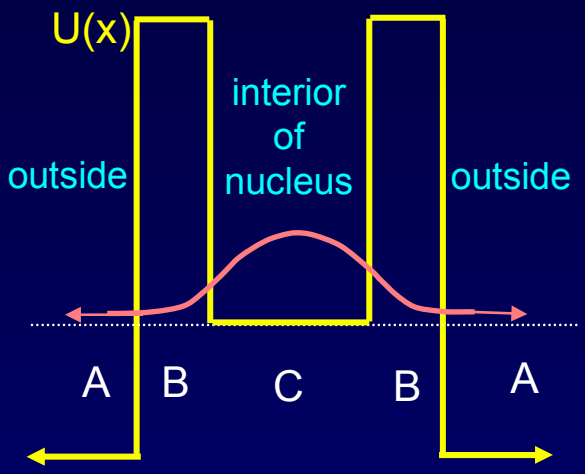
Tunneling and Radioactivity

In large atoms (e.g., Uranium), the nucleus can be unstable to the emission of an alpha particle (a He nucleus). This form of radioactivity is a tunneling process, involving transmission of the alpha particle from a low-energy valley through a barrier to a lower energy outside.



Why do we observe exponential decay?

- ψ leaks out from C through B to A – the particle "tunnels" out.
- The leakage is slow (T << 1), so ψ just outside the barrier stays negligible.
- The shape of ψ remaining in B-C shows almost no change: Its amplitude slowly decreases. That is, P_{inside} is no longer 1.
- The rate at which probability flows out is proportional to P_{inside} (by linearity) $\Rightarrow$ exponential decay in time.

$$\frac{dx}{dt} = -Ax \quad \Rightarrow \quad x = e^{-At} = e^{-t/\tau}$$

$t_{1/2}$ = (τ ln 2) is the "half life" of the substance