1 - 3 Nuclear Fragmentation Induced by Pions at the Δ-resonance Energies*

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The pion dynamics is of importance in understanding the transportation process in heavy-ion collisions and in hadron induced reactions, which also contributes other particle production as the main reaction channels, such as eta, strange particles, *etc.* Pion production in heavy-ion collisions near threshold energies has been investigated for extracting the high-density behavior of the nuclear symmetry energy (isospin asymmetric part of equation of state). The dynamics of pions produced in heavy-ion collisions is complicated, which is related to the pion-nucleon and Δ(1232)-nucleon interactions, the decay of resonances, *etc.* The in-medium properties of pion and Δ(1232) are not well understood up to now, which are related the isospin effects. In the past four decades, the pion-nucleus collisions at the Δ-resonance energies have been extensively investigated within the meson factories in the world.

In this work, the Lanzhou quantum molecular dynamics (LQMD) model is used to investigate the nuclear dynamics induced by pions in the Δ-resonance region. The energy deposition in a nucleus by pion induced reactions is realized via the pion-nucleon collisions associated with the resonance production and reabsorption, which leads to the formation of highly excited nucleus. The fragmentation reactions induced by pions are described with the help of the LQMD transport model combined with the GEMINI statistical decay code for excited fragments[1]. The nuclear dynamics is described by the LQMD model. The primary fragments formed at freeze-out stage are constructed in phase space with a coalescence model, in which nucleons are considered to belong to one cluster with the relative momentum smaller than P_0 and with the relative distance smaller than R_0 (here $P_0 = 200$ MeV/c and $R_0 = 3$ fm). The freeze-out stage is assumed that the energy deposition reaches equilibrium and the pions do not interact with nucleons at the evolution of 300 fm/c taken in this work. The excitation energies of the primary fragments are evaluated from the binding energy difference between the fragments and their ground-state ones. The de-excitation of the primary fragments leads to a broad mass distribution, in which the structure effects (shell correction, fission barrier, particle separation energy) contribute to the process. The phase-space distributions of fragments with charged number of $Z \geqslant 2$ in collisions of charged pions on ^{40}Ca is calculated and shown Fig. 1.

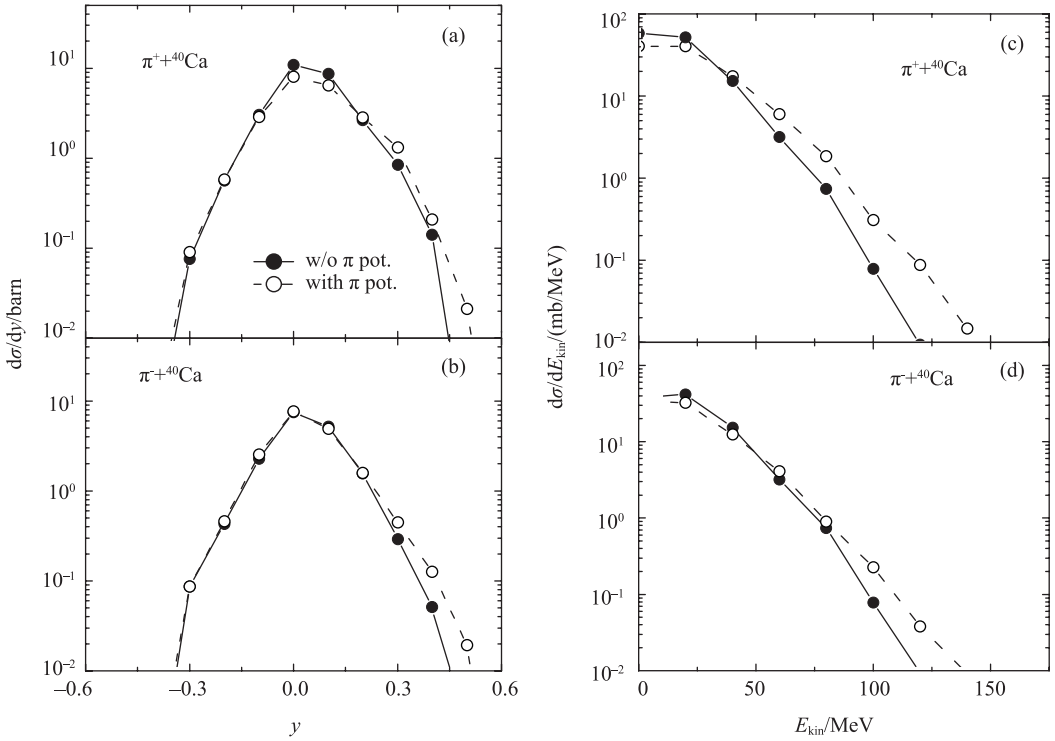

Fig. 1 Rapidity and kinetic energy distributions of fragments with charged number of $Z \geqslant 2$ in collisions of π^- and π^+ on ^{40}Ca at the incident momentum of 300 MeV/c, respectively.

