Deuteron

Spin and parity of deuteron

- The total angular momentum I of the deuteron should have three components:

  1. Sn - Spin of neutron
  2. Sp - spin of proton
  3. l - orbital angular momentum

- $I = Sn + Sp + l$

- The measured spin of the deuteron is I = 1 (experimentally)
- Since the neutron and proton spins can be either parallel (for a total spin 1) or antiparallel (for a total of zero)
- There are four ways to couple Sn, Sp, and l to get a total I of 1:

Spin and parity of deuteron

1. Sn and Sp parallel with $l = 0$
2. Sn and Sp antiparallel with $l = 1$
3. Sn and Sp antiparallel with $l = 1$
4. Sn and Sp parallel with $l = 2$

Spin and parity of deuteron

- Another property of the deuteron that we can determine is its parity (even or odd)
- Under parity operation deuteron wave function remains the same : hence **parity is even** (theoretically)

- Relation connecting parity and orbital angular momentum

  parity associated with orbital motion is $(-1)^{l}$

  even parity for $l = 0$ (s states) and $l = 2$ (d states) and odd parity for $l = 1$ (p states).
- The observed even parity allows us to eliminate the combinations of spins that include $l = 1$, leaving $l = 0$ and $l = 2$ as possibilities.
- The spin and parity of the deuteron are therefore consistent with $l = 0$ as we assumed
- But of course we cannot yet exclude the possibility of $l = 2$.

Magnetic dipole moment

- we discuss the spin and orbital contributions to the magnetic dipole moment
- If the $l = 0$ assumption is correct, there should be no orbital contribution to the magnetic moment
- we can assume the total magnetic moment to be simply the combination of the neutron and proton magnetic moments

$$\boldsymbol{\mu} = \boldsymbol{\mu}_n + \boldsymbol{\mu}_p$$
$$= \frac{g_{sn}\mu_N}{\hbar}\mathbf{s}_n + \frac{g_{sp}\mu_N}{\hbar}\mathbf{s}_p$$

$g_{sn} = -3.826084$ and $g_{sp} = 5.585691$

Magnetic dipole moment

the observed magnetic moment to be the z component of μ when the spins have their maximum value $(+\frac{1}{2}\hbar)$:

$$\mu = \tfrac{1}{2}\mu_N(g_{sn} + g_{sp}) = 0.879804\ \mu_N \tag{4.8}$$

The observed value is $0.8574376 \pm 0.0000004\ \mu_N$, in good but not quite exact

Magnetic dipole moment and electric quadrupole moment

- Magnetic dipole moment of deuteron is due to

  1. the spin of neutron and proton in it

  2. the relative orbital angular momentum (*l*) of the nucleons.

- Experimental observation indicate thet deuteron wave function is mostly (96%) $l = 0$ with a small admixture (4%) of $l = 0$.

- Electric quadrupole moment measurement shows Q = 0.00288 e * 10^(-24) cm^2