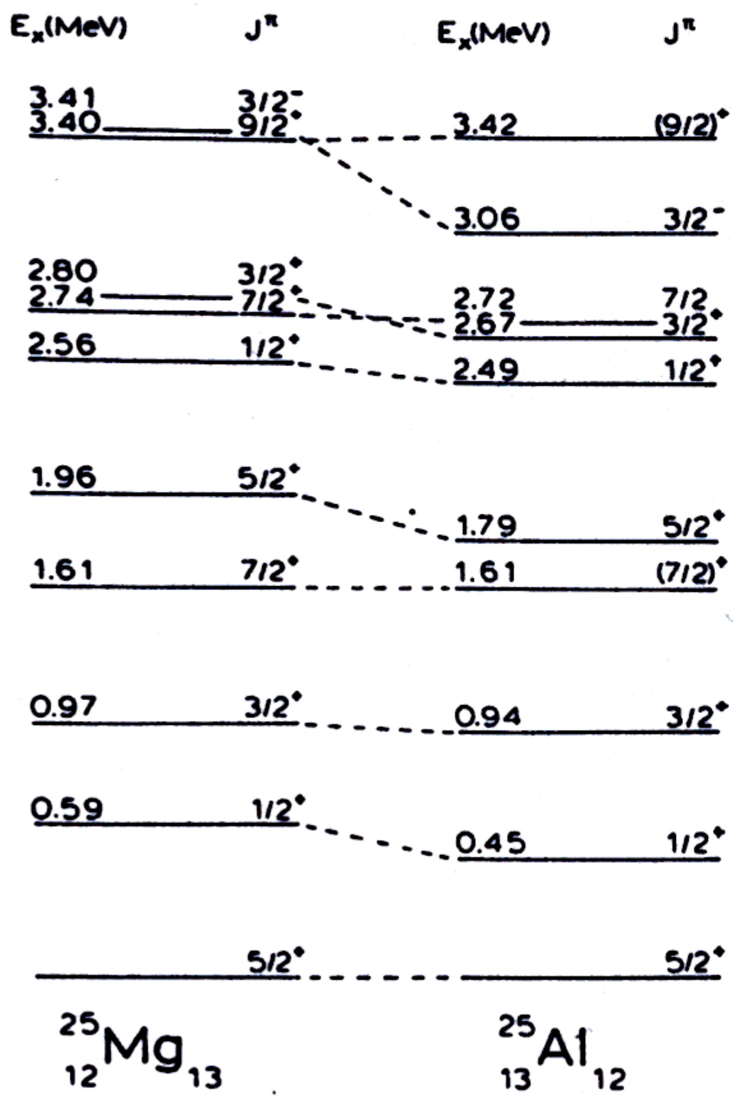
Mirror Nuclei and Charge Symmetry

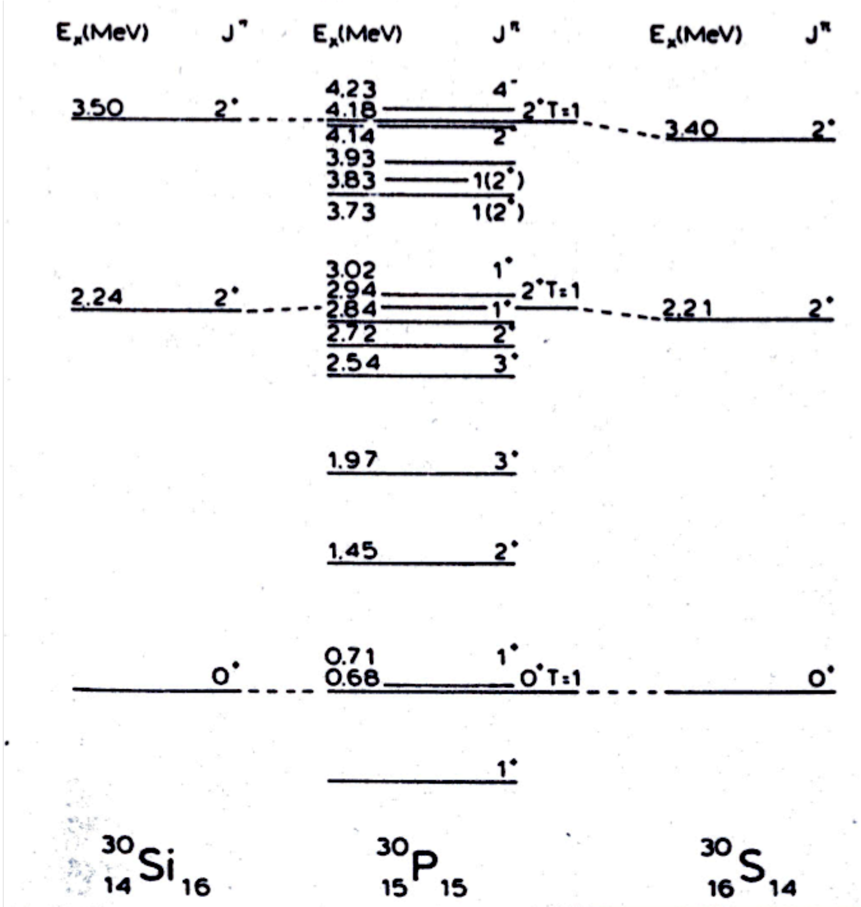


Charge Symmetry and Charge Independence

^{30}Si: n-n pairs 16x15/2=120
p-p pairs 14x13/2=91
Total like pairs = 211
n-p pairs 14x16=224

^{30}P: n-n pairs 15x14/2=105
p-p pairs 15x14/2=105
Total like pairs = 210
n-p pairs 15x15=225

From Si to P, one like-nucleon pair is lost and one unlike-nucleon pair is created.



