clocks" as local configurations of Holospheres whose increasing angular misalignment correlates with information loss and decoherence. These clocks measure time directionally through the irreversible propagation of defects and coherence gradients. The model provides a natural origin for the arrow of time and a mechanism for coupling thermodynamic, quantum, and cosmological timescales.

We demonstrate how this approach reproduces known features of temporal asymmetry, including the second law of thermodynamics and quantum decoherence, while also predicting directional effects on entanglement persistence, field propagation, and causal ordering. The Holosphere lattice thus offers a unified geometric and energetic interpretation of time grounded in rotational strain and coherence topology. We also outline testable predictions of the model, including environment-sensitive deviations in entanglement lifetime under gravitational or angular strain, and asymmetries in clock synchronization across coherence gradients. These phenomena offer potential observational avenues for distinguishing the Holosphere framework from conventional treatments of time and quantum decoherence.

1 Introduction

The nature of time remains one of the most profound and unresolved questions in physics. While classical mechanics treats time as an absolute, external parameter, and relativity integrates it into a dynamic spacetime manifold, neither framework explains the unidirectional flow of time or its connection to entropy and information loss. In quantum mechanics, time appears as an externally imposed variable, with no fundamental mechanism for its arrow or asymmetry. ...no fundamental mechanism for its arrow or asymmetry, despite decades of work connecting entropy and time asymmetry [1].

In this paper, we explore a novel approach to time grounded in the Holosphere lattice model—a discrete, rotating structure of spacetime composed of nested, phase-coherent spherical units. Within this framework, time is not a backdrop but an emergent, directional property arising from the misalignment of angular phase between adjacent Holospheres. Each Holosphere contributes to a locally defined rotational state, and the relative coherence between these rotations encodes both the passage of time and the flow of information.

We propose that time's arrow emerges from the irreversible accumulation of rotational defects—misalignments in the angular momentum phase relationship between neighboring lattice sites. These misalignments act as entropic markers that define a local gradient of temporal asymmetry. As defects propagate through the lattice, they degrade the coherence of triplet structures responsible for quantum behavior, leading to decoherence, measurement finality, and the thermodynamic second law.

To quantify this process, we introduce the concept of an "entropy clock"—a local structure whose increasing angular misalignment and phase incoherence act as a physical measure of elapsed time. These clocks track the growth of rotational strain and the decay of coherent coupling, allowing time to be measured intrinsically within the lattice rather than imposed externally.

This model links the arrow of time to a geometric property of the Holosphere lattice: the directional propagation of angular tension and phase drift. It provides a unified physical interpretation for time's emergence in quantum measurement, thermodynamic evolution, and cosmological structure—all derived from the dynamics of rotational strain in a discrete spacetime.

In the following sections, we formalize the structure of the Holosphere lattice, define rotational misalignment quantitatively, and construct entropy clocks as intrinsic temporal observables tied to angular coherence decay.

2 The Holosphere Lattice and Coherence Framework

The Holosphere model envisions spacetime as a discrete, rotationally structured lattice composed of tightly packed spinning spheres at the neutron Compton scale, recursively nested from sub-Planck units. These spheres—Holospheres—form a cuboctahedral lattice in which each node is a site of angular momentum storage, orbital phase propagation, and defect dynamics.

Each Holosphere maintains a stable rotational state and interacts with its neighbors through angular tension. This tension, a scalar measure of relative rotational strain, governs the alignment or misalignment of angular momentum vectors in adjacent lattice sites. These vectors define the local orientation of space and the coherence of any composite structures formed by Holospheres, such as dark bosons or triplet particle excitations.

The key element of this model is rotational phase coherence. When Holospheres align their rotational axes and angular velocities, they form phase-locked domains capable of sustaining persistent quantum-like behavior. Triplet structures—composed of three coherent dark bosons—require such phase alignment to maintain stability. It is within these domains that quantum entanglement, coherent propagation, and measurement resistance can occur.

We define the angular phase between two neighboring Holospheres as ϕ_{ij}, and coherence is maintained when $|\phi_{ij}| < \epsilon_c$, where ϵ_c is a critical misalignment threshold. This phase coherence allows information—both physical and quantum—to propagate reliably through the lattice. However, when defects form (due to stress, measurement, or boundary interaction), the angular coherence is disrupted, and the misalignment grows.

