Nuclear Models

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- A model is not the reality. It frequently works by simplification and/or by transferring ideas from one (usually older) part of physics to another one. It explains certain aspects of reality and may allow predictions.
- When you hear the word 'proton' you probably think about something very small but otherwise rather like a billiard ball. You might even imagine it in a particular colour (for me personally protons are red, neutrons black and electrons blue). By extension a nucleus is kind of a spherical lump of little billiard balls.
- Of course that's nonsense. A proton is a quantummechanical object that can be represented by a wavefunction. Actually, that's a model as well.
- We will study three nuclear models: the liquid drop model, the Fermi-gas model and the shell model. Later, when we look at electron-scattering we will see that regarding the nucleus as a little ball is not always complete nonsense.

Binding Energy in Liquid Drop Model

- Solid matter, i.e. a crystal, is not a good model for nuclear matter, because it would not explain any of the properties of a nucleus. Treating the nucleus as a drop of liquid matter with constant density allows to explain the observed binding energies (but only those).
- The semi-empirical mass formula, first introduced in 1935 by Weizsäcker (therefore also Weizsäcker-formula), can be written as

$$M(A, Z) = Nm_n + Zm_p + Zme - B(A, Z)$$

  where $B(A, Z)$ is the binding energy.
- The binding energy can be parameterised using five terms:

$$B(A, Z) = a_v A - a_s A^{2/3} - a_c \frac{Z^2}{A^{1/3}} + a_a \frac{(N - Z)^2}{4A} + \frac{\delta}{A^{1/2}}$$