2 - 32 Progress of Nuclear Data Research at IMP in 2014

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In 2014, the researchers of Nuclear Data Research Group at IMP have carried out their research work on nuclear data measurements, calculations and fundamental research in heavy ion reactions. Some important results have been obtained.

The experimental setup for ADS nuclear data measurement has been developed in PISA terminal of HIRLF-CSR at IMP. The first beam test experiments for the whole system of the experimental including detection system and data acquisition system were done by using measurements of emission neutron, γ and charged particle identification, energy spectrum, yield and angular distribution for 400 MeV/u ^{16}O bombardments on Pb and W targets. At present, the experimental measurement of accelerator driven white neutron energy spectrum in the range of several MeV to hundreds of MeV was done for the first time in China. The experimental results show that the experimental apparatus works well, and the experimental technique is reliable and correct[1].

The neutron production double-differential cross sections for Pb and Bi targets at incident proton kinetic energies between 800 MeV and 3 GeV are studied by calculations with Monte Carlo simulation package Geant4. The simulated results of Geant4 with several physics models are compared with available experimental data. The simulated results generated by QGSP_BERT and QGSP_INCL_ABLA physics models of Geant4 well reproduce the available experimental data. The present results validated that Geant4 Monte Carlo simulation package is suitable for simulations of neutron production double-differential cross sections of proton induced reaction on Pb and Bi targets in the incident energy range up to 3 GeV[2].

The experiments for benchmarking of evaluated nuclear data libraries were performed for $\sim$ 14.8 MeV neutrons on Gallium and Tungsten targets at China Institute of Atomic Energy (CIAE). The accuracy of evaluated nuclear data for Gallium and Tungsten has been examined by comparing measured leakage neutron spectra with calculated ones. Leak-age neutron spectra from the irradiation of D-T neutrons on Tungsten slab sample were experimentally measured at 60° and 120° by using a Time-of-Flight method.

For the first time primary hot isotope distributions are experimentally reconstructed in intermediate heavy ion collisions and used with antisymmetrized molecular dynamics (AMD) calculations to determine density, temperature, and symmetry energy coefficient in a self-consistent manner. A kinematical focusing method is employed to reconstruct the primary hot fragment-yield distributions for multifragmentation events observed in the reaction system ^{64}Zn + ^{112}Sn at 40 MeV/u. The reconstructed yield distributions are in good agreement with the primary isotope distributions of AMD simulations[3]. The characteristic properties of the hot nuclear matter existing at the time of fragment formation in multifragmentation events produced in the reaction ^{64}Zn + ^{112}Sn at 40 MeV/u are studied. Utilizing the reconstructed yields and power distribution, characteristic properties of the emitting source are examined. The primary mass distribution exhibits a power-law distribution with the critical exponent $A^{-2.3}$ for $A \geq 15$ isotopes but it significantly deviates from that for lighter isotopes. Based on the modified Fisher model, the ratios of the Coulomb and symmetry energy coefficients relative to the temperature, a_c/T and a_{sym}/T, are extracted as a function of A[4].

The mass dependence of the transverse flow in the reactions of ^{40}Ca + ^{40}Ca at 35 MeV/u has been determined for emitted isotopes with $Z = 1$ to 9. The observed flow is compared with that calculated using a constrained molecular dynamics (CoMD) simulation. With the application of the appropriate experimental filter, the general trend of the experimental mass-dependent flow is well reproduced by the simulation employing an effective interaction corresponding to a soft equation of state (K = 200 MeV). The CoMD events are further utilized to study the mechanism of generation of the mass-dependent flow. It is found that the mass-dependent flow is generated by the interplay between the thermal and collective motions under momentum conservation in the fragmenting system. With the help of the collective-thermal-interplay model, the mass-dependent flow scaled by the reduced mass of fragments A/A_{sys} is found to be almost independent of the size of the system[5].

For central collisions of ^{40}Ca +^{40}Ca at 35 MeV/u, the density and temperature of a fragmenting source have been evaluated in a self-consistent manner using the ratio of the symmetry energy coefficient relative to the temperature, a_{sym}/T , extracted from the yields of primary isotopes produced in antisymmetrized molecular dynamics (AMD) simulations. The a_{sym}/T values are extracted from all isotope yields using an improved method based on the modified Fisher model (MFM). The values of a_{sym}/T obtained, using different interactions with different density dependencies of the symmetry energy term, are correlated with the values of the symmetry energies at the density of fragment formation[6].