1 - 1 Progress of Theoretical Nuclear Research in 2022 at IMP

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In 2022, the researchers of Theoretical Physics Group at IMP have carried out research work on nuclear physics, heavy ion physics and nuclear astrophysics. Some important results have been obtained and summarized as follows.

$^{26-31}$Ne isotopes pertaining to one-neutron halo structure have been studied by using the Gamow shell model[1]. One-body density, neutron root-mean-square radii of $^{26-31}$Ne, and one-neutron overlap functions of ^{29,31}Ne have been calculated. The obtained results support the presence of a one neutron p-wave halo in ^{31}Ne, already pointed out experimentally. The present results suggest that ^{29}Ne is a good candidate for one-neutron p-wave halo in the medium-mass region. Spectroscopic factors involving well bound nucleons in light nuclei are calculated with standard shell model, no-core shell model and Gamow shell model[2]. It is showed that Gamow shell model can properly reproduce experimental data and is a predictive tool for detailed nuclear structure at drip-line, contrary to standard and no-core shell model. The low-lying spectrum and scattering proton-proton cross section of ^{16}F have been investigated within the framework of the coupled-channel Gamow shell model[3] framework. Experimental data are very well reproduced, and isospin-symmetry breaking generated by the Coulomb interaction and continuum coupling explicitly appears in our calculations.

In-medium nucleon-nucleon (NN) cross sections at various densities and isospin asymmetries have been calculated systematically in the framework of the improved Brueckner-Hartree-Fock approach[4]. Parameterized Analytical formulas have been provided with parameters calibrated to the calculated results. Using these formulas, the transverse and elliptic flows of emitted nucleons in heavy-ion collisions are studied within the isospin-dependent Boltzmann-Uehling-Uhlenbeck transport model. A way of producing large multinucleon system via multi-nucleus collision device Collider Plus in terrestrial laboratory is proposed[5]. It is shown that large chunk of nucleonic matter can be produced through nuclear ternary fusion reactions at lower beam energies and also large block of dense matter can be formed via ternary collisions of heavy nuclei at intermediate energies. Within an updated a relativistic transport model with momentum dependent isoscalar and isovector single-nucleon mean-field potentials corresponding to different symmetry energies at suprasaturation densities, the n/p,π^-/π^+,K^0_s/K^+,Σ^-/Σ^+, and Ξ^-/Ξ^0 ratios are studied for central Au+Au collisions[6]. The doubly strange Ξ^-/Ξ^0 ratio is shown to have the strongest sensitivity to the variation of high-density nuclear symmetry energy.

The light meson mass spectroscopy has been obtained from the light-front quantum chromodynamics Hamiltonian, determined for the constituent quark-antiquark and quark-antiquark-gluon Fock components, together with a three-dimensional confinement[7]. It is shown that the pion's gluon densities can be probed through the pion-nucleus induced J/ψ production data. The obtained pion parton distribution functions provide excellent agreement with J/ψ production data from widely different experimental conditions.

References

[1] J. G. Li, N. Michel, H. H. Li, et al., Phys. Lett. B, 832(2022)137225.
[2] M. R. Xie, J. G. Li, N. Michel, et al., Phys. Lett. B, 839(2023)137800.
[3] N. Michel, J. G. Li, L. H. Ru, et al., Phys. Rev. C, 106(2022)L011301.
[4] S. C. Han, X. L. Shang , W. Zuo, et al., Phys. Rev. C, 106(2022)064332.
[5] G. C. Yong, Phys. Lett. B, 832(2022)137260.
[6] G. C. Yong, B. A. Li, Z. G. Xiao, et al., Phys. Rev. C, 106(2022)024902.
[7] J. S. Lan, K. Y. Fu , Chandan Mondal, et al., Phys. Lett. B, 825(2022)136890