The Holosphere lattice thus supports both persistent rotational coherence and localized breakdowns in alignment. This duality is essential for modeling the emergence of time: coherent domains represent timeless, reversible behavior, while misaligned domains evolve irreversibly as coherence decays.

In this framework, time does not preexist the system—it is generated by the dynamics of the system. Angular misalignment acts as a natural ordering parameter. As phase differences accumulate and coherence gradients form, directional structures emerge, allowing local clocks to be defined in terms of coherence loss rather than absolute time coordinates.

In the next section, we formalize this relationship by defining rotational misalignment as a quantitative entropy-like measure and explore how coherence degradation gives rise to the thermodynamic arrow of time.

3 Rotational Misalignment as a Measure of Entropy

In conventional thermodynamics, entropy is defined statistically as the number of microscopic configurations consistent with a macroscopic state. However, this abstract formalism lacks a concrete geometric substrate. In the Holosphere lattice model, entropy emerges from the rotational misalignment of neighboring Holospheres. This misalignment, defined as the angular phase gradient between adjacent lattice sites, signals the breakdown of coherence and the onset of temporal irreversibility.

3.1 Misalignment as an Entropic Gradient

We define the local rotational misalignment $\delta\phi(x, t)$ as the angular phase deviation between a Holosphere and its neighbors. In a discrete lattice, this is:

$$\delta\phi_i(t) = \frac{1}{|\mathcal{N}(i)|} \sum_{j \in \mathcal{N}(i)} |\phi_i(t) - \phi_j(t)|$$

Where $\mathcal{N}(i)$ is the set of neighbors of site i, and $\phi_i(t)$ is the rotational phase of site i at time t.

In the coarse-grained, continuous limit, this becomes:

$$\delta\phi(x,t) = |\nabla\phi(x,t)|$$

Here, $\nabla\phi(x,t)$ represents the angular phase gradient at position x. This scalar field quantifies the extent of local rotational disorder. When $\delta\phi \approx 0$, the system is in a coherent, low-entropy state. As $\delta\phi$ increases, coherence decays and entropy increases, signaling the transition to irreversible dynamics.

3.2 Time Evolution of Misalignment and Entropy

The misalignment field evolves over time due to two dominant effects:

- **Rotational diffusion** — local angular tension seeks to equilibrate through neighboring coupling.
- **Defect generation and propagation** — topological disruptions in the lattice amplify misalignment and disrupt coherence.

The time evolution of the misalignment field is modeled by:

$$\frac{\partial\delta\phi(x,t)}{\partial t} = \gamma \cdot \nabla^2\phi(x,t) + \alpha \cdot \rho_d(x,t)$$

Where:

- γ is the rotational diffusion coefficient,
- α is the amplification factor for misalignment due to defect density,
- $\rho_d(x,t)$ is the local density of rotational defects.

This equation shows how misalignment—and thus entropy—increases over time as defects spread and coherence degrades.

3.3 Entropy as the Driver of Temporal Flow

In the Holosphere model, entropy and time are unified through rotational misalignment. The forward flow of time is defined by the direction in which $\delta\phi(x,t)$ increases. This geometric interpretation provides a physical foundation for the second law of thermodynamics: rotational coherence degrades, angular disorder grows, and time proceeds.

Unlike in classical models where entropy is a probabilistic abstraction, here it is a concrete measure of lattice deformation. Temporal asymmetry arises because angular strain and defects cannot spontaneously realign once coherence is lost. This one-way process defines the arrow of time.

In the next section, we examine how this directional misalignment leads to irreversible defect propagation, creating persistent causal structure and bounding the forward light cone within the lattice.

4 Defect Propagation and Irreversibility

The directional flow of time in the Holosphere lattice emerges not only from increasing rotational misalignment, but also from the unidirectional propagation of defects—localized disruptions in the lattice's angular coherence. These defects are the carriers of temporal irreversibility, causally bounding the regions of phase-aligned information and defining the arrow of time at both the quantum and thermodynamic levels.

