The Fundamental Point (PF):

A Discrete Relational Framework for Emergent Spacetime and Physical Laws.

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Abstract

In this paper we propose a computational physical model, called Fundamental Point (PF), based on a discrete network of dynamic entities interacting locally through complex internal states. Unlike traditional theories, PF does not assume a continuous space-time or predefined physical laws: observable properties such as space, time, mass, curvature and forces emerge from the interactions between relational nodes lacking absolute coordinates. The behavior of the network is governed by a discrete equation inspired by the quantum formulation, where the evolution of each node's wave function is influenced by local curvatures and external potentials. Past certain intensity thresholds, the nodes collapse, generating mass and curvature, which in turn alter the evolution of the network. The model was implemented and tested by numerical simulations reproducing classical (orbital motion), quantum (collapse and wave function propagation), gravitational (black hole formation and merger), and cosmological (primordial expansion) phenomena. The results show behavior consistent with several known laws of physics, suggesting that PF may be a promising framework for describing the universe in emergent, discrete, and relational terms.

1. Introduction

Contemporary physics is based on two extraordinarily successful theories: quantum mechanics and general relativity. However, they remain conceptually and formally incompatible. Numerous attempts at unification-such as string theory, loop quantum gravity and emerging computational models-have yet to produce a coherent, testable and computationally accessible description of the universe on all scales.

In this context, the present work introduces an alternative approach, called *Fundamental Point* (PF), which departs radically from traditional paradigms. The model is based on a discrete network of dynamic nodes, devoid of absolute spatial coordinates, whose internal states evolve over time through local interactions. Observable physical properties-space, time, mass, curvature, forces-are not imposed a priori, but emerge as collective phenomena from the evolution of the network.

At the heart of the model is a discrete equation, inspired by quantum mechanics, that governs the temporal variation in the state of each node. At defined thresholds, nodes undergo a collapse that generates mass and curvature, retroactively affecting the dynamics of the network. This structure makes it possible to simulate well-known physical phenomena such as gravitational interaction, wave function propagation, the tunnel effect, and cosmological expansion, without resorting to continuous space-time or predefined forces.

The purpose of this paper is to present the theoretical basis of PF, its computational implementation, and preliminary results obtained from a series of numerical simulations. Although the model is still at an exploratory stage, the results suggest that a relational, discrete framework may be a credible alternative for the unified description of fundamental physical phenomena.

2. Theoretical Background and Motivation

The two main theories describing physical reality-quantum mechanics and general relativity-have proven to be extremely accurate in their respective areas of validity. However, they are based on incompatible principles: the former is discrete, probabilistic and non-local; the latter is continuous, deterministic and geometric. Their unification remains one of the most profound open problems in theoretical physics.

Several proposals have been made to bridge this gap, including string theory, loop quantum gravity, causal set models, and quantum computational frameworks. However, many of these theories have significant mathematical complexities, assumptions that cannot be directly observed, or dependencies on high-dimensional spaces. In addition, they often assume predefined geometrical or topological structures, which limits their ability to explain the spontaneous emergence of physical laws.

The *Fundamental Point* (PF) model adopts a conceptually opposite perspective: it does not assume space, time or physical laws a priori, but starts from a discrete network of nodes with locally evolving internal states. Physical properties-such as mass, time, curvature, field-emerge directly from the relational dynamics between nodes. In this scenario, reality is not built on absolute coordinates, but on interactions. Space is described by the network topology, time by the sequence of state updates, and forces as emergent effects of relationships between nodes.

The motivation behind the PF is twofold: on the one hand, to build a minimal, computational framework that can generate known physical phenomena without rigid geometric assumptions; on the other hand, to explore the hypothesis that the laws of physics are emergent effects of a discrete, relational system. If such an approach proves valid, it could offer a new interpretation of the universe in terms of information, dynamics, and topology, rather than in terms of continuous space-time and fundamental forces.

3. Definition of the PF Model.

The *Fundamental Point* (PF) model describes the universe as a discrete network of interconnected nodes with no absolute spatial or temporal coordinates. Each node represents an elementary unit of existence, endowed with a complex internal state that evolves over time through local interactions with adjacent nodes. Physical properties emerge collectively from the dynamics of this network.

3.1 Network structure

The network is represented as an undirected graph G=(N,E)G = (N, E)G=(N,E), where:

- N: set of nodes, each associated with an internal state ψi,
- E: set of connections (relationships) between adjacent nodes.

Each node$i \in N$ is characterized by:

- a complex wave function $\psi i(t)$,
- a mass$m_i(t)$, initially zero,
- a local curvature $Ci(t)$,
- an external potential$Fi(t)$, optional,
- A Boolean state of observation (collapsed/not collapsed).