* Foundation item: National Basic Research Program of China (973 Program) (2014CB845405, 2015CB856903), National Natural Science Foundation of China (11675226, 11175218, U1332207)

Comparison of calculations with the available experimental data from the LAMPF[2] is shown in Fig. 2 for bombarding ^{197}Au with π^+ at the incident energy of 100 MeV, 180 MeV and 300 MeV, respectively. The fragment production in the target-mass region is nicely reproduced. The bump structure of intermediate mass fragments comes from the fission of heavy fragments. The absorption process in pion-nucleon collisions to form the $\Delta(1232)$ resonance dominates the heating mechanism of target nucleus. The excitation energy transferred to the target nucleus increases with the pion kinetic energy[3].

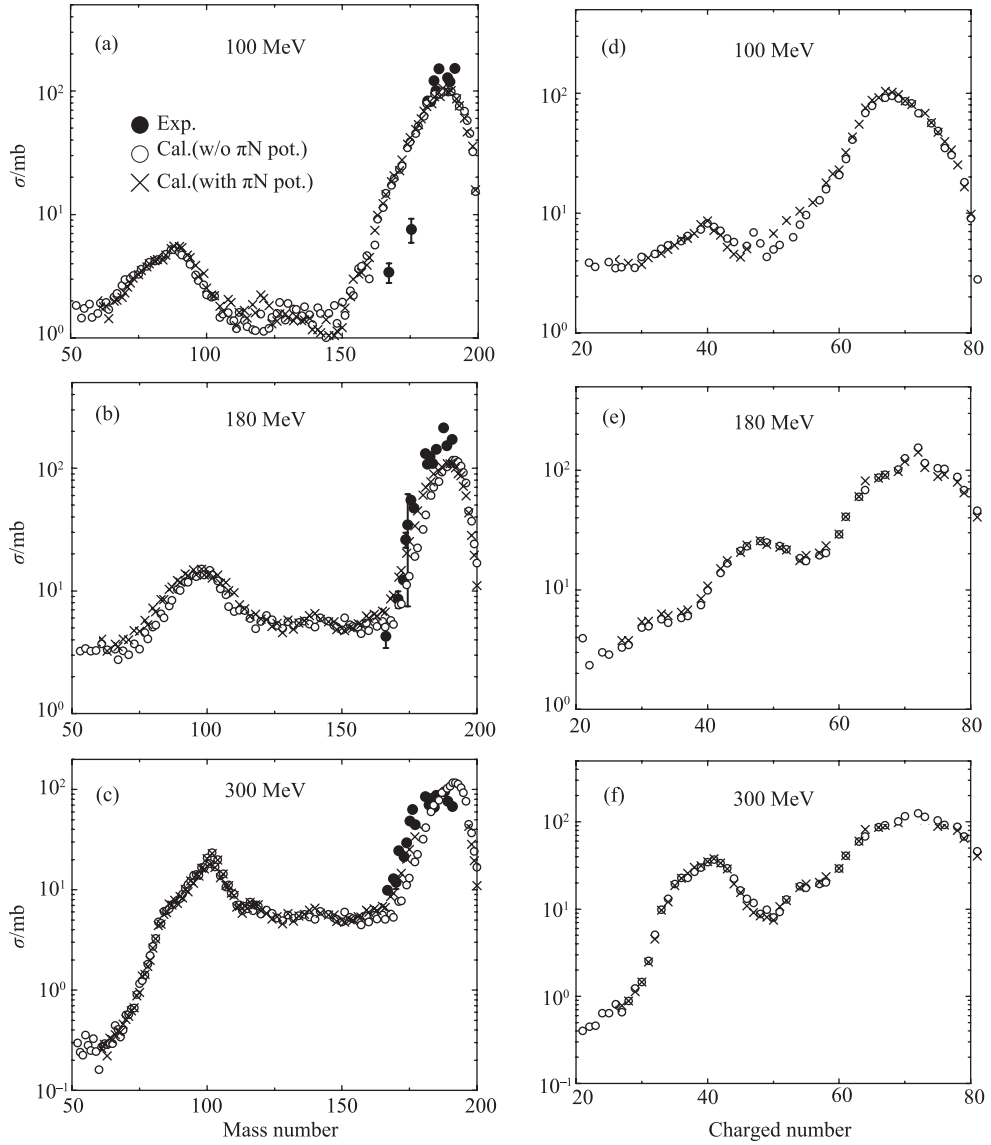

Fig. 2 Fragment distributions with and without the pion-nucleon potential in the π^-+^{197}Au reaction at incident energy of 100 MeV, 180 MeV and 300 MeV, respectively. The available data are from the LAMPF measurements[2].

The fragmentation mechanism and the charge-exchange reactions in pion induced nuclear reactions have been investigated within the LQMD model. The attractive pion-nucleon potential near the Δ-resonance energies (E=0.19 GeV, p=0.298 GeV/c) influences the kinetic energy spectra, but has negligible contribution on the fragmentation process. The relative motion energy is deposited in the nucleus via the pion-nucleon collisions. The transferred energy weakly depends on the incident pion energy. The pion induced reactions could be performed in the future facilities, such as the FAIR (GSI, Germany), HIAF (IMP, China), *etc.*

References

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