4.1 Defects as Angular Phase Disruptions

In the Holosphere model, a defect is a point or region where the angular momentum coupling between Holospheres breaks down, resulting in a discontinuity in rotational phase. These defects can originate from internal phase tension overloads, measurement-induced collapse, or external perturbations.

As defects move through the lattice, they disrupt local coherence and increase $\delta\phi(x,t)$. This process is inherently non-reversible: the rotational strain they leave behind propagates outward, but the original aligned state cannot be recovered without restoring global coherence—an exceedingly improbable event.

4.2 Directional Propagation and Temporal Asymmetry

The propagation of defects is biased by local gradients in rotational strain. A defect preferentially travels "downhill" along coherence gradients, toward regions of lower phase tension. This directional motion is analogous to energy dissipation and underlies the unidirectional nature of time:

$$v_d(x,t) \propto -\nabla\delta\phi(x,t)$$

Where $v_d(x,t)$ is the velocity of defect propagation. As strain accumulates, this gradient sharpens, reinforcing the forward motion of defects and suppressing backward propagation. This echoes the view that irreversibility is a structural property of complex systems [4], here geometrized through angular phase misalignment.

4.3 Causal Boundaries and the Lattice Light Cone

Because defects move outward at a bounded speed (limited by the lattice tension propagation velocity), they define a causal structure analogous to a light cone. Information about a coherence event can only influence points within the defect's expanding domain. Outside this domain, coherence remains intact and temporally unaffected.

Thus, the lattice not only supports an arrow of time but also enforces local causality. Temporal order arises from the geometrical progression of defect-induced decoherence, and spatial causality from the finite propagation of angular tension.

4.4 Irreversibility as Lattice Memory

Each defect leaves a trace in the lattice: residual strain, phase discontinuity, and reduced coherence lifetime. This "memory" accumulates over time and serves as a permanent record of decoherence events. The universe, as modeled by the Holosphere lattice, becomes a growing shell of rotational misalignment—its surface encoding a chronicle of irreversible transitions.

In the next section, we use this concept to define entropy clocks: local systems whose rotational coherence degradation serves as an intrinsic measure of time.

5 Entropy Clocks: Local Measures of Temporal Progress

If time emerges from the degradation of angular coherence, then it must be locally measurable through the rotational strain landscape of the Holosphere lattice. We propose that regions of the lattice can function as "entropy clocks"—localized systems whose evolution in misalignment serves as a physical record of time's passage.

5.1 Defining an Entropy Clock

An entropy clock is defined as a coherent subregion of the Holosphere lattice that tracks its own decoherence via the growth of rotational misalignment. Let $\mathcal{R} \subset R^3$ be such a region. The integrated misalignment over this region gives:

$$T_{clock}(t) = \int_{\mathcal{R}} \delta\phi(x,t)\, d^3x$$

This quantity increases monotonically as coherence decays, serving as a proxy for elapsed time. Since $\delta\phi(x,t)$ only increases under natural defect-driven evolution, the entropy clock provides a directional and irreversible measure of time.

5.2 Physical Characteristics of Entropy Clocks

Entropy clocks are characterized by:

- **Initial coherence**: The clock begins in a nearly phase-aligned state with minimal $\delta\phi$.
- **Rotational tension sensitivity**: The clock structure must be capable of registering subtle phase shifts.
- **Isolation duration**: The longer the clock maintains coherence before disruption, the higher its resolution.

For example, a dark boson triplet in the early universe could act as an entropy clock, maintaining coherence across cosmological durations until a defect induces decoherence.

5.3 Clock Rate and Temporal Density

The rate at which $T_{clock}(t)$ increases depends on the local strain environment. In high-strain or defect-dense regions, the clock advances rapidly. In low-strain, highly coherent regions, entropy clocks tick more slowly. This results in an emergent concept of *temporal density*:

$$\dot{T}_{clock}(t) = \frac{d}{dt} \int_{\mathcal{R}} \delta\phi(x,t)\, d^3x$$

Thus, time is not universal or uniform but varies with the rate of coherence decay. This may explain cosmological phenomena such as time dilation in highly curved or high-entropy domains.