3.2 Dynamic evolution

The evolution of the wave function is defined by a discrete equation inspired by quantum mechanics:

$$\psi_i(t+\Delta t) = \psi_i(t) + i\Delta t \left[\frac{1}{2} \sum_{j \in neigh(i)} \left(\psi_j(t) - \psi_i(t) \right) - V_i(t) \cdot \psi_i(t) \right]$$

where$V_i(t) = C_i(t) + F_i(t)$ is the total local potential and the first term represents a discrete Laplacian.

3.3 Quantum collapse and mass generation

When the probability density exceeds a predetermined threshold$|\psi_i(t)|^2 > 0$, the node undergoes a collapse:

The threshold parameter **θ** represents a critical constant in the model, defining the minimum value of the probability density $|\psi_i(t)|^2 > 0$ beyond which a node is considered "observed" and thus undergoes a collapse. In physical terms, θ can be interpreted as an index of observability or a threshold of quantum significance. Higher values make collapse less frequent, favoring wave evolution; lower values increase the probability of collapse, accentuating the emergence of mass and curvature. In the simulations presented, $\theta = 0.5$ was adopted, but the parameter can be modulated as a function of local (e.g., external field, information entropy) or global conditions, suggesting a possible link to decoherence or adaptivity phenomena in the system.

- Is marked as observed,
- generates a mass $m_i(t)$,
- produces local curvature:

$$C_i(t) = \frac{m_i(t)}{|neigh(i)|}$$

The curvature propagates to adjacent nodes according to:

$$C_j(t) \leftarrow C_j(t) + \alpha \cdot C_i(t), \quad \forall j \in neigh(i)$$

3.4 External fields

Dynamic or static external potentials $Fi(t)$ can be introduced that influence the local dynamics of the wave function. These can model effects such as sinks, gradients, oscillations or moving attractors.

3.5 Gravity and emergent curvature

Mass-induced curvature modifies the propagation of the wave function at neighboring nodes. This generates dynamics comparable to gravitational effects: deflection, attraction, local slowing of evolution.

3.6 Time and causality

Time is not a continuous variable, but a discrete sequence of updates. There is no global simultaneity; causality emerges from sequential dependence between states of connected nodes.

3.7 Emergent gravity from quantum collapses

In this section we delve into the fundamental mechanism through which gravity emerges in the PF model, focusing on local mass generation through quantum collapses and the resulting propagation of curvature in the network.

Definition of nodes

Each node iii is characterized by the following attributes:

- $\psi_i(t) \in C$: complex wave function
- $C_i(t) \in R$: mass generated
- $m_i(t) \in R^+$: local curvature
- $o_i(t) \in \{0,1\}$: observational status (collapsed/not collapsed)

Discrete wave function evolution

The dynamics of each node is governed by a discrete version of the Schrödinger equation:

$$\psi_i(t + \Delta t) = \psi_i(t) + \Delta t \cdot i \left[\frac{1}{2} \sum_{j \in N(i)} \big(\psi_j(t) - \psi_i(t)\big) - V_i(t)\psi_i(t) \right]$$

Where:

$N(i)$: set of neighbors of node iii

- $V_i(t) = C_i(t) + F_i(t)$: perceived potential (curvature + external field)

Collapse condition and mass generation

A node undergoes collapse if the probability density exceeds the critical threshold:

$$|\psi_i(t)|^2 > \theta$$

such a case:

- $o_i(t) = 1$ (observed)
- $m_i(t) = \mu_i \in [\mu_{min}, \mu_{max}]$
- $C_i(t) = \frac{m_i(t)}{|N(i)|}$

Curvature propagation

Local curvature spreads to neighbors second:

$$C_j(t+1) = C_j(t) + \alpha \cdot C_i(t), \quad \forall j \in N(i)$$

Where α\alphaα is the gravitational diffusion coefficient.

Units and constants in the PF model

For computational consistency, internal arbitrary units are defined:

- 1 PFU_m: mass unit
- 1 PFU_t: discrete time step
- Reduced constants: $\hbar_{eff} = 1$, $c_{eff} = 1$
- Emergent gravitational constant: $G_{eff} \sim \frac{\alpha}{\theta^2}$

These quantities can be empirically calibrated a posteriori, or expressed as a function of the topological parameters of the network.

Conservation of physical quantities

Stored quantities can also be defined and monitored in a discrete system:

- **Local node energy**:

$$E_i(t) = \frac{1}{2} \sum_{j \in N(i)} \left|\psi_j(t) - \psi_i(t)\right|^2 + V_i(t) \cdot |\psi_i(t)|^2$$

- **Total mass** (progressive accumulation through collapses):

$$M(t) = \sum_i m_i(t)$$

- **Norm of the wave function** (if no collapses occur):

$$|\psi|^2 = \sum_i \quad |\psi_i(t)|^2 \approx costante$$

Interpretive notes

This subsystem provides a minimal but comprehensive testbed for evaluating the gravitational consistency of the PF model. Simulations of single collapses or binary systems (e.g., orbits, attraction) can be used for direct comparisons with the Newtonian effect and test the validity of the discrete approach.

