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Exercise Sheet 3

Task 3.1: Deformed nucleus

For a deformed nucleus with a surface given by the multipole expansion with coefficients $\alpha_{\ell m}$, calculate:

1. The nuclear volume in second order of $\alpha_{\lambda\mu}$. How can we ensure that it is unnafected by deformations from a sphere?
2. The center of mass vector in first order of $\alpha_{\lambda\mu}$. What is the physical interpretation?

Task 3.2: Uranium nucleus

In Cartesian coordinates, the radius of a uranium-238 nucleus with a quadrupole deformation is given by

$$R(x,y,z)=R_0\Big(1+\sum_{i,j\in\{x,y,z\}}\alpha_{ij}x_ix_j\Big) \tag{1}$$

where

$$\alpha_{ij}=\begin{pmatrix} 0.0974076 & -0.03602963 & 0.08174144 \\ -0.03602963 & -0.06457203 & -0.01736175 \\ 0.08174144 & -0.01736175 & -0.03283557 \end{pmatrix}_{ij}. \tag{2}$$

1. Calculate the eigenvalues of this matrix. What do they tell you about the symmetries of the nucleus?
2. Calculate the deformation parameters a_0 and a_2. Make sure to choose your major axes such that you exploit any symmetries.
3. Measuring these deformation parameters is not trivial, since the body-fixed frame is not usually accessible in experiment. Read the first 3 pages of this Nature paper [?] (also accessible in the OLAT) and summarize: what are the differences between high and low-energy collisions, when it comes to measuring the excitations of ^{238}U? How can we understand the effect that the nuclear shape has on the observables v_2 and δp_T?