import numpy as np

import matplotlib.pyplot as plt

from scipy.integrate import trapezoid

grid\_size = 60

timesteps = 90

dt = 0.18

width = 3

r = np.linspace(0, grid\_size, grid\_size)

dr = r[1] - r[0]

# Start closer together and head straight at each other

xL, xR = 15, 45

k = 2.0

ψ1 = np.exp(-((r - xL)\*\*2)/(2\*width\*\*2)) \* np.exp(1j \* k \* r)

ψ2 = np.exp(-((r - xR)\*\*2)/(2\*width\*\*2)) \* np.exp(-1j \* k \* r)

ψ = np.array([ψ1, ψ2])

n = len(ψ)

ψ\_total = []

overlap = []

CoMs = []

for t in range(timesteps):

V = 0

for i in range(n):

lap = np.zeros\_like(ψ[i], dtype=complex)

lap[1:-1] = (ψ[i][2:] - 2\*ψ[i][1:-1] + ψ[i][:-2]) / dr\*\*2

ψ[i] += dt \* (0.8 \* lap)

norm = np.sqrt(trapezoid(np.abs(ψ[i])\*\*2, r))

if norm != 0:

ψ[i] /= norm

ψ\_total.append(np.sum(ψ, axis=0))

ov = trapezoid(np.abs(ψ[0] \* np.conj(ψ[1])), r)

overlap.append(ov)

CoMs.append([trapezoid(r \* np.abs(ψ[i])\*\*2, r)/trapezoid(np.abs(ψ[i])\*\*2, r) for i in range(n)])

ψ\_total = np.array(ψ\_total)

CoMs = np.array(CoMs)

colors = ['royalblue', 'tomato']

fig, axs = plt.subplots(3, 1, figsize=(10,10))

for i in range(n):

axs[0].plot(r, np.abs(ψ[i])\*\*2, label=f'ψ{i+1}', color=colors[i])

axs[0].plot(r, np.abs(ψ\_total[-1])\*\*2, color='black', lw=2, label='Total (Final Interference)')

axs[0].set\_title("Superposition & Interference — MBT, Colliding Wavepackets")

axs[0].legend()

axs[1].plot(np.linspace(0, dt\*timesteps, timesteps), overlap, color='purple')

axs[1].set\_ylabel("Overlap")

axs[1].set\_title("Entanglement / Interference Monitor")

for i in range(n):

axs[2].plot(np.linspace(0, dt\*timesteps, timesteps), CoMs[:, i], label=f'ψ{i+1} CoM', color=colors[i])

axs[2].set\_title("Centers of Mass Evolution (Collision)")

axs[2].set\_xlabel("Time")

axs[2].legend()

plt.tight\_layout()

plt.show()