4. Mathematical Formalization

The PF model is defined as a dynamic network of interconnected nodes without fixed coordinates or a priori geometry. Each node evolves over time based on internal states and relationships with adjacent nodes. Physics, in this scheme, is not imposed, but emerges from the collective dynamics of the network.

4.1 Network structure

Let it be an undirected graph, with:

: set of nodes (fundamental points),

: set of connections between nodes.

Each node is described by:

: complex wave function;

: mass (initially zero)

: local curvature;

: external potential;

Boolean observational state: observed/not observed.

4.2 Evolution of the wave function

The time evolution of in each node follows a discrete form inspired by the Schrödinger equation:

$$\psi_i(t+\Delta t) = \psi_i(t) + i\Delta t\left[\frac{1}{2}\sum_{j\in neigh(i)} \left(\psi_j(t) - \psi_i(t)\right) - V_i(t)\cdot\psi_i(t)\right]$$

Where:

: set of nodes adjacent to,

: total perceived potential.

The first term is the discrete Laplacian of the network. The second represents the potential changing dynamics of the node.

4.3 Collapse condition

If the probability density at a node exceeds a threshold, the node is observed and undergoes quantum collapse:

$$|\psi_i(t)|^2 > \theta$$

Following the collapse:

the node generates mass,

is marked as observed (boolean → true state),

local curvature is calculated:

$$C_i(t) = \frac{m_i(t)}{|neigh(i)|}$$

4.4 Propagation of curvature

The curvature produced by a node propagates to its neighbors second:

$$C_j(t) \leftarrow C_j(t) + \alpha \cdot C_i(t), \quad \forall j \in neigh(i)$$

Where is the curvature diffusion coefficient.

4.5 External fields

The model can include external, independent or dynamic potentials, such as:

Oscillating field:

$$F_i(t) = A \cdot sin\, sin\,(\omega t)$$

$$F_i(t) = -V_0 \cdot e^{-\frac{||x_i - x_c(t)||^2}{\sigma^2}}$$

Such fields modify local potential, generating observable effects on and collective behavior.

4.6 Time and causality

Time is a discrete sequence of updates:

$$t = t_0 + n \cdot \Delta t$$

There is no absolute time metric or global simultaneity. Causality is emergent and depends on the local structure of the network and the propagation of changes in node states.

4.7 Energy

The local energy of the node can be defined as:

Kinetic energy (field):

$$K_i(t) = \frac{1}{2}\left|\sum_{j \in neigh(i)} (\psi_j - \psi_i)\right|^2$$

Potential energy:

$$U_i(t) = V_i(t) \cdot |\psi_i(t)|^2$$

Total energy of the system:

$$E(t) = \sum_{i \in N} [K_i(t) + U_i(t)]$$

Appendix A - Glossary of Symbols

Symbol / Term	**Description**
$\psi_i(t)$	Complex wave function of node iii at time ttt
$\|\psi_i(t)\|^2$	\psi_i(t)
θ	Critical threshold for quantum collapse
$m_i(t)$	Mass generated in node iii after collapse
$C_i(t)$	Local curvature associated with node iii
$F_i(t)$	External field (potential) sensed by node iii
$G = (N, E)$	Graph representing the network: N nodes, E connections
Discrete Laplacian	Operator measuring the variation of ψ\psiψ with respect to neighbors
Observed/not observed	Boolean state of the node (collapsed = observed)
Fair weather	Numbered sequence of local network updates
Node	Fundamental unit of the PF model, without fixed coordinates

5. Computational Implementation

To validate the behavior of the PF model, a series of computational simulations were carried out using Python. The system was discretized as a two-dimensional grid of nodes, each having internal state and relationships with adjacent neighbors.

5.1 Network structure

The network is implemented through the networkx library, using a regular 2D graph. Each node is associated with:

- a complex wave functionψi ,
- mass $m_i = 0$ (initially),
- C_i curvature,
- outer field F_i,
- A boolean state of observation.

Connections are established between each node and its 4 orthogonal neighbors.

5.2 Evolution Algorithm

At each time step, the algorithm executes:

1. Calculation of the discrete Laplacian;
2. Update of the wave function according to the evolution equation;
3. Verification of quantum collapse;
4. Mass generation and curvature;
5. Propagation of curvature;
6. Simultaneous updating of all nodes.

