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Séminaire de Physique Nucléaire Théorique

Role of octupole deformed shell effects on the fission of actinides and in the mercury region.

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Nuclear fission of heavy (actinide) nuclei results predominantly in asymmetric mass-splits. Without quantum shells, which can give extra binding energy to these mass-asymmetric shapes, the nuclei would fission symmetrically. The strongest shell effects are in spherical nuclei, so naturally, the spherical "doubly-magic" ^{132}Sn nucleus, was expected to play a major role.

However, systematic studies of fission have shown that the heavy fragments are distributed around Z=52 to 56, indicating that ^{132}Sn is not the only driver. Reconciling the strong spherical shell effects at Z=50 with the different Z values of fission fragments observed in nature has been a longstanding puzzle. Here, we show that the final mass asymmetry of the fragments is determined by the extra stability of octupole (pear-shaped) deformations which have been recently found experimentally around ^{144}Ba (Z=56), one of the very few nuclei with shell-stabilized octupole deformation. Using a modern quantum many-body model of superfluid fission dynamics, we found that heavy fission fragments are produced predominantly with 52-56 protons, associated with significant octupole deformation acquired on the way to fission. These octupole shapes favouring asymmetric fission are induced by deformed shells at Z=52 and 56 [1]. In contrast, spherical "magic" nuclei are very resistant to octupole deformation, which hinders their production as fission fragments. These findings also explain surprising recent observations of asymmetric fission of lighter than lead nuclei.

[1] G. Scamps and C. Simenel, Nature 564, 382-385 (2018).

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