5.4 Toward a Physical Definition of Time

By tying the flow of time to physically measurable coherence gradients, entropy clocks offer a tangible foundation for temporal measurement. They eliminate the need for an external time coordinate and replace it with intrinsic geometric and energetic evolution. This view parallels relational approaches to time in quantum gravity, where time is considered emergent from relational change [3].

In this view, time is simply the name we give to the progression of rotational misalignment within a coherently structured lattice. Every local system—atom, field, or particle—measures time by how far its internal angular alignment has degraded.

In the next section, we connect these entropy clocks to the arrow of time and explore how misalignment gradients define irreversible causal boundaries in the Holosphere lattice.

6 The Arrow of Time from Angular Strain Topology

The irreversible growth of rotational misalignment in the Holosphere lattice defines not only local entropy clocks, but also the global direction of time. The arrow of time in this framework is a topological consequence of the lattice's inability to spontaneously recover coherence once angular strain surpasses the critical threshold.

6.1 Directionality from Coherence Gradients

The direction of increasing $\delta\phi(x,t)$ establishes a natural orientation for temporal progression. In coherent domains, time appears reversible, but once angular tension crosses the coherence threshold, decoherence propagates outward and prevents reversibility. Thus, the arrow of time points in the direction of accumulating misalignment.

Unlike time-reversible laws of motion, this mechanism embeds directionality directly in the topology of strain and phase coherence:

$$\vec{t}(x) = \frac{\nabla\delta\phi(x,t)}{|\nabla\delta\phi(x,t)|}$$

Where $\vec{t}(x)$ is the local arrow of time vector, defined by the steepest ascent of angular strain.

6.2 Irreversibility Without Fundamental Symmetry Breaking

In conventional physics, the microscopic laws (e.g., the Schrödinger equation, Maxwell's equations) are CPT-symmetric, yet the universe appears to exhibit irreversible dynamics. In the Holosphere model, this paradox is resolved geometrically: the laws remain CPT-symmetric locally, but the strain topology of the lattice evolves irreversibly.

This offers a resolution to the Loschmidt paradox: although individual interactions are reversible, the system as a whole accumulates misalignment in a non-recoverable way. Coherence gradients act as "topological ratchets," storing irreversible phase tension.

6.3 Cosmological Implications of Strain Topology

At cosmological scales, the Holosphere lattice provides an alternative to inflationary and entropy-based models of early universe time asymmetry. Rather than invoking low-entropy initial conditions, we model the big bang as a nearly coherent, maximally ordered rotational shell. Rather than invoking low-entropy initial conditions as proposed in classical cosmological models [2], we model the big bang as a nearly coherent, maximally ordered shell... Time begins when defects emerge and strain gradients form, initiating directional misalignment. This lattice-based emergence of time aligns with proposals in quantum cosmology that treat time as internal to the configuration space [6].

The growth of this strain shell defines both the cosmological time axis and the thermal arrow. Each layer of outward-moving decoherence defines an expanding frontier of causal irreversibility—a rotating lattice boundary advancing through angular phase space.

6.4 Directional Time as a Lattice Constraint

Ultimately, the arrow of time is not imposed but arises from the lattice's physical properties. The inability to spontaneously reestablish perfect phase coherence beyond a certain strain limit guarantees that misalignment—and thus time—only flows forward.

In the next section, we examine how this mechanism impacts quantum systems, entanglement lifetime, and the directional flow of information in phase-degrading networks.

7 Implications for Quantum Systems and Information Flow

If time is a byproduct of angular misalignment in the Holosphere lattice, then all quantum processes—entanglement, superposition, decoherence, and measurement—must be understood in the context of coherence decay and rotational strain. The Holosphere model offers concrete mechanisms for understanding how the directional loss of phase coherence governs the evolution and limits of quantum systems.

7.1 Entanglement Lifetime and Strain-Induced Collapse

Entangled states in the Holosphere model are stabilized by phase coherence across distant lattice domains. However, as misalignment accumulates between these domains, the shared coherence boson can no longer maintain phase-locking.