Intuition

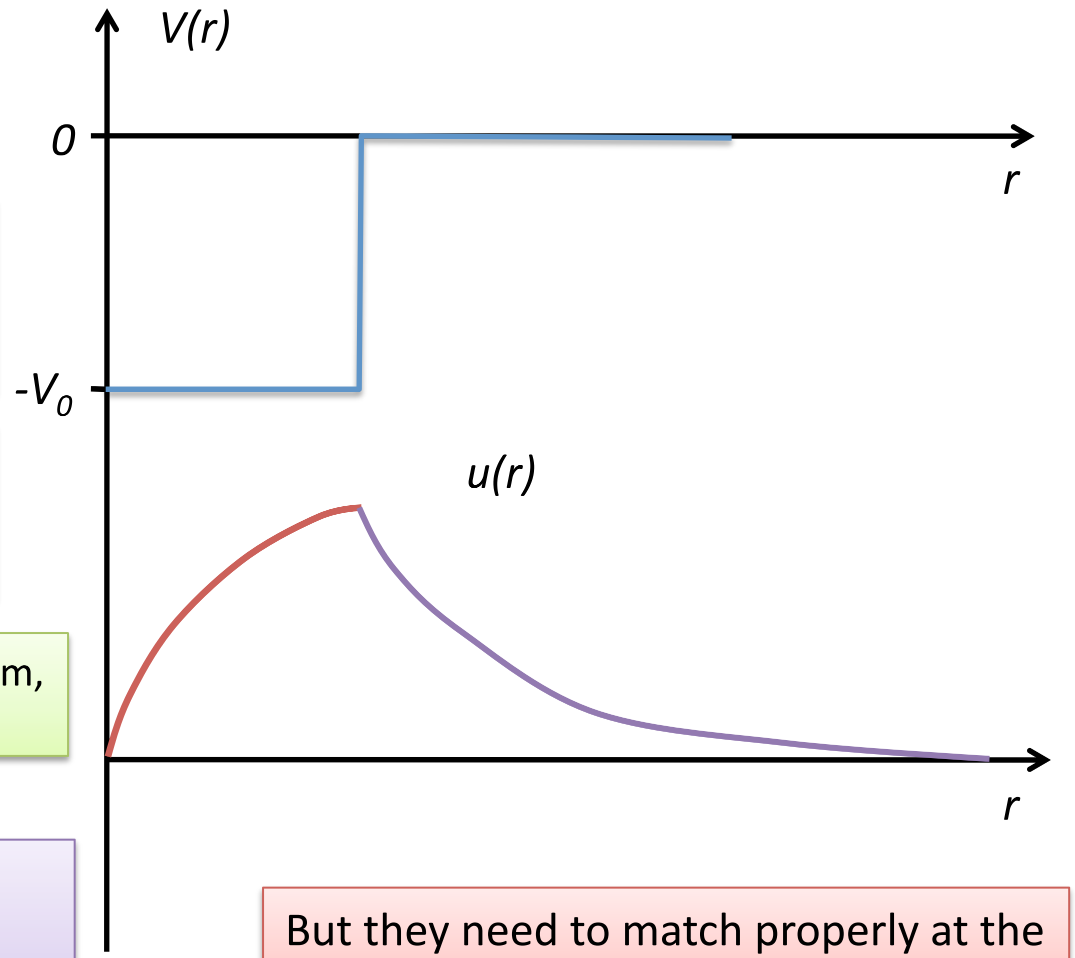
If bound, *E<0*.

So for *r<a*, *V<E* and *V* constant: wave function must be harmonic.

Since radial component is *u(r)/r*, need *u(r)* as a sine wave to stop blow up as *r* tends to zero.

Low energy states have low momentum, so long wave lengths λ=h/p.

So for *r>a*, *V>E* and *V* constant: classically forbidden region, so wave function decaying exponential.