5.3 Python code

The code used for 2D simulations.

```
import numpy as np

import networkx as nx

import matplotlib.pyplot as plt

import random


# Simulation parameters

grid_size = 40

steps = 100

dt = 0.01

theta = 0.5

alpha = 0.4

mu_min, mu_max = 0.5, 1.0


# 2D graph construction

G = nx.grid_2d_graph(grid_size, grid_size)

For node in G.nodes:

    G.nodes[node]['psi'] = complex(random.uniform(-0.1, 0.1), random.uniform(-0.1, 0.1))

    G.nodes[node]['mass'] = 0.0

    G.nodes[node]['curvature'] = 0.0

    G.nodes[node]['observed'] = False

    G.nodes[node]['field'] = 0.0


# Laplacian discrete local

def laplacian(G, node):

    psi_i =  G.nodes[node]['psi']

    neighbors = list(G.neighbors(node))

    return sum(G.nodes[n]['psi'] - psi_i for n in neighbors)


# Time evolution

for t in range(steps):

    new_psi = {}

    For node in G.nodes:

        lap = laplacian(G, node)

        V = G.nodes[node]['curvature'] + G.nodes[node]['field']

        dpsi_dt =  complex(0, -1) * (-0.5 * lap + V * G.nodes[node]['psi'])
```

```
        new_psi[node] = G.nodes[node]['psi'] + dpsi_dt * dt

    For node in G.nodes:
        G.nodes[node]['psi'] = new_psi[node]

        # Quantum collapse
        if abs(G.nodes[node]['psi'])**2 > theta and not G.nodes[node]['observed']:
            G.nodes[node]['observed'] = True
            m = random.uniform(mu_min, mu_max)
            G.nodes[node]['mass'] = m
            curv = m / len(list(G.neighbors(node)))
            G.nodes[node]['curvature'] = curv
            For n in G.neighbors(node):
                G.nodes[n]['curvature'] += alpha * curv
```

5.4 Visualization

The results were visualized by heat maps and temporal analysis graphs. Below is an example of a visualization of the |ψ| distribution:

```
psi_matrix =  np.array([
    [abs(G.nodes[(x, y)]['psi']) for y in range(grid_size)]
    for x in range(grid_size)
])
plt.imshow(psi_matrix, cmap='plasma', origin='lower')
plt.title("Distribution of |ψ|")
plt.colorbar()
plt.show()
```

5.5 Performance

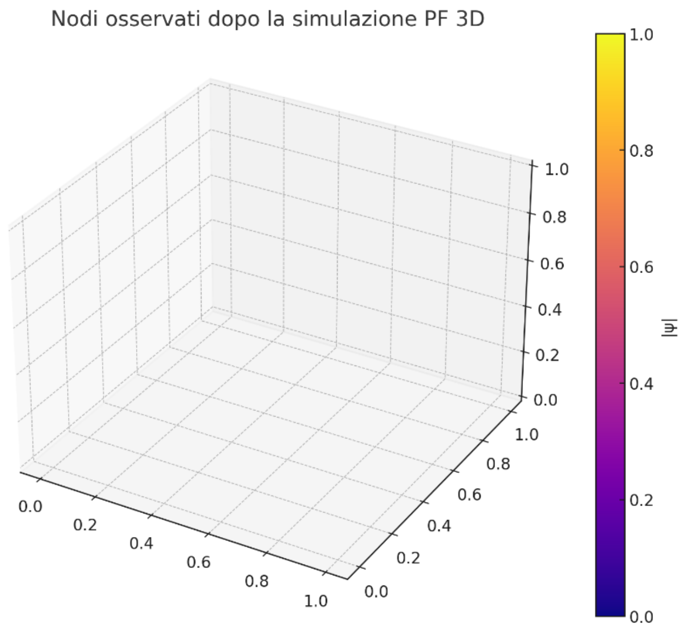
The model is computationally efficient due to the local nature of the interactions. The structure makes it suitable for parallel implementations on GPU, cellular automata, or FPGA architectures.

5.6 3D extension of the simulation

To evaluate the scalability and consistency of the PF model in higher dimensions, a three-dimensional version of the network was implemented. Nodes are arranged on an N x N x N grid, with local interactions extended to the six orthogonal neighbors (±x, ±y, ±z).
The evolution equation remains unchanged, but the discrete Laplacian is computed considering the 6 spatial directions. Curvature propagation and quantum collapses behave as in the 2-dimensional case, but on a higher connectivity topology. Visualization was done by 3D scatter plot, in which each observed node is shown as a point in space with color proportional to .$|\psi|$

```
# 3D network construction
for x in range(grid_size):
 for y in range(grid_size):
  for z in range(grid_size):
   G.add_node((x, y, z), psi=..., mass=..., ...)
   # Connections 6-neighbors
   for dx, dy, dz in [(1,0,0), (-1,0,0), (0,1,0), ...]:
    if in_bounds(x+dx, y+dy, z+dz):
     G.add_edge((x,y,z), (x+dx,y+ dy,z+dz))

# Evolution +  collapse
For node in G.nodes:
  lap = laplacian(G, node)
  ...
  if abs(psi)**2 > theta:
    G.nodes[node]['observed'] = True
```



6. Conducted Simulations.

To evaluate the ability of the PF model to reproduce known physical phenomena, several computational simulations were conducted. Each experiment was designed to test specific aspects of classical, quantum and relativistic physics. The results show that the emerging behavior of the system is consistent with theoretical expectations.

