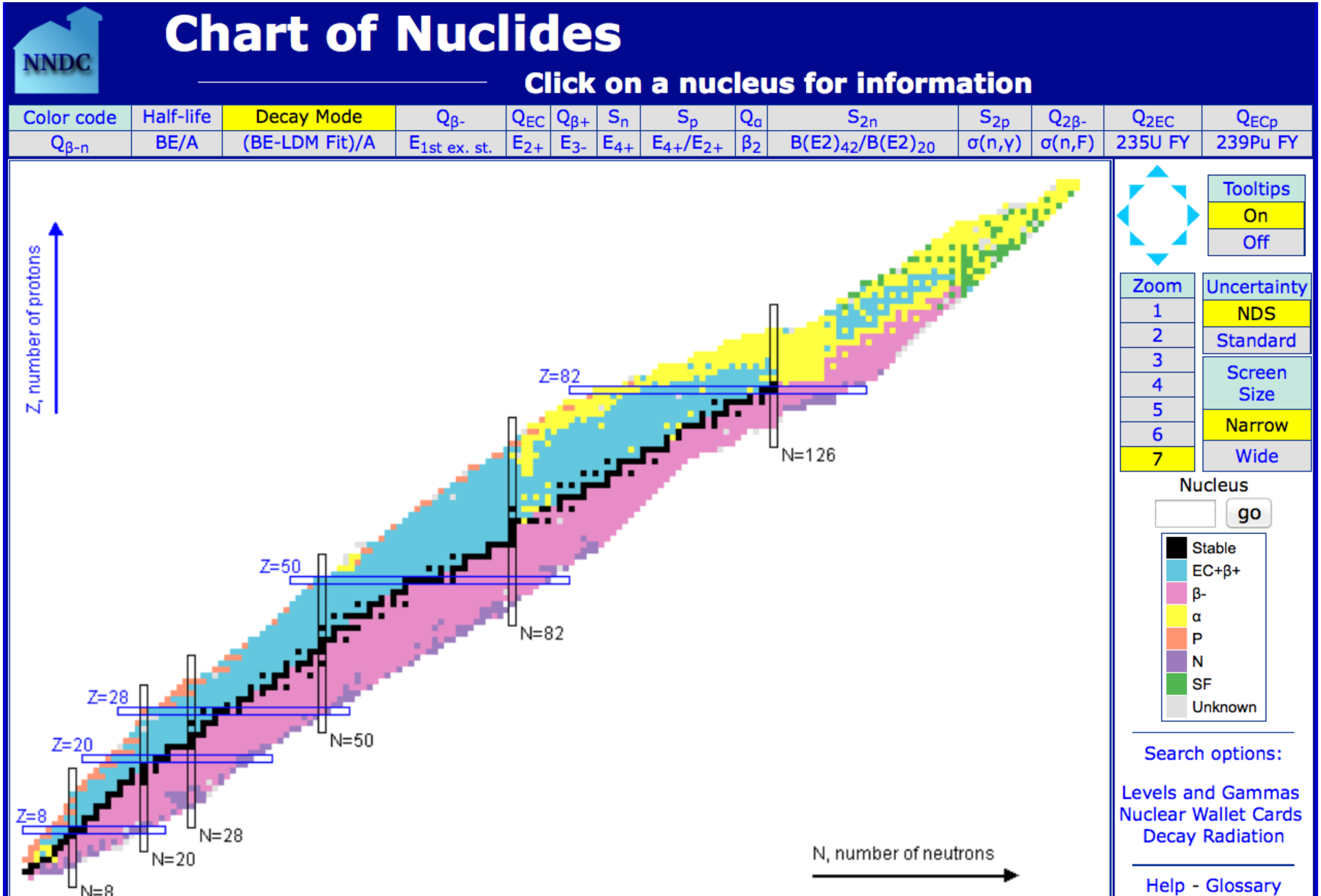
Alpha decay

Alpha Decay



NNDC
Chart of Nuclides
Click on a nucleus for information
Color code
Half-life
Decay Mode
Qβ-
QEC
Qβ+
Sn
Sp
Qα
S2n
S2p
Q2β-
Q2EC
QECp
Qβ-n
BE/A
(BE-LDM Fit)/A
E1st ex. st.
E2+
E3-
E4+
E4+/E2+
β2
B(E2)42/B(E2)20
σ(n,γ)
σ(n,F)
235U FY
239Pu FY
Z, number of protons
Z=8
Z=20
Z=28
Z=50
Z=82
N=8
N=20
N=28
N=50
N=82
N=126
N, number of neutrons
Tooltips
On
Off
Zoom
1
2
3
4
5
6
7
Uncertainty
NDS
Standard
Screen Size
Narrow
Wide
