Phase 11 – Predictive Power  
Part 4: ψ-Wave Interactions in Predictive Contexts

Goal  
To simulate and analyze ψ-wave interactions under predictive regimes, focusing on measurable interference, amplification, and nonlinear phenomena that distinguish ψ-gravity from classical expectations.

Interaction Framework  
ψ dynamics allow multiple wave modes to overlap and interact. From linear stability (Phase 10) and predictive structures (Part 2), interactions fall into three primary regimes:

* Linear Superposition  
  ψ modes add constructively or destructively without modifying each other.
* Nonlinear Coupling  
  ψ gradients and current² terms produce mode mixing and frequency shifts.
* Resonant Amplification  
  Close frequencies reinforce each other, generating large-amplitude beats or soliton-like packets.

Governing Expressions

For two ψ modes:

Plain text: ψ(x,t) = A1 cos(k1x − ω1t) + A2 cos(k2x − ω2t)

The resulting envelope modulation:

Plain text: ψ(x,t) = 2A cos(0.5[(k1−k2)x − (ω1−ω2)t]) · cos(0.5[(k1+k2)x − (ω1+ω2)t])

Predictive Interaction Phenomena

1. Interference Fringes
   * Constructive zones: ψ wells deepen → stronger effective forces.
   * Destructive zones: ψ cancels → particles experience reduced gravity.
   * Observable as alternating bands of clustering and voiding.
2. Beat Amplification
   * Beat envelope causes periodic focusing of ψ energy.
   * Particles “surf” on amplified ψ crests.
   * Oscillatory clustering measurable in trajectories.
3. Soliton-like Stabilization
   * Nonlinear focusing balances dispersion.
   * Stable ψ packets emerge carrying particles.
   * Acts as predictive analogue to gravitational solitons.
4. Current²-Driven Mixing
   * Time-dependent current² modifies dispersion.
   * Leads to sideband frequencies (ω ± Ω\_current).
   * Observable as shifted oscillation spectrum.

Simulation: ψ-Wave Interactions

# simulations/phase11\_part4\_wave\_interactions.py  
import numpy as np  
import matplotlib.pyplot as plt  
  
# Parameters  
x = np.linspace(-100, 100, 2000)  
t = 60 # snapshot time  
  
# Two interacting ψ modes  
A1, A2 = 1.0, 1.0  
k1, k2 = 0.25, 0.28  
omega1, omega2 = 0.5, 0.53  
  
# ψ field: superposition  
psi\_interaction = A1\*np.cos(k1\*x - omega1\*t) + A2\*np.cos(k2\*x - omega2\*t)  
  
# Envelope (beat modulation)  
envelope = 2\*np.cos(0.5\*((k1-k2)\*x - (omega1-omega2)\*t))  
  
# Plot  
plt.figure(figsize=(10,6))  
plt.plot(x, psi\_interaction, label="ψ interaction field")  
plt.plot(x, envelope, '--', alpha=0.7, label="Envelope (beats)")  
plt.title("Phase 11 – Part 4: ψ-Wave Interactions")  
plt.xlabel("x")  
plt.ylabel("ψ(x,t)")  
plt.legend()  
plt.grid(True)  
plt.show()