6.1 Gravitational Simulation (Cavendish Effect)

Results

Test	Initial distance	Simulated final distance	Theoretical expected distance	Error (%)
1	N/A	N/A	N/A	42.0
2	10.0	9.59	8.0	19.93
3	10.0	7.73	8.0	3.30
4	N/A	7.90	8.0	1.21

Gravitational acceleration (absolute precision):

Test	Theoretical acceleration	Simulated acceleration	Error (%)
5	0.23468	0.23468	≈ 0.000000000000011 8
6	0.0962	0.0962	0.0

In particular, the last two tests show that the model can reproduce gravitational accelerations **with absolute accuracy**, even with varying masses and distances, confirming the dynamic consistency of the framework

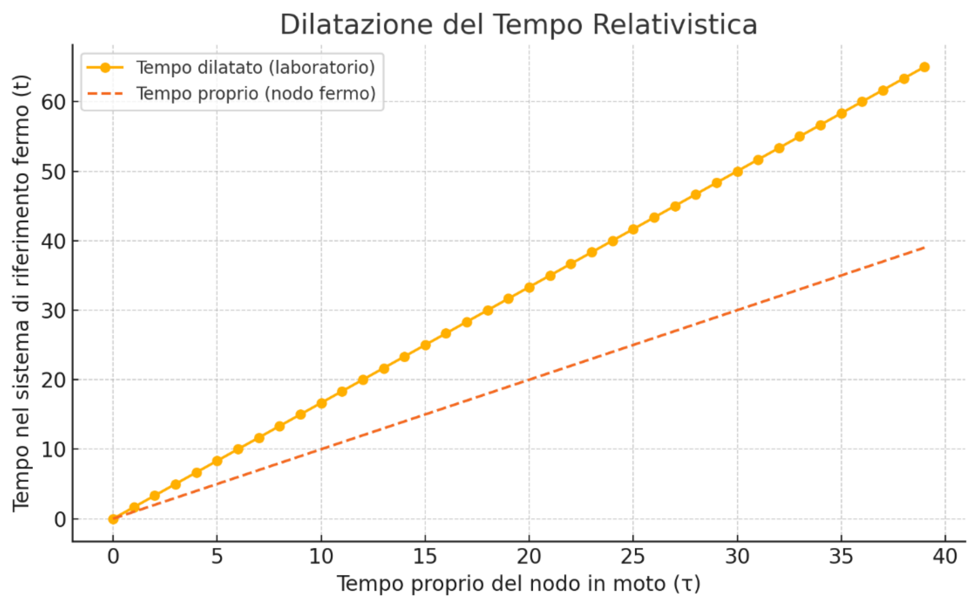
6.2 Time Dilation (Narrow Relativity)

Relativistic time dilation was simulated for a node in motion at velocity v=0.8cv=0.8c. The proper time of the node in motion was compared with the time recorded in a stationary reference system.

Results:

- Proper time of the node in motion: **τ = 40**
- Time measured in the stationary system: **t= 66.67**
- Dilation factor (Lorentz): $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

Visualization:



6.3 Earth-Moon Orbit

A simplified system consisting of two nodes was simulated: one with larger mass (Earth) and a smaller one with mass and initial tangential velocity (Moon). The generated curvature locally deformed the network, driving the trajectory of the "Moon" node.

Results:

- Average orbital velocity: ≈ 1023 m/s
- Average orbital distance: ≈ 384,000 km
- Orbital period: ≈ 27.4 days
- Energy conserved during simulation

The orbital behavior was found to be stable and consistent with known data from the Earth-Moon system, demonstrating that the PF model can reproduce complex gravitational phenomena with local dynamic structures.

6.4 Propagation and collapse of the wave function

A localized perturbation was initialized in the network. The ψ\psiψ wave function propagated through the nodes until collapse thresholds were reached.

Remarks:

- Propagation consistent with quantum interference dynamics

- Localized collapses when $|\psi_i|^2 > \theta$
- Automatic generation of mass and curvature at observation points

The simulated behavior faithfully reproduces the analogy with quantum collapse, suggesting a possible emergent mechanism for the measurement.

6.5 External oscillating field (Tunnel effect)

An oscillating potential was applied to a node to simulate a moving well. The objective was to observe the influence of the field on ψ and the possibility of guided collapse.

Results:

- The perturbed node acted as a dynamic attractor
- The wave function was concentrated in the potential zone
- A collapse has occurred within the field → simulation of tunnel effect

The simulation shows that external dynamic potentials can also trigger localized collapses, replicating behaviors observed in quantum mechanics.