Nucleus
go
Stable
EC+β+
β-
α
P
N
SF
Unknown
Search options:
Levels and Gammas
Nuclear Wallet Cards
Decay Radiation
Help - Glossary

Alpha Decay

Energy relations

$$S_\alpha(A,Z) = -Q_\alpha(A,Z) = B(A,Z) - B(A-4,Z-2) - 28.3\text{MeV}$$

experimental binding energy of ^{4}He

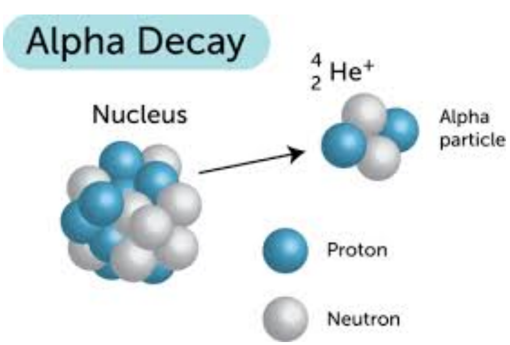
$$Q_\alpha = T_\alpha + T_d =$$

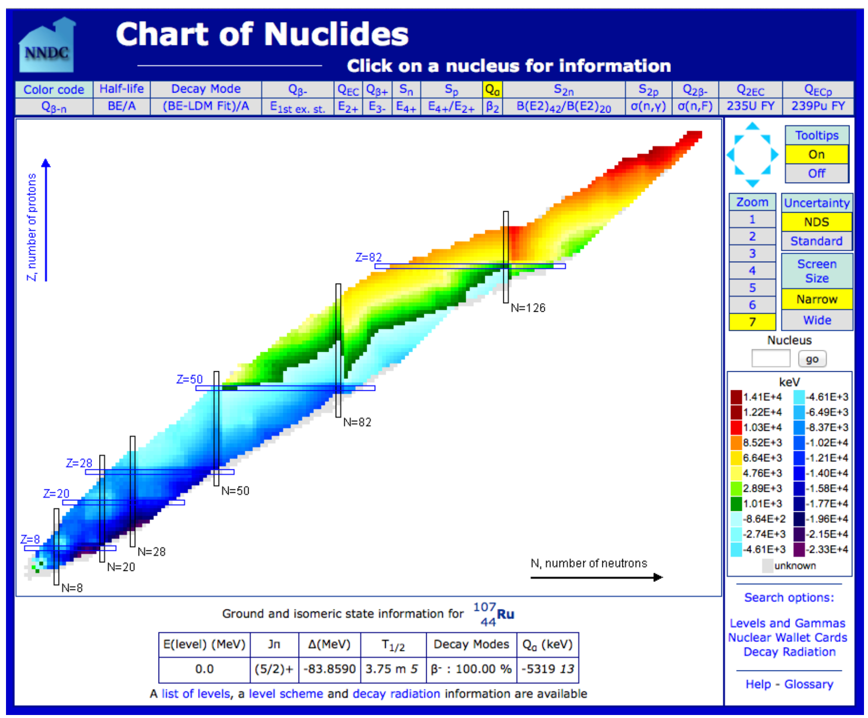
$$T_\alpha\left(\frac{M_D + M_\alpha}{M_D}\right) \approx T_\alpha\left(\frac{A}{A-4}\right)$$

