TITLE:- CURVATURE THROUGH INFORMATIONAL DECAY: ANALYZING INTERNAL MEMORY LEAK

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Abstract:- Internal Memory Leakage represents a Silent Decay of Operational Integrity inside Computational Architectures. Unlike external Disruptions (solar flares, impact), Internal leaks Self-originate, self-Amplify, and threaten we model, Simulate and theorize Leak Dynamics, establishing Both Empirical Behaviour and Fundamental Physical Analogues to spacetime Entropy Distortion.

Introduction:- Modern Computational Systems assume Permanence of stored Digital Information. However., Time, Entropy, and material physics together Degrade Memory Cells even in Zero- Radiation Shielding Environments.

Definition of Memory Leaks:- "Internal Memory Leak is the gradual Corruption of logical Storage states without External error Injection". It's measured by;

- ★ *Error Bit Density (Corrupted bits per Megabit)*
- ★ *Corruption Rate (New Bitflips per cycle)*
- ★ *Criticality Ratio (Corrupted Bits/ Total Bits)*

Entropy and Information Decay:- Information Storage is never Thermodynamically free. Landaur's principle States;

$$\Delta S \geq k_B \ln(2)$$

For every bit loss. Thus., Spontaneous Data Decay Increases System Entropy, paralleling Heat Death Models at Cosmological Scales.

Quantum Noise Contribution:- At Scales below 5nm, quantum Tunneling And Zero-point fluctuations allow random Charge migration across Transistor gates. This Introduces unavoidable Stochastic leakage;

$$P_{tunnel} \sim e^{-2\sqrt{2m\phi}d/\hbar}$$

Where., ϕ = *Barrier Potential*

d = *Barrier Thickness*

Mathematical Leakage Model:- Modeling Cumulative Memory Loss;

$$d\phi/dt = \gamma(1 - \phi)$$

Solution.,

$$\phi(t) = 1 - e^{-\gamma t}$$

Where., γ = *Leak Rate Coefficient*

$\phi(t)$ = *Corrupted Memory Fraction over time*

Memory Leak Rate factors:- Leak Rate (γ) *depends on;*

★ *Temperature Rise* ($T\uparrow$)

★ *Write/ Erase frequency* ($\tau \uparrow$)

★ *Material Disorder (Q ↓)*
★ *Cosmic Neutrino Background N (hypothetical)*

Thus., $\gamma = f(T, \tau, Q, N)$

Subsystem Risk Analysis:-

Subsystem	*Leak Impact*
CPU Core	*Silent Logic failure, false corruptions*
RAM Buffers	*Sensor Misreadings, Wrong telemetry*
Comm Module	*Packet Corruptions, Bad Encoding*
Flight Controller	*Orbital Deviation, Mission loss*
Sensor Hub	*Ghost events, Missing Critical Data*

Threshold Models for fallback:-

Define Safe operation up to corruption fraction (ϕ_c).

Trigger Fallback when;

$$\phi(t) \geq \phi_c$$

Typical $\phi_c \approx 0.05$ *(5% Corruption)*

Detection Strategies:- ★ *CRC Checksum Errors*
★ *Hamming Code correction Exceeding Threshold*
★ *Machine Learning Anomaly Prediction*
★ *Redundant Multi-bit Voting*

Physical System Leak- Curvature Decay:- *As memory Decays↣ Logical Information Decays ↣ Local Entropy Increases.*

Mirco Curvature Collapse Hypothesis;

$$\delta R_{logical} \propto \delta S_{memory}$$

Future Research Extension:- ★ *Model Quantum Stabilized memory cells (QRAM) under Long term stress.*

★ *Study gravitational Wave effects on memory Corruption rates.*

★ *Biological Redundancy (like neuron networks)*

References:- (1) R. Landauer, "irreversibility and heat generation in the computing process". IBM Journal of Research and Development (1961)

(2) C.H. Bennett, "The Thermodynamics of Computation– A review". International Journal of Theoretical Physics (1982)

(3) Jacob Bekenstein, "Information in the Holographic Universe". Scientific American (2003)

(4) Seth Lloyd, "Ultimate Physics Limits to Computation". Nature (2000)

(5) NASA JPL Deep Space 1 Final Report, "Autonomous Spacecraft memory Degradation analysis". NASA Jet propulsion laboratory (2002)

(6) Richard Feynman, "Simulating Physics with Computers". International Journal of Theoretical Physics (1982)

(7) M. Zwolak, H.T.Quan, and W.H. Zurak, "Quantum Darwinism in a mixed Environment". Physics Review Letter (2009)

(8) Charles E. Shannon, "A Mathematical Theory of Communication". Bell Systems Technical Journal (1948)

(9) K. Nakata and M. Nomura, "Radiation Effects on Memory Devices in Space". IEEE Transactions on Nuclear Science (1998)

(10) Project SOLIS Internal Theoretical Extension (Heet Trivedi), "Curvature Collapse through Information Decay: Analyzing Internal Memory leak". (Original Work – Self Published Research (2025))