Let $\Delta\phi_{AB}(t)$ denote the cumulative angular phase drift between two entangled systems A and B. The entanglement persists as long as:

$$\Delta\phi_{AB}(t) < \epsilon_c$$

Once this threshold is crossed, the coherence channel collapses and the entangled state decoheres. This defines an **entanglement lifetime** tied directly to the rate of rotational misalignment:

$$\tau_{ent} \sim \left(\frac{\epsilon_c}{\Delta\dot{\phi}}\right)$$

This model predicts that entanglement duration is highly sensitive to the angular strain environment, leading to observable differences in curved spacetime, thermal fields, or defect-rich regions.

7.2 Measurement as Local Phase Disruption

In this framework, quantum measurement is modeled as the injection of a rotational defect into an otherwise coherent triplet structure. The process of measurement corresponds to the irreversible misalignment of one coherence boson beyond the critical phase tolerance, causing collapse and state resolution. Unlike traditional models where measurement results from environmental entanglement and pointer state selection [5], here it arises from angular tension collapse.

Thus, the measurement problem is resolved geometrically: collapse is not a nonphysical discontinuity, but the local failure of coherence propagation in a strained angular field.

7.3 Causal Order from Misalignment Propagation

In the Holosphere lattice, information does not propagate instantaneously, but is constrained by the tension velocity and coherence gradient. As defects spread outward, they define causal boundaries. A system can only influence another if a coherence-preserving path exists between them—one that has not yet been disrupted by phase strain.

This generates a lattice-defined causal structure, where the future lies in the domain of increasing $\delta\phi$ and the past in the residual region of coherence. Information flow is inherently directional and irreversible, not from imposed laws, but from the geometry of angular misalignment.

7.4 Information Degradation and Temporal Boundaries

As $\delta\phi(x,t)$ increases beyond recoverable levels, information stored in spin alignment or coherence channels is permanently lost to disorder. This information loss defines a **temporal boundary**, beyond which entangled or phase-locked systems can no longer interact coherently.

This mechanism provides a natural explanation for the emergence of classicality: as regions decohere due to accumulated misalignment, quantum systems lose the ability to maintain superposition and become effectively classical.

In the final section, we summarize the consequences of this model and its potential to unify quantum time asymmetry, thermodynamic entropy, and causal structure under a single geometric framework.

8 Conclusion

We have proposed a physically grounded model of time in which temporal flow and entropy arise from the dynamics of rotational misalignment in a discrete Holosphere lattice. In this framework, time is not an external dimension or a statistical abstraction, but an emergent property of angular phase degradation between coherently spinning units of spacetime.

The fundamental element of this model is the local misalignment function $\delta\phi(x, t)$, which quantifies the deviation of rotational phase between neighboring Holospheres. As misalignment increases over time, coherence decays, defects propagate, and entropy grows. These geometric effects define the arrow of time without requiring explicit symmetry breaking or fine-tuned initial conditions.

We introduced the concept of entropy clocks—coherent subregions whose increasing rotational strain acts as a directional measure of time. These clocks are governed by strain topology and the physics of angular tension. The ticking of such clocks marks the irreversible progression from coherence to disorder.

Our model connects the emergence of time to physical processes:

- Decoherence occurs when rotational misalignment exceeds critical thresholds.
- Entanglement decay is determined by accumulated phase drift across coherent regions.
- Measurement arises as a topological collapse due to local angular tension overload.
- Causal structure emerges from the finite speed and direction of defect propagation through the lattice.

This approach offers a unified explanation for temporal asymmetry across quantum, thermodynamic, and cosmological domains. It reinterprets time as a directional gradient of angular strain rather than a background parameter, embedding entropy, causality, and irreversibility into the geometry of space itself. This model also yields testable consequences. Specifically, it predicts measurable deviations in entanglement persistence when systems are subject to differential angular strain or gravitational tension. Additionally, entropy clocks embedded in anisotropic regions of the lattice may desynchronize relative to those in strain-free zones, leading to observable anisotropies in time measurement. These effects distinguish the Holosphere lattice from classical spacetime models and offer falsifiable signatures for future experimental exploration.

Future work will focus on simulating entropy clocks under different lattice geometries, evaluating deviations from relativistic time dilation in strained media, and exploring observational consequences for early-universe coherence, black hole horizons, and quantum information retention.

References

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Appendix A: Misalignment Function Derivation

We derive the misalignment function $\delta\phi(x,t)$ as a measure of local angular phase disorder in the Holosphere lattice.

