Investigations of magnetic moments and spin alignment in Coulomb fission reaction

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As one of the most accurate probes of the nuclear wave-functions, the magnetic moments of excited states in nuclei are both important and interesting. Their measurement has several difficulties and particularities. One of the most crucial ones is the spin alignment of the nuclear ensemble which is produced in the reaction populating the nucleus of interest. In such an experiment we have investigated the Coulomb fission reaction, which was not previously studied, aiming to probe the nuclear alignment trough the measurement of magnetic moments.

Nuclei around ^{132}Sn form a key region of the nuclear chart from astrophysics and nuclear structure point of view. In particular, below ^{132}Sn, several isomeric structures emerge as for example in the ^{124,125}Ag isotopes, which have interesting behaviour of the three proton holes below $Z = 50$ closed-shell coupled to even or odd amount of neutron holes from predominantly the last three $\nu h_{11/2}$, $d_{3/2}$ and $s_{1/2}$ neutron orbitals below $N = 82$.[1] Measuring nuclear moments of such excited isomeric states allows to find what type of configurations are formed in these nuclei, and at the same time, investigate unknown properties of the fission reaction mechanism.

The experiment was carried out in December 2019 at the RIBF using the BigRIPS spectrometer. Primary ^{238}U beam with an energy of 345 MeV/nucleon and an intensity of the order of 100 pnA was used to induce Coulomb fission onto a thin ^{184}W production target. This very thin foil of only 0.1 mm was used for the first time in our experiment and performed well at the used very high flux. The isotopes of interest produced in the reaction were separated, transported and identified using the standard methods for BigRIPS and using Al wedges at the F1 and F5 focal planes of 7 mm and 1 mm, respectively. Our detection setup was placed at the F8 focal plane where the beam was stopped in a sandwich of 2 mm thick plastic and 3 mm thick Cu host.

The momentum distribution for ions produced in the fission reaction is generally wide and it is only partially accepted (*e.g.* ±3%) by the BigRIPS spectrometer.[2]

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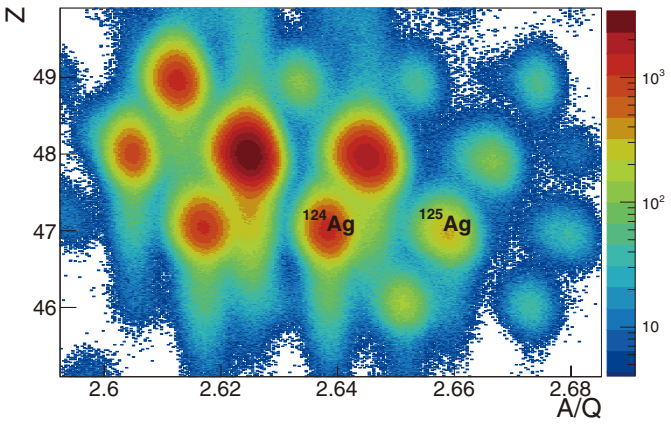

Fig. 1. Particle-identification for the central setting.

In addition, in order to select certain parts of this momentum we have performed F1 slit cuts by accepting only the high or only the low part of momentum distribution for the ions of interest.

Typical particle-identification spectrum from this experiment for the central selection is shown in Fig. 1 for about 10% of the collected data. Similar statistics was obtained also for the wing setting. For the measurement of the nuclear moments we have employed the well-known TDPAD method, applied successfully at RIBF.[3,4] We used four HpGe detectors at 90° with respect to each other and two $LaBr_3$ detectors of 1.5 × 1.5 in. They were all placed in a horizontal plane, while the magnetic field used to induce the precession of the nuclear spins was provided by a compact electromagnet and applied in a vertical direction.

Data analysis for the oscillation pattern and magnetic moment for the nuclei of interest are currently in progress.

References

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