B.2 Wave-particle duality

Perform the double-slit experiment with three different kinds of objects.

B.2.a Classical Particles

¶1. Define $P_j(x)$ is the probability of a particle arriving at x with just slit x open.
Define $P_{12}(x)$ is the probability of a particle arriving at x with both open.

¶2. We observe $P_{12} = P_1 + P_2$, as expected.

B.2.b Classical Waves

¶1. The energy I of a water wave depends on the square of its height H, which may be positive or negative.

¶2. Hence $I_{12} = H_{12}^2 = (H_1 + H_2)^2 = H_1^2 + 2H_1H_2 + H_2^2 = I_1 + 2H_1H_2 + I_2$.

¶3. The $2H_1H_2$ term may be positive or negative, which leads to constructive and destructive interference.

B.2.c Quantum Particles

¶1. The probability of observing a particle is given by the rule for waves.

¶2. The probability P is given by the square of a complex amplitude A.

¶3. $P_{12} = |A_1 + A_2|^2 = P_1 + \overline{A_1}A_2 + A_1\overline{A_2} + P_2$.

¶4. How does a particle going through one slit "know" whether or not the other slit is open?