import numpy as np

import matplotlib.pyplot as plt

# Função da onda gaussiana inicial

def wave\_packet(x, t, k0=10, sigma=0.1):

return np.exp(-(x - 0.3 - 0.1 \* t)\*\*2 / (2 \* sigma\*\*2)) \* np.cos(k0 \* (x - 0.3 - 0.1 \* t))

# Definir espaço e tempo

x = np.linspace(0, 1, 500)

t\_values = np.linspace(0, 10, 10)

# Criar o gráfico

plt.figure(figsize=(10, 5))

# Plotar diferentes tempos

for i, t in enumerate(t\_values):

color = plt.cm.plasma(i / len(t\_values))

plt.plot(x, wave\_packet(x, t), color=color, alpha=0.6, label=f"t = {t:.2f} s")

# Marcar as fases

plt.axvline(0.25, color="green", linestyle="--", label="Constancy (Wave - Continuous Movement)")

plt.axvline(0.55, color="orange", linestyle="--", label="Inconstancy (Measurement - Wave Collapsing)")

plt.axvline(0.75, color="red", linestyle="--", label="End (Collapse - Particle State)")

# Personalização do gráfico

plt.title("Wave-Particle Duality: Constancy, Inconstancy, and End")

plt.xlabel("Position (m)")

plt.ylabel("Wave Function (Ψ)")

plt.legend(loc="upper right")

plt.grid(True, linestyle="--", alpha=0.6)

# Exibir o gráfico

plt.show()