Due Date: 10-22-08

Nuclear Physics 621

Homework 5 – Fission

Send your answer to:
Nicolas Schunck,
schuncknf@ornl.gov

In spherical nuclei, the Liquid Drop (LD) binding energy expression, in its simplest form, reads:

$$E_{LD} = a_{vol}A - a_{surf}A^{2/3} - a_{sym}\frac{(N-Z)^2}{A} - a_{Coul}\frac{Z^2}{A^{1/3}}$$

(see lecture notes on nuclear masses). In deformed nuclei, the surface and Coulomb terms are modified by the factors $B_s(def)$ and $B_c(def)$ respectively (see lecture notes on fission).

The nuclear surface is often modeled by the multipole expansion (see lecture notes on nuclear shapes). The radius of a point on the surface is given by:

$$R(\theta,\varphi) = R_0 c(\alpha)\left[1 + \sum_{\lambda=2}^{\infty}\sum_{\mu=-\lambda}^{+\lambda}\alpha_{\lambda\mu}Y_{\lambda\mu}(\theta,\varphi)\right]$$

Assuming only axial quadrupole deformations (λ=2, μ=0), the deformation factors of B_s and B_c are given (in the lowest order) by:

$$B_s(\alpha_{20}) = 1 + \frac{1}{2\pi}\alpha_{20}^2 \qquad B_c(\alpha_{20}) = 1 - \frac{1}{4\pi}\alpha_{20}^2$$

Compute and plot the deformation energy, i.e. the difference between the binding energy of the deformed drop and the spherical binding energy, as function of α_{20} between 0 and 0.8, for various Z and N values around Z=126 and N=184 (use the values of a_{vol}, a_{surf}, a_{sym} and a_{Coul} given in the class).

Discuss your results.

The nucleus Z = 126 and N = 184 is often cited as the next spherical “doubly-magic” nucleus. Is its LD energy stable to fission ?