## # Title: Numerical Feedback and Emergent ψ–Curvature Dynamics

🔹 Objective  
Explore the computational feedback loop between ψ(x) and curvature(x) using numerical methods in 1D. We aim to simulate how ψ evolves due to curvature, and how that feedback may lead to equilibrium, divergence, or pattern formation. This forms a precursor to emergent gravitational behavior.

🔹 Key Equations Recap  
We use: 1. Initial ψ field  
Rendered:

Plaintext:  
ψ₀(x) = A \* exp( - (x - x0)**2 / (2 \* sigma**2) )

1. Curvature definition  
   Rendered:

Plaintext:  
Curvature(x) = Laplacian of (space(x) + time^2)

1. Updated ψ with feedback  
   Rendered:

Plaintext:  
ψₙ₊₁(x) = ψₙ(x) + β \* Curvature(x)

1. Gravity field  
   Rendered:

Plaintext:  
Gravity(x) = ψ(x) \* Curvature(x)

🔹 Discrete Numerical Setup  
We model a 1D grid with 100 spatial points:

(pytthon)

import numpy as np

import matplotlib.pyplot as plt

# Grid setup

N = 100

x = np.linspace(-10, 10, N)

dx = x[1] - x[0]

# Initial ψ

A, x0, sigma = 1.0, 0.0, 3.0

psi = A \* np.exp(-(x - x0)\*\*2 / (2 \* sigma\*\*2))

# Space and time²

space = x.copy()

time\_squared = 1.0

field = space + time\_squared

# Discrete Laplacian operator

def laplacian(f, dx):

return (np.roll(f, -1) - 2\*f + np.roll(f, 1)) / dx\*\*2

# Curvature

curvature = laplacian(field, dx)

# Parameters

beta = 0.1

timesteps = 10

history = [psi.copy()]

# Evolution loop

for \_ in range(timesteps):

psi = psi + beta \* curvature

history.append(psi.copy())

# Gravity at final step

gravity = psi \* curvature

plt.figure(figsize=(12,6))

plt.plot(x, history[0], label='Initial ψ₀')

plt.plot(x, history[-1], label='Final ψ')

plt.plot(x, curvature, '--', label='Curvature')

plt.plot(x, gravity, '-.', label='Gravity = ψ × curvature')

plt.legend()

plt.title("1D Feedback Evolution: ψ and Curvature")

plt.xlabel("x")

plt.grid(True)

plt.show()

This reveals the nature of the interaction:  
• Curvature is static in this case  
• ψ amplifies or decays depending on β and curvature sign  
• Gravity emerges as a shaped response to both

🔹 Interpretation  
• If curvature(x) is positive and constant, then ψ(x) monotonically increases.  
• Negative curvature causes ψ(x) to decrease or flatten.  
• The gravity field becomes stronger where ψ aligns with the curvature sign.  
• There are no instabilities at this stage, since curvature is held constant.  
However, if curvature is made dynamic (∝ ψ), then nonlinear feedback may emerge.

🔹 ψ-Curvature Coupling (Future Consideration)  
If we define:  
Rendered:

Plaintext:  
Curvature(x) = Laplacian of [space(x) + time^2 + α \* ψ(x)]

Then ψ and curvature dynamically influence each other.

We may get:  
• Stable wells (ψ clusters around minima)  
• Oscillatory solutions (if α or β tuned)  
• Runaway feedback (if feedback too strong)

We will analyze those dynamics symbolically and numerically in Part 6 or in extended versions of Phase 5.

🔹 Implications for Gravity as Emergence  
• Gravity(x) is not caused by ψ alone; it is an emergent product of curvature interacting with a generative field ψ.  
• This justifies modeling gravity as geometry × field, not geometry alone (unlike Einstein field equations).  
• The shape of ψ(x) responds to how space is curved, and in turn, shapes that curvature.

🔹 Summary of What We’ve Built

| Component | Role |
| --- | --- |
| ψ(x) | Generative field, reacts to curvature |
| space(x) + time² | Base geometric potential |
| ∇²(space + time²) | Source of curvature, acts on ψ |
| β | Coupling between ψ and curvature |
| Gravity(x) | Emerges from ψ(x) × curvature(x) |

🔹 Questions Leading to Part 6  
• What happens when ψ and curvature update together?  
• Can equilibrium ψ wells form? Do they resemble gravitational attractors?  
• What is the energy associated with the ψ field?  
• Can this lead to a Lagrangian or field-theoretic formulation?