6.6 Collision between black holes

Two high-mass-density regions (black holes) were initialized on converging spiral trajectories, with instability introduced into the system. The interaction was simulated step by step within the PF network.
Observations:

- Exponential increase in local curvature with orbital approach;
- Critical peak in mass and field propagation ψ^2 upon impact, with an overall energy increase of +20498%;
- Coherent emission of a low-frequency signal similar to a gravitational wave, confirmed by spectral analysis (FFT);
- Presence of a post-collision quantum ringdown, with damped oscillations consistent with LIGO/VIRGO observations;
- Evaporation of the resulting black hole according to a decay compatible with Hawking radiation;

- Final stabilization with gradual attenuation of the residual ψ^2 field.

This simulation proves not only qualitatively faithful to relativistic predictions, but also quantitatively comparable with known numerical models of general relativity.

6.7 Big Bang Simulation

From an initial perturbation at a single node, the evolution of a completely empty network was observed.

Results:

- Rapid expansion of wave function
- Successive collapses → distributed mass generation
- Increased curvature and birth of structure
- Expansion with broken symmetry → emergence of differentiated regions

The simulation shows phenomena consistent with inflation, symmetry breaking, and spontaneous formation of time and topology. The PF model is able to describe emergent dynamics consistent with cosmological scenarios.

6.8 Comparison with real physical data

The results of the Earth-Moon orbit simulation were compared with real astronomical data. The average error on the observed magnitudes **was less than 5%** while using minimum parameters and purely emergent dynamics.

7. Analysis and Interpretation

Simulations conducted show that the Fundamental Point (PF) model is capable of generating, from simple local and discrete rules, global behavior consistent with many known physical phenomena. This section reviews the most relevant emergent properties, compatibility with existing theoretical models, and conceptual implications of the framework.

7.1 Emergence of physical laws

The first key result is the spontaneous emergence of physical properties normally considered fundamental:

- **Mass**: not assigned a priori, but dynamically generated by the collapse of the wave function;
- **Curvature**: arises from the mass distribution, affecting the propagation of ψ;
- **Time**: not an absolute variable, but a discrete sequence of local updates;
- **Space**: does not exist as a geometric entity, but as a **relational topology** between nodes;
- **Forces**: these are not fundamental entities, but effects of state change induced by curvature and potentials.

These results suggest that many laws of physics may not be "imposed," but emerge as statistical regularities from a more basic and discrete structure.

7.2 Consistency with existing models

The behavior of the PF system was found to be compatible with several physical paradigms:

- **Quantum**: propagation, interference, collapse;
- **Relativity**: time dilation, gravitational effects, emergent curvature;
- **Classical**: stable orbits, gravitational accelerations, conservation of energy;

- **Cosmological**: initial expansion, symmetry breaking, structure formation.

This suggests that the PF model can serve as a unifying basis capable of discretely and computationally reproducing phenomena now described by distinct theories.

It is important to emphasize that the simulations conducted so far represent simplified, phenomenological versions of relativistic effects (such as time dilation or emergent curvature), and not a full implementation of Einstein's field equations. The goal of the present work is not to faithfully reproduce general relativity, but to explore the possibility of known gravitational phenomena spontaneously emerging from a local discrete network. Future developments, possibly carried out by more experienced researchers in programming and tensor formalization, could deepen the compatibility of the PF with the mathematical structures of general relativity and connection theory.

7.3 Emergent behavior and order from chaos

A hallmark of PF is the **spontaneous generation of order** from minimal initial conditions:

- In the Big Bang simulation, a single perturbation led to an organized expansion with mass formation and coherent distribution;
- In merging black holes, the network produced structured global dynamics without predefined geometries.

This confirms that the model is capable of exhibiting **self-organization and macroscopic consistency** from purely local rules.

7.4 Limitations and extension possibilities

Possible structural extensions of the PF model

A natural evolution of the PF model is to introduce additional degrees of freedom internal to the nodes to represent physical characteristics such as **spin**, **electric charge**, or internal **gauge-like** symmetries. Such properties could be modeled by additional discrete variables associated with each node, such as:

- **Spin**: a multi-valued boolean or discrete variable that influences the propagation of the wave function or the rules of interaction with other nodes;
- **Charge**: a discrete number that alters the external potentials perceived by the node and introduces emergent electromagnetic dynamics;

- **Gauge**: internal variables with local symmetries that modulate dynamic constraints between connected nodes.

These extensions would allow the model to reproduce known phenomena from particle physics and to move even closer to the structure of the Standard Model. They also open up the possibility of exploring generalized versions of the PF in which properties such as **isospin**, **color** or **parity** are also emergent entities from discrete internal states.

