University of Tsukuba | Center for Computational Sciences

Computational Nuclear Physics

Nuclear shapes

Nuclei are tiny quantum objects, but have a variety of shapes. Using the density functional theory, we can calculate and predict the density distribution of protons and neutrons for each nucleus. The figure shows deformed nuclei in the nuclear chart with different types of shape, such as prolate (a), oblate (b), triaxial (c), and octupole (d).

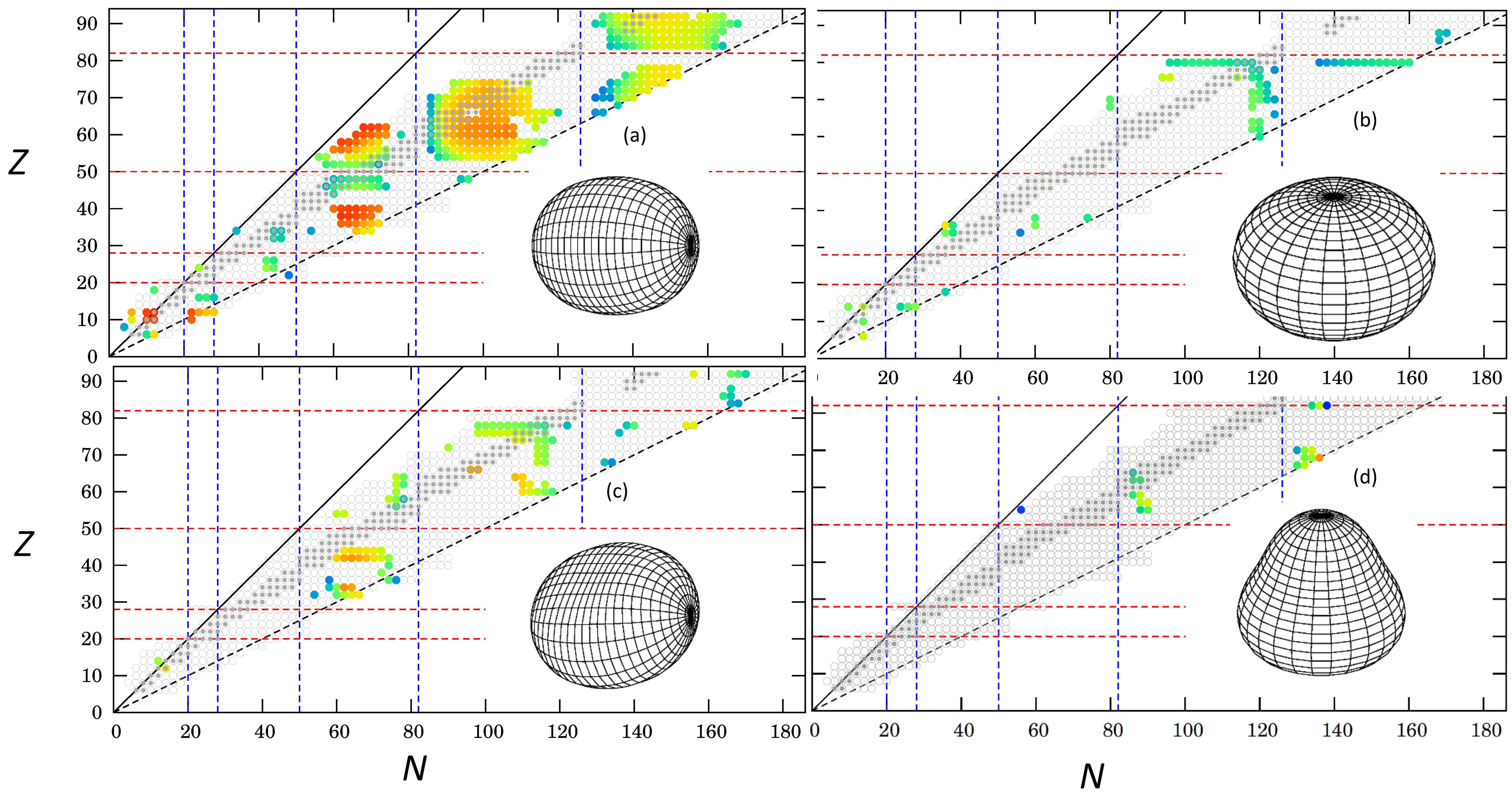

Fig. 1: Calculated shapes of nuclei. Color indicates the size of deformation (red: largest, blue: smallest).

Asymmetric fission of actinide nuclei

Special numbers of neutrons and/or protons, known as "magic numbers" (e.g., 50 and 82), provide extra binding energy to nuclei. Thus, for fission products, we naively expect that fragments with these magic numbers of nucleons are strongly populated. However, the observed fragment distribution is peaked around different numbers (Z=54 and N=84).