recoil term effect

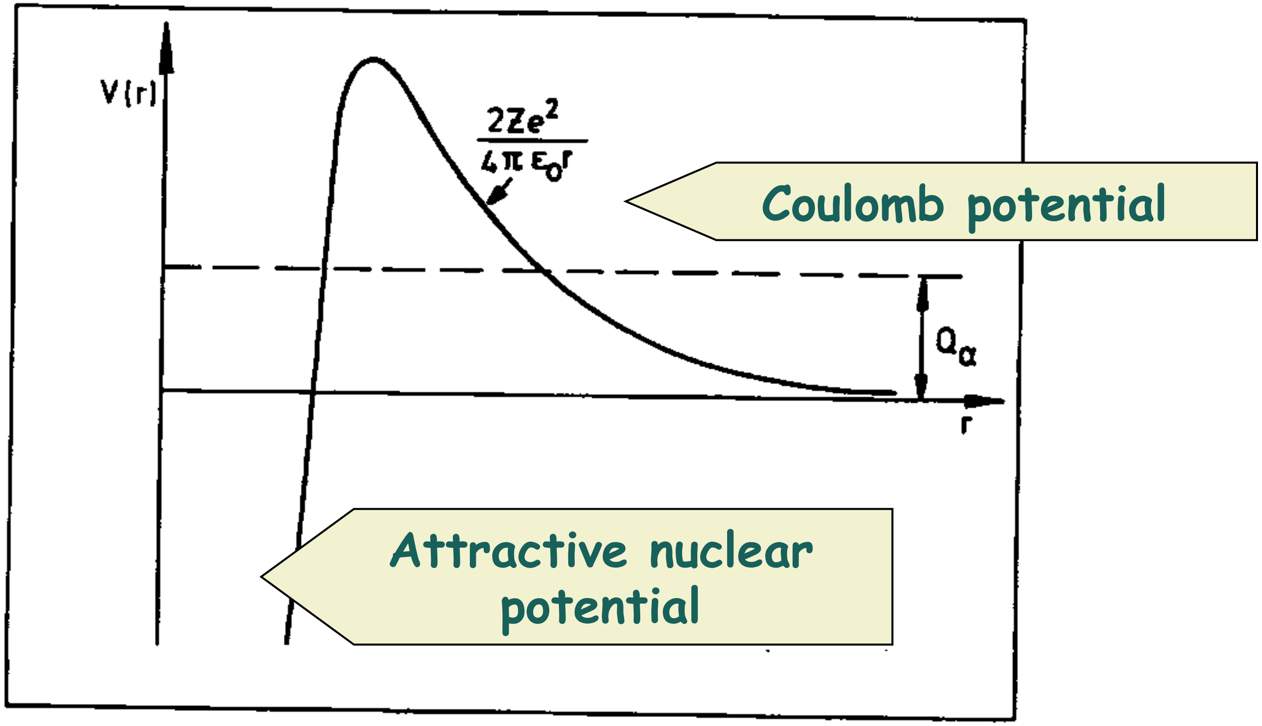
+electron screening
+bremsstrahlung

http://www.nndc.bnl.gov/chart/reColor.jsp?newColor=qa





Theory of Alpha decay: Gamow 1928

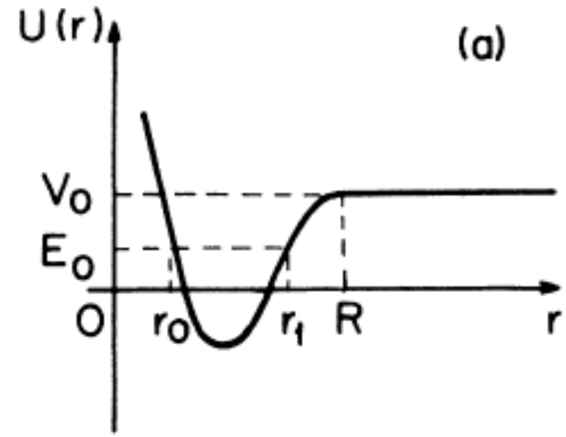


At t=0, alpha particle is localized inside the nucleus. It can be represented by a wave packet. At large times, the wave function is an outgoing wave.