But they need to match properly at the boundary r=a! Both *u(a)* and *du(a)/dr*

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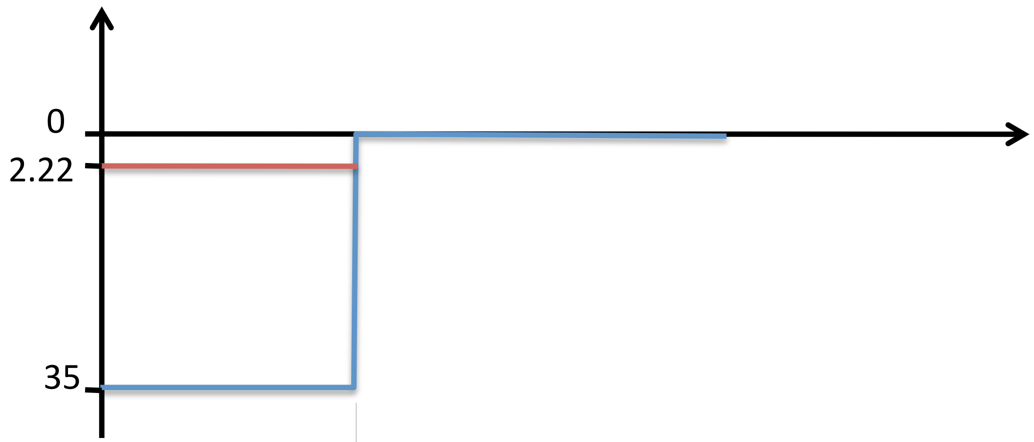
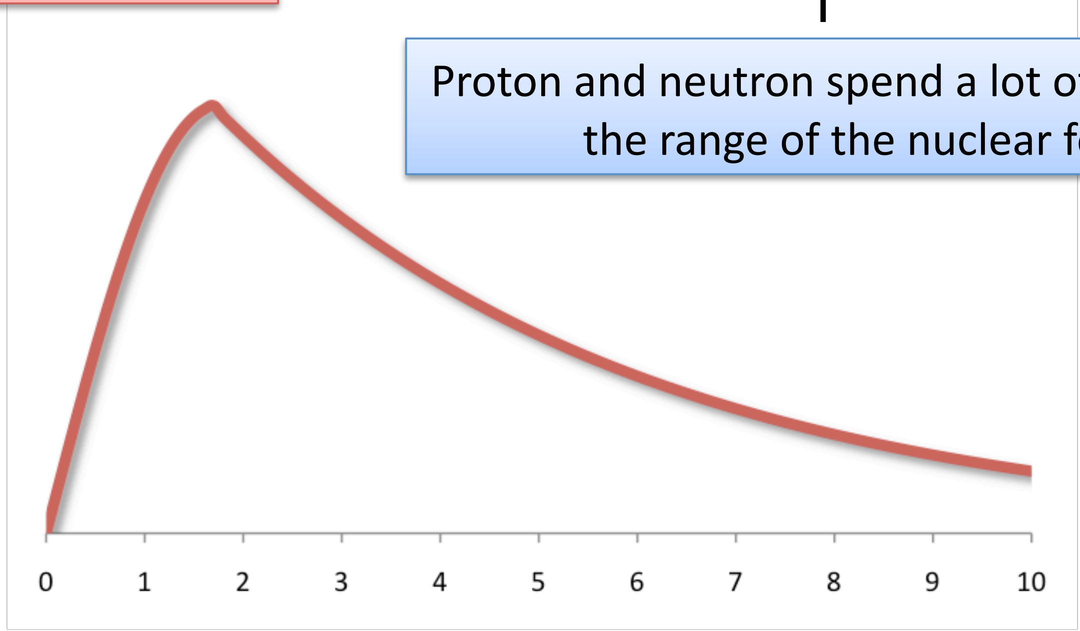
So where does that leave us?

If a is something like the range of nuclear forces 1 to 2 fm, say 1.8 fm…
Then V_0 is 40 MeV.
But E is only 2.22 MeV !



Average kinetic energy is comparable to the depth of the potential.

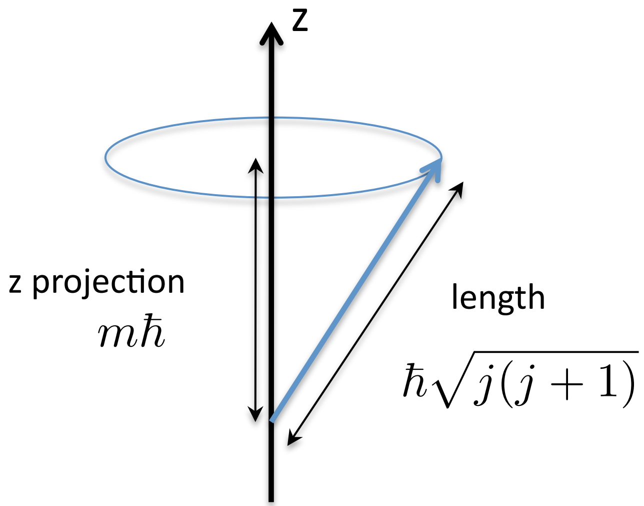
Weakly bound!



Proton and neutron spend a lot of time outside the range of the nuclear forces!

No room for excited states! Addition of the centrifugal term makes well even shallower and narrower…levels with *l>0* move above *E=0* and are unbound!

Reminder about Angular Momentum



$$-j \leq m \leq j \text{ integer steps}$$

Example: spin-1/2