

## Reflection delay (adapted from Le Bellac, problem #9.7.6)

(a) Consider the reflection coefficient  $B$  for wave  $e^{ikx}$  incident at a potential step of height  $V_0$ , where  $E = \hbar^2 k^2 / 2m < V_0$ . Show that  $|B| = 1$  so we can write  $B = e^{-i\phi}$  with  $\phi$  a real quantity which you must determine.

(b) Given the incident wave packet

$$\varphi(x, t) = \int \frac{dk}{\sqrt{2\pi}} A(k) e^{i(kx - \omega(k)t)}$$

determine the reflected wave packet and show that the reflection occurs with a delay

$\tau = -\hbar d\phi/dE > 0$ . Interpret your result in terms of motion in the classically forbidden region.