

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 amu = 1876.12 MeV/c<sup>2</sup> (Mass excess 13.136 MeV over 1/6 <sup>12</sup>C mass)

Binding energy: 2224.573 +- 0.002 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<sup>2</sup>)

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.