

Nuclear and Particle Physics - Problem Set 8 - Solution

Problem 1)

Atomic Percent Abundance: 0.015% of all Hydrogen

Natural occurrence: Sea water

Z, N, A = 1, 1, 2

Mass: $2.0141018 \text{ amu} = 1876.12 \text{ MeV}/c^2$ (Mass excess 13.136 MeV over 1/6 ^{12}C mass)

Binding energy: $2224.573 \pm 0.002 \text{ keV}$

Radius: 2.13 fm (charge radius); average p-n distance is 1.96 fm

Spin: 1

Parity: +

Total Isospin: $I = 0$

Magnetic moment: $0.85744 \mu_N$

Quadrupole moment: 0.003 b (0.29 e fm^2)

Excited states: None bound

Problem 2)

There are no other bound 2-nucleon states (nuclei with $A = 2$). One could think that in the case of a bound two-proton state, this is prohibited by their mutual Coulomb repulsion, but for two neutrons, this shouldn't be a problem (until one of them decays). Instead, it is the Pauli principle combined with the fact that the strong force prefers aligned spins. The fact that there is no $J=0$ bound state of a proton and a neutron (an excited deuteron) shows that the latter is the case; however, for 2 equal particles (nn or pp) and an $L=0$ symmetric ground state, it would be impossible to have aligned spins.