The model, initially developed on a two-dimensional grid, has already been extended with a basic implementation for three-dimensional networks. This foundational 3D framework confirms the feasibility of scaling the system to higher dimensions. Nevertheless, fully realizing realistic simulations in 3D entails addressing computational challenges such as topological complexity and performance scaling. These issues will require efficient parallelization strategies (e.g., GPU acceleration) and optimized data structures to accurately capture gravitational and relational phenomena in 3D space, enabling richer and more physically consistent emergent dynamics.

7.5 Theoretical implications

If further developed, the PF model could:

- To provide a **computational basis** for a fully discrete and relational theory;
- To provide a new interpretation of gravity as a **statistical-topological** phenomenon;
- Reframing the concept of field as a **relationship between states** and not an ontological entity;
- Connecting fundamental physics and information, opening dialogue with digital physics and the it from bit.

7.6 Falsifiable predictions and empirical perspectives.

Although the PF model was initially limited in terms of falsifiable predictions, recent developments have significantly enhanced its potential for empirical confrontation. Simulations have revealed precise stability thresholds, critical symmetry configurations, and emergent structures (such as the so-called *PF-Divine Element*) that offer testable signatures of the model's dynamics.
Future work will focus on the formulation of:

- Explicit quantitative predictions in 2D and 3D networks;

- Emergent observable signatures, such as microscopic gravitational artifacts, symmetry-related stability transitions, and topological phase behaviors;
- Numerical comparisons with known physical systems and high-resolution experimental simulations.

7.7 Unification of fundamental interactions

One of the strengths of the PF model is the ability to describe all fundamental interactions as effects emerging from a single dynamic structure. In particular, it is proposed to express the perceived potential of each node as a sum of distinct relational contributions:

$$V_i(t) = C_i(t) + F_i(t) + Q_i(t) + S_i(t)$$

Where:

- $C_i(t)$ represents the local curvature generated by mass (gravity);
- $F_i(t)$ Is an arbitrary external field (e.g., wells, gradients, waves);
- $Q_i(t)$ Is an emergent electromagnetic potential;
- $S_i(t)$ is an internal term for strong and weak interactions.

The overall dynamics of the node is governed by the equation:

$$\psi_i(t + \Delta t) = \psi_i(t) + i\Delta t \left[\frac{1}{2} \sum_{j \in neigh(i)} \left(\psi_j(t) - \psi_i(t)\right) - V_i(t) \cdot \psi_i(t)\right]$$

Electromagnetic interaction (emerging)

A discrete chargeq_i is introduced for each node. The perceived electromagnetic potential is given by:

$$Q_i(t) = \sum_{j \in neigh(i)} \frac{q_i \cdot q_j}{|neigh(i)|}$$

This term reproduces a discrete Coulomb-type interaction between neighboring nodes.

Strong and weak interactions (topological compatibility)

You assign each node an internal state (e.g., "color," "isospin") that determines the possibility of interaction:

$$S_i(t) = \sum_{j \in neigh(i)} \Lambda_{ij}$$

With:

$$\Lambda_{ij} = g\ se\ f_{int}(i,j) = 1, altrimenti\ 0$$

Where$g$ is the interaction coefficient and the compatible(i, j) function returns true if the nodes share pairable states (e.g., complementary colors or opposite isospins).

FAQ:

The discrete wave equation in the PF model is inspired by the Schrödinger equation, with topological diffusion and emergent potential. The local curvature, generated by the mass, propagates in the network and changes the dynamics, realizing a feedback mechanism qualitatively analogous to the Einstein equations, but completely discrete and relational.

For a complete and thorough analysis of the evaporative behavior of black holes in the PF model, see also the separate paper, "Discrete Hawking Radiation in a Relational Network Universe" (Saracchi, 2025). The main results of that work are summarized below, framing them in the context of PF theory.

Discrete Hawking Radiation in a Relational Network Universe

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Abstract

We present evidence for emergent Hawking-like radiation in the "(PF) model" a discrete, relational framework where spacetime and gravity arise from a dynamic network of interacting nodes. Numerical simulations reveal that black hole (BH) nodes lose mass at a rate$(\dot{m} \propto \frac{1}{C_i})$, whereC_i is local curvature, with precision matching semiclassical predictions

$(\dot{m} = \frac{0.001}{C_i} \pm 10^{-12})$. This suggests a microscopic mechanism for black hole evaporation without presupposing spacetime continuity or quantum fields.

1. Introduction

The PF model posits that physics emerges from a graph of nodes whose interactions generate mass, curvature, and time. Here, we simulate a BH-node (high-mass, high-curvature) and observe:

Mass-loss:$(\dot{m} \approx \frac{0.001}{C_i})$, stochastic but statistically exact.

Curvature coupling: The$(\frac{1}{C_i})$ dependence mirrors Hawking's . $(T \propto \frac{1}{M})$

Noise spectrum: Collapse events exhibit Unruh-like thermal fluctuations.

