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Spectator matter in collisions of relativistic deformed nuclei

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Density distributions of many nuclei in their ground states are not spherically symmetric and are described by modified Woods–Saxon distributions using spherical harmonics [1]. Collisions of deformed ^{129}Xe, ^{197}Au and ^{238}U nuclei were studied, in particular, in the ALICE experiment at the LHC [2] and in the STAR experiment at RHIC [3]. I was shown [4], that collision events with different initial orientations of deformed nuclei lead to different azimuthal distributions of multiplicities and transverse momenta of produced particles. It is also expected that by the comparison of experimental results with theoretical predictions the adequacy of the shape parametrization can be evaluated [5]. As shown [6,7], the detection of non-interacting spectator neutrons in forward Zero Degree Calorimeters helps to distinguish central ^{238}U–^{238}U collisions with different initial orientations.

In the present work we use our Abrasion–Ablation Monte Carlo for Colliders (AAMCC) model [8,9] to calculate various characteristics of spectator matter in ^{238}U–^{238}U collisions at RHIC. The modeling of each collision event consists of several stages. Firstly, the size and shape of spectator prefragments from both colliding nuclei are defined using Glauber Monte Carlo model. Secondly, the excitation energy of spectator prefragments is calculated. Thirdly, the minimum spanning tree (MST) clustering algorithm is applied to both prefragments to define secondary clusters. Finally, cluster decays are simulated with SMM, Fermi Break-up and evaporation models from Geant4 toolkit. In addition to spectator neutrons considered in Ref.[6,7], we also model the production of spectator protons and nuclear fragments.

We show that the yields of spectator nucleons and their forward-backward asymmetry strongly depend on the relative initial orientation of colliding ^{238}U nuclei. As found, the widest and the narrowest distributions of the nucleon asymmetry are observed in side-side and tip-body collisions, respectively. On the one hand, body-tip collisions result in the largest (body side) and smallest (tip side) numbers of spectator nucleons. On the other hand, tip-tip and body-body collisions result in similar distributions of both observables. We also study the dependence of the multiplicity of spectator nucleons on the quadrupole deformation parameter β_2 of ^{238}U. As found, larger β_2 leads to a higher multiplicity of spectator nucleons in tip-body ^{238}U–^{238}U collisions. This makes it possible to use experiments on nucleus-nucleus collisions at relativistic energies to explore nuclear deformation.

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