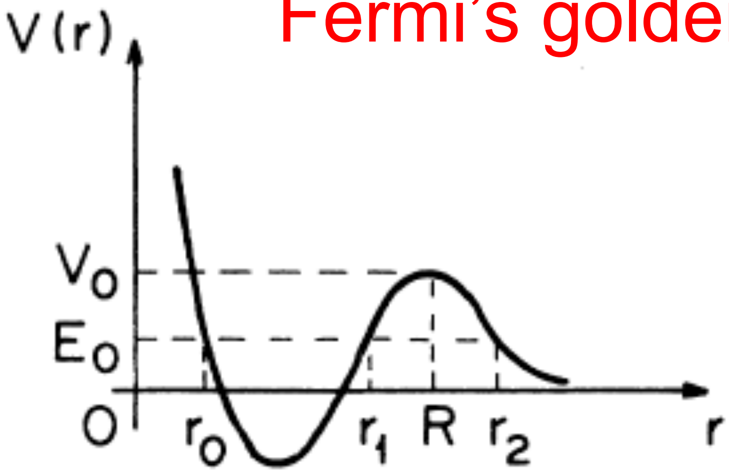
Two potential approach to tunneling

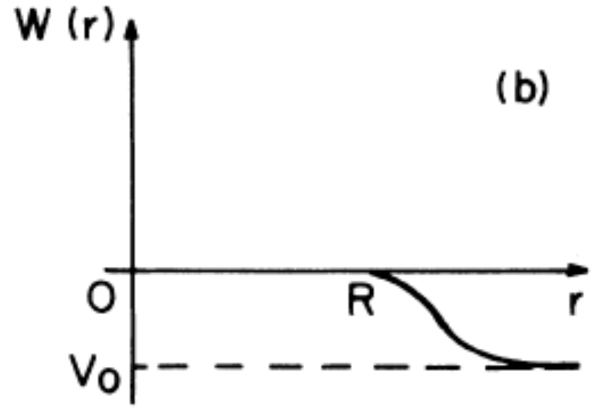
(decay width and shift of an isolated quasistationary state)

Phys. Rev. A 38, 1747 (1988); Phys. Rev. A69, 042705 (2004)



Fermi's golden rule!

