Problem 1

a) Evidences for Shell Model

- 2-proton / 2-neutron separation energy
- ...

b) Look at atomic vs nuclear shell model

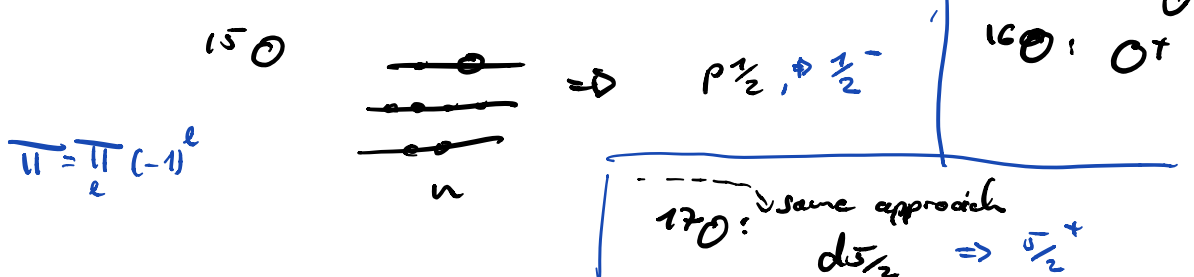atomic: L·s between electron mag. moment & magnetic field by its motion around nucleus ⟶ small shifts

vs **(≪)**

nucleon-nucleon spin-orbit force
⊥ major reorientation of levels

c) 2, 8, 20, 28, 50, 82, 126, 184   (non-deformed case)

d) 0^+

e) for 'ug' ⟹ J^π of the unpaired nucleon

^{15}O

⟹ $p\frac{1}{2}, \diamond \frac{1}{2}^-$

$^{16}O: 0^+$

$\Pi = \prod_\ell \Pi (-1)^\ell$

n

$^{17}O:$ ⤳ same approach
$d\frac{5}{2}$ ⟹ $\frac{5}{2}^+$

f) Coupling of free proton and neutron $\vec{J} = \vec{s_1} + \vec{s_2}$

__Other__ effect not covered:

- coupling of more than 1 valence nucleon
- pair breaking
- collective structure ⟹ big research topic
  in Oslo
  { vibrations and rotations
  "what's the shape of a nucleus

g) see   Mayer - kuck uck

Deuteron and the nuclear force

a) __p-n__ bound state, but not p-p, or n-n

⟹ nuclear force is spin dependent, and on
whether spins are parallel (↑↑) or
antiparallel (↑↓)   (or triplett!)

↳ bound with $l=0$ ⟹ special of symmetrial
under exchange

As the force is believed to be charge
independent, n-n and n-p would have
same lowest level, $l=0$

But for n-n, and p-p, as fermions, they need
to have diff. quantum numbers ⟹ ↑↓

vs p-n that can be in the tripplet "↑↑" ...

b) Expected values for I ; $I^{\pi}_{\text{obs}} = 0^+$, 96%

2% 4%.

$I = S_n + S_p + \ell$

so triplett: $I = 1$, singlet $= I = 0$
"↑↑" "↑↓"
(..1)

	ℓ
↑↑	0
↑↓	1 ⎫
↑↑	1 ⎬ not possible, as $\pi_{\text{obs}} = +$, and
↑↑	2	$\pi = \pi (-1)^{\ell}$

c) $g_{sn} = -3.82$ $g_{sp} = 5.58$
$\downarrow_{spin}$

non-zero: inner structure

d) $\mu_{\text{Deut}} \neq \mu(\ell=0)$

$\mu_{\text{Deut}} = a_s^2 \mu(\ell=0) + a_d^2 \mu(\ell=2)$ ⟹ mixed wave fk., not a pure state

e)

very short repulsive

$\to$ 0

$) r$

attractive

$V_{S_1 \cdot S_2}$
↓
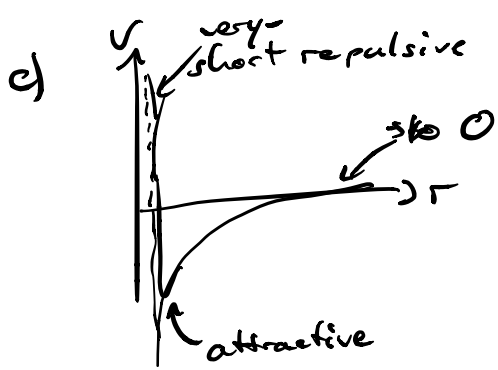
tensor
∫ force
√

f) $V^{\text{eff}}_{\text{nucl}} = V_{\text{central}} + V_{\text{spin}} + V_{(S_1 \cdot r)(S_2 \cdot r)} + \left(V_{\text{rep}} ? \right)$

ℓ, spin dep
(↑↑ or ↑↓)