*Important examples*

- Nuclear fission.
  - Tunneling prob $\propto$ decay rate per unit time
  - $V$ sensitive to details of the potential and the initial state energy
  - A wide range of half-lives for different unstable nuclei

- $\alpha$-particle emission: think of $\alpha$-particle as initially confined by a nuclear potential.

  - A $\alpha$ particle bounces between potential barriers created by nuclear "shells" for a long time but eventually tunnels through and escapes.

- $\alpha$-particle model $\alpha$-particle tunnelling by directly calculating a consistent solution in the SE.
Important examples

- Nuclear fission.
- Nuclear fusion.
*Important examples

- Nuclear fission.
- Nuclear fusion.
- Muon-catalysed nuclear fusion.

Bohr radius ~ $1/\text{m}_e$
$\text{m}_\mu \sim 207 \text{ m}_e$

Muon has $-\text{ve}$ charge (like electron) but higher mass.

Muon remains much closer below potential barrier than relevant fusion rate is much greater for muonic hydrogen.

Muon catalyzed fusion ($\mu$CF) - principle and motivations

After injection of muons into D/T mixture (or other hydrogen isotopes)
- Formation of muonic atoms and muonic molecules
- In small $d\mu$ molecule, Coulomb barrier shrinks and d-t fusion follows
- Muon released after d-t fusion
  - muon works as catalyst

**History**
- 1947 Hypothesis of $\mu$CF (Frank)
- 1957 observation of $p\mu$ fusion (Alvarez)
- 1966 observation of resonant $d\mu$ formation
- 1967 hypothesis of resonant formation (Vesman)
- 1979-82 observation of large $d\mu$ formation rate
- 1987 observation of x-rays from $(\alpha\mu)^*$(PSI,KEK)
- 1993 large $d\mu$ formation rate in solid
- 1995 study with eV beam of $(\mu\mu)$
- 1996 systematic study starts at RIKEN-RAL

Prob of fusion from hydrogen isotopes is low because the relevant potential scale is $\sim$ Bohr radius of electron orbit.

Alas: muon catalyzed fusion doesn't (quite) give net energy gain.
*Important examples*

- Nuclear fission.
- Nuclear fusion.
- Muon-catalysed nuclear fusion.
- **Scanning tunnelling electron microscopy.** *

$$|T|^2 \approx \exp\left(-\frac{2a}{\hbar} \sqrt{2m(U - E)}\right). \quad (5.39)$$

Scanning tunnelling microscopy image of a carbon nanotube.

(Source of images: Wikipedia)