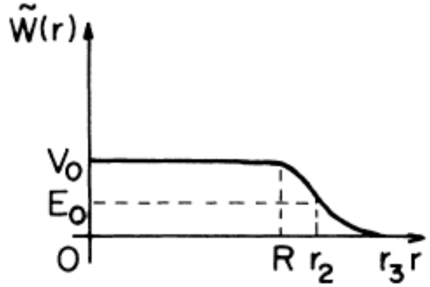


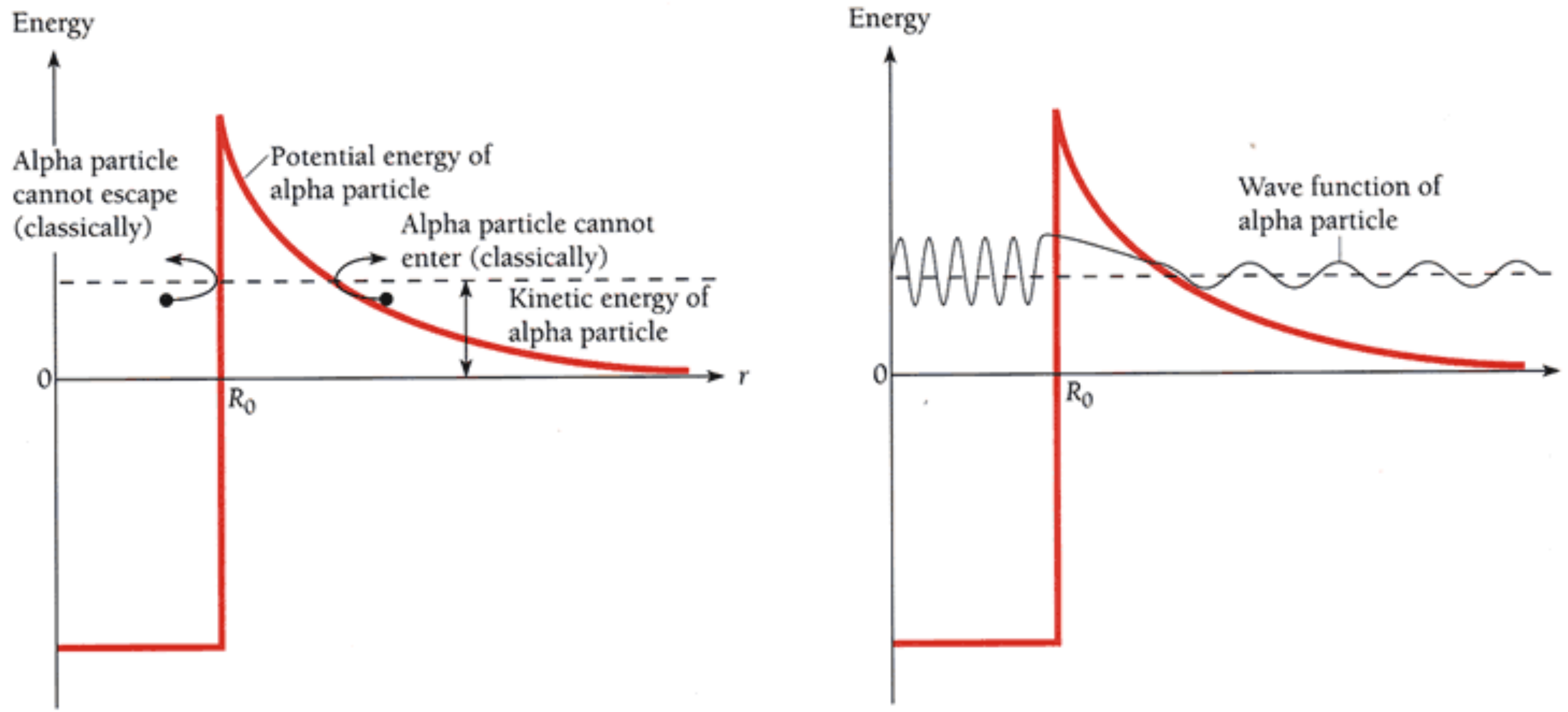


$$V(r) = U(r) + W(r)$$

open closed scattering

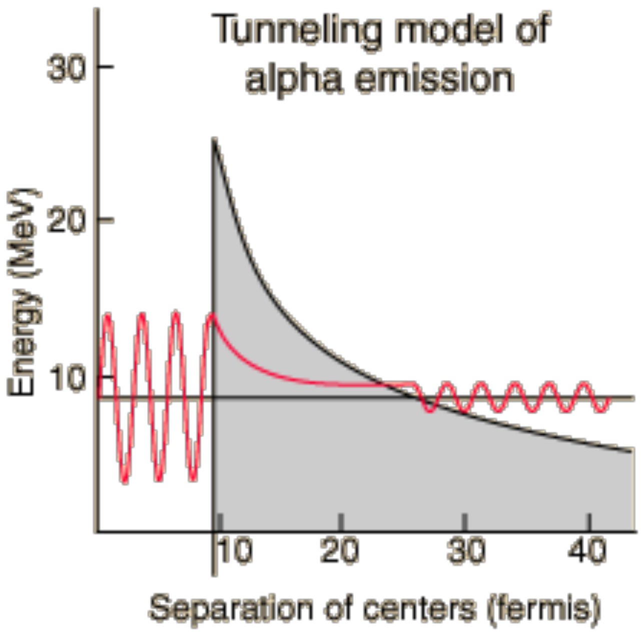
$$\tilde{W} = W + V_0$$





Energy
Alpha particle
cannot escape
(classically)
Potential energy of
alpha particle
Alpha particle cannot
enter (classically)
Kinetic energy of
alpha particle
0
R_0
r
Energy
Wave function of
alpha particle
0
R_0
r

$$P = \frac{|\chi_{III}|^2}{|\chi_I|^2} \propto \exp\left[-2\int_{r_1}^{r_2} k(r)\,dr\right] \qquad T \propto \frac{1}{P}$$



In the case of the Coulomb barrier, the above integral can be evaluated exactly.

$$\log T = a + \frac{b}{\sqrt{Q_\alpha}}$$

Geiger-Nuttall law of alpha decay 1911

For the Coulomb barrier above, derive the Geiger-Nuttal law. Assume that the energy of an alpha particle is $E=Q_\alpha$, and that the outer turning point is much greater than the potential radius.

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