Gamma spectroscopy of the fission products with Gas-Filled Magnet

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Fundamental nuclear physics its applications in reactor physics and astrophysics require accurate fission data as well as information on the nuclear structure of the exotic nuclei. The measurement of fission observables from a variety of fissile systems is also crucial for the theoretical modeling. Moreover, the study of neutron-rich nuclei produced in such reactions is important for applications in astrophysics such as r-process.

From decades the studies of the structures of neutron-rich nuclei are conducted via γ-ray spectroscopy of products following the spontaneous fission. It allows to investigation the nuclear properties of about hundreds of nuclei in the specific mass range. Efficient arrays of HPGe detectors, such as GAMMASPHERE [1], allow high fold γ-ray coincidences analysis. However, only the ^{252}Cf and ^{248}Cm fission sources are available for such measurements. In order to extend the number of accessible nuclei, one can produce very neutron-rich nuclei using the induced fission process. About ten different fissile targets are available to perform such experiments with cold or/and thermal neutron beam leading to the slightly different product distribution than in spontaneous fission. This kind of measurements have been recently performed at Institut Laue-Langevin (ILL) during the EXILL campaign [2], where intense continuous neutron beam is produced by the reactor. Complementary experiments have taken places at IPN Orsay. In this case fast neutrons from LICORNE [3] have been employed in the ^{238}U(n,f) and ^{232}Th(n,f) reactions producing even more “exotic” fragments during the campaign named ν-ball.

The detailed study of the fission products requires at least triple gamma coincidences relation what implies that only nuclei with the yield of the order 10^{-2} per fission or higher can be accessible. An additional information in the mass of one of the fragments would significantly improve the possibilities to identify new γ-rays. Therefore, the concept to couple the high efficiency Ge array with Gas-Filled Magnet (GFM) [4] will be presented. A design of the combined setup being develop at ILL. During the fission process, two fragments are emitted back to back. The first one will be stopped in the target backing allowing a Doppler-free prompt gamma spectroscopy using the Ge detectors array. The second fragment will fly to the magnet spectrometer allowing very selective delayed gamma spectroscopy of the isomeric decay as well as daughter nucleus after beta emission.

In order to access to the more exotic nuclei we propose to employ this setup with the proton induced fission experiments. Intense proton beam in a wide energy range available at CCB gives the possibility to exploit various targets which is associated with different product distributions. For example in the ^{232}Th(p,f) reaction, poorly exploited region of north-east of doubly magic ^{78}Ni can be reached. Moreover, the unique concept of the Gas-Filled Magnet makes this setup fully moveable, therefore, possible to employ also at HIL where the mechanism of the heavy ion induced fission reaction can be studied.

Bibliography

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