To understand this unexpected deviation, the fission phenomena are simulated on computers using the Time-Dependent Density-Functional Theory (TDDFT). It turns out that the extra binding associated with octupole (pear-shaped) deformation in the course of fission is responsible for these strange numbers. This finding may also explain surprising observations of asymmetric fission of light nuclei.

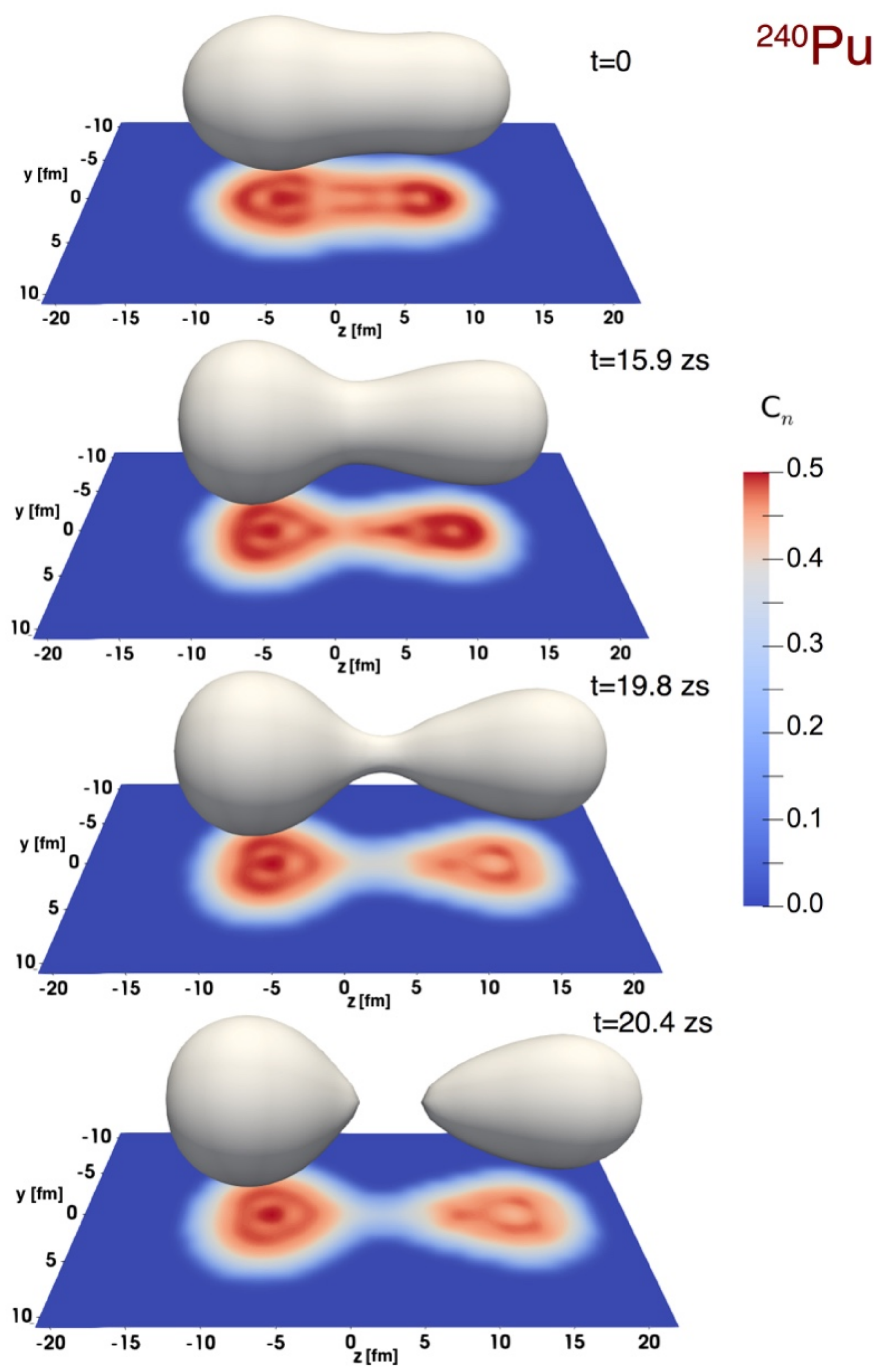

Fig. 2: TDDFT simulation of the fission of the ^{240}Pu as a function of time. The projections show the nucleon localization function that reveals the shell structure (extra binding) effect of the fragments. The unit of time is zeptosecond (zs) which is equal to 10^{-21} s.

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