STATUS AND PROSPECTS OF COLLINEAR CLUSTER TRIPARTITION EXPERIMENTAL STUDIES

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In our experiments carried out so far multiple manifestations of the new multi-body decay of ^{252}Cf (sf) were observed. Principal result obtained in the missing mass approach consists in revealing of the rectangular like structures bounded by magic clusters in the fission fragments correlation mass distributions. The result is confirmed by the direct registration of three decay partners. Further development of the experimental methodic is planning to provide in three different directions, namely, by increasing of both aperture and granularity of the COMETA mosaic setup, by using of the electrostatic guide based system at the IBR-2 reactor and developing flesh-ADC based technique.

1. Status

1.1. *Missing mass approach*

In the series of experiments at the different time-of-flight spectrometers we have observed multiple manifestations of a new type of multibody decay of low excited heavy nuclei called by us collinear cluster tri-partition (CCT) [1–4]. The most pronounced manifestation of this unusual decay mode looks like a

bump in the fission fragments (FFs) mass correlation plot in the region of big missing mass (Figure 1). Actually a whole sequence of bumps was revealed [3] based on different magic clusters. The first one seen in Figure 1a is linked with Ni isotopes and was called "Ni"- bump. The internal structure of the bump is vividly seen in the distribution obtained at the COMETA setup (Figure 1b).

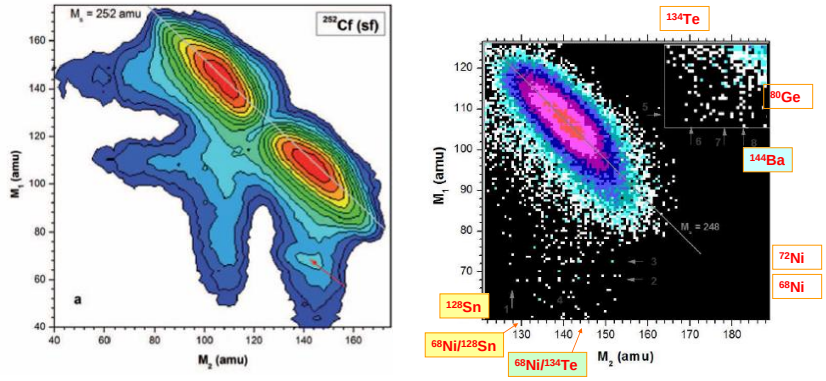


Figure 1. a) Contour map (in logarithmic scale, the steps between the lines are approximately a factor 2.5) of the mass-mass distribution of the collinear fragments of ^{252}Cf (sf), detected in coincidence in the two opposite arms of the FOBOS spectrometer. The specific bump in the yields in arm1 is indicated by the red arrow. b) The region of the mass –mass distribution obtained at the COMETA setup around the "Ni" bump. No additional gates were applied. Very low background of scattered fragments is due to the use of PIN diodes. An internal linear structure of the "bump" is seen (the lines are marked by the arrows and numbers). A part of the plot just below the locus of binary FFs produces the rectangular structure is shown in a larger scale in the panel.

The background produced by the scattered fragments of binary fission is the main factor giving rise to the imitation of ternary events. In order to distinguish ternary events from the background ones different selections sensitive to the CCT events are used.

In our works [2, 4] the CCT events were selected with the help of the experimental observables sensitive to the fission fragment nuclear charge.

Selection of the events, showing increased experimental neutron multiplicity, proved to be a very effective way to reveal the CCT events. A special design of the mosaic neutron detector delivers preferential registration of the neutrons emitted from the isotropic source linked with the CCT [3].

Regular nonrandom structures, observed in the mass-mass correlation plots for the neutron gated data in the region of a meaningful missing mass, are treated as the manifestations of at least ternary decays. The structures are bounded by magic nuclei being "start" and "stop" points for the specific trajectories observed.

1.2. *Real detection of three decay partners*

Mosaic stop-detectors of the COMETA setup let to detect separately the partners of the multi-body decays. Some hundreds of ternary coincidences were actually detected. The points in the mass correlation plot for the heaviest fragments from each event form the regular rectangular structure bounded by the magic clusters. It is strong argument in favor of its nonrandom nature. At the same time the total mass of the bulk of the detected fragments is significantly less than the mass of the mother system. *It can be an indication that at least quaternary decay took place.*

2. Prospects

We are planning to develop three different methodical approaches in order to perform cinematically complete experiment i.e. with direct registration of all (three and more) decay partners.

2.1. *High aperture and high granularity mosaic system*

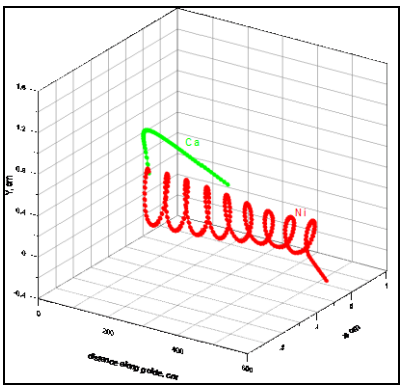
Development of the COMETA setup is in progress. Additional mosaics of PIN-diodes will let to increase essentially the aperture. New more transparent construction of the start-detector is aimed for diminishing of the background of scattered fragments.

2.2. *Electrostatic guide based system at the IBR-2 reactor channel*

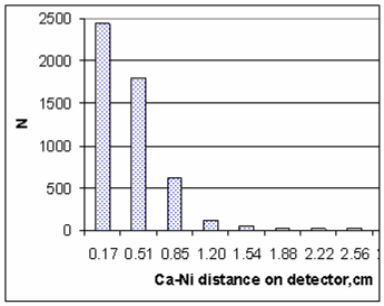
Detection of almost collinear fragments is very complicated experimental task keeping in mind the necessity to shadow the edges of PIN diodes. The width of the frame between neighboring diodes put a limit for distinguishing two fragments. For the moment this limit is about 1^0 and hardy can be decreased due to quick loss of registration efficiency.

We are going to use electrostatic guide system for transporting of the fission fragments from the target in the vicinity of the IBR-2 active zone to the detectors placed in some meters from the target. Similar guide system has been already used at the reactor [5].

Modeling of the trajectories of two initially collinear CCT partners (Ni and Ca ions) shows (Figure 2) that they can be detected separately due to the divergence occurred in the direction perpendicular to the system axis after passing the guide system (Figure 2b).



a



b

Figure 2. 3D trajectories of the initially collinear ions of Ca and Ni – a), spectrum of distances on the mosaic plane between initially collinear ions of Ca and Ni – b).

2.3. *Flesh-ADC based technique for the double-hit events from the CCT*

In the frame of this approach the double-hit events from the CCT are under analysis. Digital image of the current impulses from the two CCT partners hit the same PIN-diode during registration gate are obtained using fast flesh-ADC. Both energy and time-reference linked with each impulse will be calculated event by event.

3. Conclusions

1. For the moment we have reliable experimental confirmations obtained in the frame of the missing mass approach of the existence of new multi-body collinear decay channel of the low excited heavy nuclei.
2. Direct detection of three CCT partners at the COMETA setup was performed. For the bulk of the events detected the mass deficit is observed to be an indication of at least quaternary decay.
3. Further both experimental and theoretical efforts are needed for understanding of the physical mechanism of the new phenomenon under study.

References

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