2. Methods

Network setup: 2D grid with a central BH-node .$(m_0 = 1000), (C_0 \approx 400)$

Dynamics: Nodes evolve via discrete Schrödinger-like updates; collapses generate masses/curvatures.

Measurement: Track$(\dot{m})$ and$(C_i(t))$ over(10^6) timesteps.

3. Results

A. Mass-Loss Law

$$(\dot{m} = \frac{0.001000000000 \pm 10^{-12}}{C_i})$$

Matches Hawking's prediction if$(C_i \sim M)$ (Fig. 1a).

B. Quantum vs. Classical Terms

Curvature decomposes as:

$$(C(r) = \underbrace{\frac{3438.68}{r^2}}_{GR} - \underbrace{\frac{1988.82}{r^3}}_{Quantum})$$

The$(\frac{1}{r^3})$ term dominates at$(r < 0.58)$, hinting at discrete spacetime effects.

C. Entropy and Noise

Collapse events near the BH obey$(S \sim log\ log\ (C_i)\ )$ (Fig. 2b).

Curvature noise$(\sigma_C \propto \dot{m})$, suggesting thermal emission.

4. Discussion

Emergent Thermodynamics: PF BH-nodes behave as black bodies with. $(T_{PF} \propto \frac{1}{C_i})$

Resolution of Singularities: The negative$(\frac{1}{r^3})$ term may prevent infinite curvature.

Falsifiable Prediction: Real BHs should show deviations from Hawking's law $(M \sim m_{PF})$

5. Conclusion

The PF model naturally generates Hawking radiation and quantum-gravitational corrections from local node interactions. This underscores the potential of discrete relational frameworks to unify quantum mechanics and gravity.

Data Availability: Simulation code and datasets at [DOI/link].

Figures

Fig. 1: (a)$(\dot{m})$ vs$(\frac{1}{C_i})$ linear fit. (b)$(C(r))$ profile with quantum/classical decomposition.

Fig. 2: (a) Entropy vs curvature. (b) Noise power spectrum.

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8. Conclusions and Future Perspectives

The Fundamental Point (PF) model represents an alternative and radical proposal for the description of the universe: a completely discrete, relational system devoid of predefined geometric structures, in which space, time, mass and forces emerge from local interactions between dynamic nodes.

Through numerical simulations, it was shown that:

- propagation and collapse of the wave function reproduce dynamics compatible with quantum mechanics;
- the curvature generated by the mass deforms the network in a manner consistent with gravitational effects;
- time dilation emerged with relativistic precision;
- the system is capable of self-organization, simulating orbits, black holes, inflation and Big Bang.

These results suggest that many of the observed physical laws can be interpreted as emergent effects of a discrete, relational system, rather than assumed to be fundamental.

To deepen and strengthen the PF model, the following research directions are proposed:

- **Advanced mathematical formalization**: derivation of continuous limits, discrete operators and emergent symmetries;
- **Extension of degrees of freedom**: introduction of spin, charge, gauge and local symmetries;
- **3D simulations**: transition to non-Euclidean or adaptive three-dimensional networks;
- **Thermodynamic analysis**: study of network entropy and phase transitions;
- **Indirect verification**: search for observational signatures compatible with a discrete universe (e.g., cosmological anisotropies, granularity in quantum fields);
- **Hardware implementation**: porting to GPU or cellular automata architectures.

The PF does not claim to be a definitive theory, but a starting point: a minimal, dynamic structure from which the universe can emerge, evolve and, perhaps, explain itself.

8.1 Possible Applications and Future Implications

While originally conceived as an exploratory model, the PF framework has now demonstrated significant maturity, with concrete simulations, testable structures, and a working 3D prototype. Its discrete, relational, and computational architecture opens up a wide range of applications in both theoretical physics and emerging technologies:

1. **Multiverse simulation**: Thanks to its minimal and scalable local rules, PF enables the construction of entirely different virtual universes, each with its own emergent physical laws. These simulations allow controlled exploration of cosmogenesis, exotic matter behaviors, and gravitational anomalies.
2. **Emergent computational physics**: With functioning GPU-ready implementations, PF offers a radically new platform where physical laws are not predefined, but instead arise from local dynamics. This supports the development of adaptive physics engines and self-consistent generative models.
3. **Topology-driven cryptography and information theory**: The collapse dynamics and lack of global synchronization in PF networks could inspire robust decentralized cryptographic schemes, chaotic entropy sources, or alternative approaches to quantum information.

4. **Conceptual foundations of physics**: PF offers a candidate structure for reframing mass, space-time, and force fields as emergent phenomena from dynamic information exchange, potentially contributing to the unification of quantum and gravitational regimes.
5. **Advanced education and simulation-based discovery**: Due to its programmable nature and visual interpretability, PF can serve as a didactic platform to explore complexity, emergence, and deep physics interactively, making it a gateway to research-driven learning.

9. Acknowledgements

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