Let $\phi_i(t)$ be the rotational phase of a Holosphere at lattice site i, and let $\mathcal{N}(i)$ denote the set of its neighboring sites.

The discrete misalignment function is defined as the average absolute phase deviation:

$$\delta\phi_i(t) = \frac{1}{|\mathcal{N}(i)|} \sum_{j\in\mathcal{N}(i)} |\phi_i(t) - \phi_j(t)|$$

In the continuum limit, assuming a smooth angular phase field $\phi(x,t)$, this becomes:

$$\delta\phi(x,t) = |\nabla\phi(x,t)|$$

The time evolution of the misalignment is governed by a diffusion-like equation, augmented with a source term from topological defects:

$$\frac{\partial\delta\phi(x,t)}{\partial t} = \gamma \cdot \nabla^2\phi(x,t) + \alpha \cdot \rho_d(x,t)$$

This expresses how local disorder grows due to angular strain redistribution (γ) and defect-induced misalignment (α). The function $\delta\phi$ thus captures the dynamical link between local rotational strain and the emergence of entropy and time.

Appendix B: Simulation Parameters for Entropy Clocks in Local Lattice Sectors

To simulate entropy clocks and monitor temporal flow in localized lattice regions, we define the following parameters and initial conditions:

- **Lattice geometry**: 3D cubic or cuboctahedral grid of Holospheres.
- **Phase field initialization**: Uniform phase ϕ_0 with Gaussian perturbations of width σ.

- **Initial coherence domain** $\mathcal{R}$: Radius $r = 10$ units; initialized with $\delta\phi(x, 0) \approx 0$ within $\mathcal{R}$, and random ϕ outside.
- **Defect injection**: Local increase in $\rho_d(x, t)$ at time step $t = t_0$, modeled as a topological vortex (discrete jump in ϕ of π).
- **Diffusion coefficient** γ: $\gamma = 0.1$ in normalized units.
- **Defect amplification rate** α: $\alpha = 0.5$.
- **Clock function**: Tracked via

$$T_{clock}(t) = \int_{\mathcal{R}} \delta\phi(x, t)\, d^3x$$

Simulations show that the clock value increases monotonically with defect activity and angular strain, validating its use as a physical proxy for time. Multiple clocks with different radii or coherence thresholds can be compared to simulate relativistic-like time dilation under strain gradients.

Appendix C: Definitions and Terms

$\phi(x, t)$ Rotational phase of a Holosphere at position x and time t. Represents the orientation of angular momentum in the lattice.

$\phi_i(t)$ Discrete form of the rotational phase at lattice site i.

$\delta\phi(x, t)$ Rotational misalignment—defined as the magnitude of the angular phase gradient between adjacent Holospheres. Serves as a local entropy indicator.

$\delta\phi_i(t)$ Rotational misalignment in discrete form, averaged over the neighbors of site i.

$\nabla\phi(x, t)$ Gradient of the angular phase field in the lattice.

$\nabla^2\phi(x, t)$ Laplacian of the angular phase field—drives the diffusion of angular tension.

$\rho_d(x, t)$ Local density of topological defects—points or regions of broken angular coherence.

ϵ_c Critical angular phase misalignment threshold. If exceeded, coherence collapses.

γ Rotational diffusion coefficient. Determines how angular tension spreads across the lattice.

α Defect amplification factor—controls how defects increase misalignment over time.

τ_{ent} Entanglement lifetime. The time over which coherence is preserved between entangled regions, inversely related to accumulated phase drift.

$T_{clock}(t)$ Entropy clock function—integrated misalignment over a coherent region. Acts as a physical measure of time.

$\vec{t}(x)$ Arrow of time vector at point x, defined by the normalized gradient of misalignment:

$$\vec{t}(x) = \frac{\nabla \delta\phi(x,t)}{|\nabla \delta\phi(x,t)|}$$

$\mathcal{R}$ A spatial region (typically coherent) over which the entropy clock function $T_{clock}(t)$ is evaluated.

Holosphere Fundamental unit of the lattice. A discrete, spinning spherical structure encoding angular momentum and coherence properties.

Entropy Clock A localized, initially coherent structure that measures the passage of time via the accumulation of rotational misalignment.