

Nuclear Physics in 60 Seconds

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Notation: An atomic nucleus is the small, dense core of an atom, consisting of a collection of protons and neutrons. The number of protons contained within a given nucleus is given by the atomic number, Z , while the number of neutrons is given by N . The mass number, A , is the sum of the number of neutrons and protons. A neutral atom, X , is typically written with the A and Z numbers prepended, i.e., A_ZX , with the neutron number implicit.

Mass: Masses on the nuclear scale are typically expressed in units of *atomic mass units* (u), defined so that the mass of a neutron atom of ${}^{12}_6C$ is exactly 12 u.

Quantum Description: A common and quite accurate quantum description of the nucleus is given by the *shell model*, which is analogous to the description of atomic electrons. Neutrons, protons and electrons are all classified as *fermions*, which are particles with a spin of $\frac{1}{2}\hbar$ that obey the Pauli exclusion principle. Neutrons and protons in a nucleus reside in discrete energy states and possess angular momentum that also occurs in discrete amounts. The angular momentum is specified by the positive, integer quantum number $\ell \geq 0$, and the first few angular momentum states are labeled *s*, *p*, *d*, *f*, etc, again in analogy to atomic electrons. The *ground state* of a nucleus occurs when all of the nuclear particles are in the lowest energy states allowed by the Pauli exclusion principle. An *excited state* occurs when a nucleon is elevated to a higher (and unstable) energy level.