Physics with neutrons 1

Michael Leitner, michael.leitner@frm2.tum.de
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Exercise sheet 3
To be discussed 2016-11-11, room C.3202

Franz Haslbeck, franz.haslbeck@frm2.tum.de

Exercise 3.1

Given is a sample consisting of one isotope A with the properties given in Fig. 1. The exponential decay constants are $\lambda_B = 4 \cdot 10^{-6}\,\frac{1}{\mathrm{s}}$ and $\lambda_C = 2 \cdot 10^{-4}\,\frac{1}{\mathrm{s}}$. The sample has a density $\rho = 5\,\frac{\mathrm{g}}{\mathrm{cm}^3}$ and a mass $m = 10\,\mathrm{g}$. The isotope A has an atomic mass $m_A = 74\,\mathrm{u}$, a total neutron cross section of $\sigma = \sigma_{abs} + \sigma_{scattering} = 10\,\mathrm{barn}$ and an absorption cross section $\sigma_{abs} = 7\,\mathrm{barn}$. A thermal neutron beam with a flux of $I_0 = 10^8\,\frac{\mathrm{neutrons}}{s}$ hits the cubic sample.

1. Calculate the production rate R of the nuclei B. Note that the neutron beam is inhomogeneous throughout the sample due to absorption and scattering. Make the assumption that a neutron interacts with the sample only once or not at all.
2. The nuclei B decay via a β^- decay into the excited nuclei state C^* with decay rate λ_B. Calculate $N_B(t)$, the number of nuclei B, as function of time t.
3. After seven days the sample is removed from the beam. Calculate the activity directly after removing the sample.
4. Can you imagine a scenario where the radioactivity of a sample increases even further after stopping exposing it to neutrons?

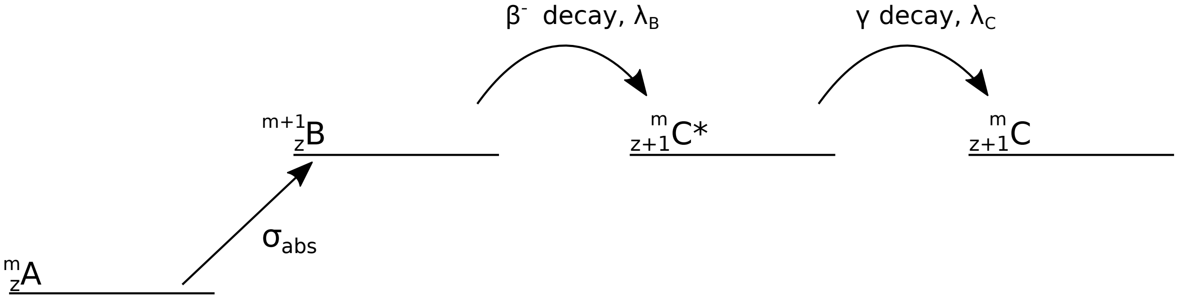

Figure 1