

Massachusetts Institute of Technology

Department of Physics

Course: 8.701 – Introduction to Nuclear and Particle Physics
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Discussion Problems

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Problem 1: Stable or not

Consider the isotope Curium-250 ($^{250}_{96}\text{Cm}$), with mass 232.938 GeV. Given its A and Z numbers, do you expect this isotope to be stable?

- The ratio of the mass and proton number is $Z/A \approx 0.384$. We know that for heavy stable nuclei this ratio is instead ≈ 0.41 ($Z \approx A/2$ only for light nuclides). Thus we expect this isotope to be unstable and to decay by a process that will make it shed some neutrons or acquire smaller A. Curium-250 is the lightest nuclide to undergo spontaneous fission as the main decay mode.

Problem 2: Deuterium

If the nuclear force is charge independent and a neutron and a proton form a bound state, then why is there no bound state of two neutrons or two protons? What information does this provide for the nucleon-nucleon force?

- A system of a neutron and a proton can form either a singlet or a triplet spin state. The bound state is the triplet state because the energy level of the singlet state is higher. A system of two neutrons which are in the same energy level can form only a singlet spin state and no bound state is possible. This shows the spin dependence of the nuclear force.

Problem 3: Nuclear Shell Model

Discuss briefly the main experimental finding which led to the shell model description for nuclear states. Give examples of nuclei which correspond to closed shells and indicate which shells are closed.

- The existence of magic numbers 2, 8, 20, 28, 50, 82, and 126.

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