Abstract

This paper proposes a novel mathematical framework, "P-adic Carry Dynamics," to explain energy density accumulation and dispersion in multi-dimensional spaces. By extending the classical Pascal's Triangle into a P-adic numbering system, we reinterpret the "carry" phenomenon as a geometric trigger for topological phase transitions within non-linear lattice networks. We demonstrate that when density at a node exceeds a critical threshold P, it triggers a dimensional jump, leading to the emergence of higher-dimensional structures. This model provides a new geometric lens for interpreting particle showers in high-energy physics and designing entropy-dissipating security architectures.

1. Introduction

Natural systems often respond to extreme stress not by collapsing, but by undergoing phase transitions that create new levels of order. In high-energy physics, these transitions involve particles traversing hidden dimensions or decaying into new states. While individual interactions are well-documented, a unified geometric model that links discrete numerical carries to continuous topological shifts has remained elusive. This research introduces the "Carry Pyramid" as a solution, grounding abstract dimensional jumps in the rigorous arithmetic of P-adic logic.

2. Mathematical Foundation: The Lattice Flow

We model energy propagation as a density flow through a multi-dimensional lattice. Unlike linear models, this framework accounts for the accumulation of density at specific geometric intersections (nodes). The density flow at a node at time t +1 is determined by the transition tensor of its adjacent nodes:

$$\rho(x_i, t+1) = \sum_{j \in N(x_i)_{ij}^{T}} \rho(x_j, t)$$

3. The Mechanism of Dimensional Jump

The core of the theory lies in the P-adic threshold. When the density $\rho(x_i)$ exceeds the base P, the system undergoes a "carry" operation, splitting the energy into a residual component and a higher-dimensional trigger.

- **Residual Density:** $\mathrm{R}(x_i) = \rho(x_i) \pmod{P}$
- **Carry Energy:** $C(x_i) = \left\lfloor \frac{\rho(x_i)}{P} \right\rfloor$

When $C(x_i) > 0$, the system triggers a spontaneous symmetry breaking, represented by the state function Ψ:

$$\Psi_{total} = \Psi_{self-similar} \cdot \left(1 - \Theta\big(C(x_i)\big)\right) + \Psi_{hetero}^{(D+1)} \cdot \Theta\big(C(x_i)\big)$$

This transition marks the jump from a self-similar fractal state to a heterogeneous $D + 1$ dimensional topology.

4. Physical Interpretation & Dual Applications

Based on Landauer's Principle, this geometric model translates computational carries into extreme physical heat (entropy). Depending on the application, this acts as a trigger with two distinct purposes:

- **High-Energy Physics (Data Capture):**

  In the Large Hadron Collider (LHC), the thermodynamic pulse generated when density exceeds P serves not as a system collapse, but as a "zero-time active hardware trigger" to reversely detect the exact fraction of a second a dimensional jump (birth of a new particle) occurs, capturing the data.

- **Security Architecture (Physical Ghost):**

  Conversely, when applied to chip security, the simultaneous switching heat across the tensor network caused by a logical attack serves as an integrity shield, intentionally inducing system delays (Tar-pit) and physical zeroization.

5. Critical Review & Information-Thermodynamic Supplement

Theoretical leaps within this model are validated by integrating core principles of modern physics:

- **Map-Territory Isomorphism:** The architecture forces an isomorphism between the mathematical threshold (P) and the hardware's physical energy threshold, aligning logical operations with actual thermodynamic reality.

- **Defense against Causality Reversal:** The lattice is a "topological inversion" holographic lens tracing backward from the outcome to the origin. A carry within the hardware represents the moment the wave function holographically synchronizes with the origin of the past symmetry breaking and collapses.
- **Quantization of the Critical Constant:** The constant P is not an arbitrary cut of continuous energy, but a hardcoded "discrete topological invariant" within the Renormalization Group flow, representing the necessary tensor couplings that must tear for a specific particle to emerge.
- **Holographic Mapping of Dimensions:** Dimensional increase here is not the creation of spatial axes, but the exact mapping of "Degrees of Freedom" acquired by particles during high-energy phase transitions onto the computational phase space, compliant with the Holographic Principle (AdS/CFT).

6. Conclusion and Future Works P-adic Carry Dynamics offers a bridge between discrete arithmetic and continuous topological evolution. By formalizing the "Carry" as a physical event, we provide a mathematical basis for understanding how systems dissipate extreme entropy by evolving into higher-dimensional structures.

[Future Works] The design of a non-linear Analog-to-Digital Converter (ADC) encoding algorithm that losslessly quantizes the analog energy of particles captured by LHC detector sensors into the initial P-adic tensor density $\rho(x_0, t_0)$ within the chip remains a critical next step. This will bridge the ultimate gap toward a fully realized empirical hardware implementation.

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