Theory activities 2012

Research subjects in the RCNP theory group covers a wide range of nuclear and hadron physics. Three permanent staff members, visiting professors and postdocs are the main leaders of the projects. Graduate course students are also involved in the projects according to their interests. Researches are also made actively by the RCNP supercomputer users. Here are several important achievements in 2012.

Hadron physics:

(1) Exotic hadrons with heavy mesons are investigated. Many observed exotic states were interpreted as molecular states near thresholds, Fig. 1 [1]. In these works, the role of pion-exchange force and coupled channels are emphasized, which are the two important features of QCD, chiral symmetry and heavy quark symmetry. This idea can explain, for instance, the nature of X(3872) and Zb(10610, 10650).

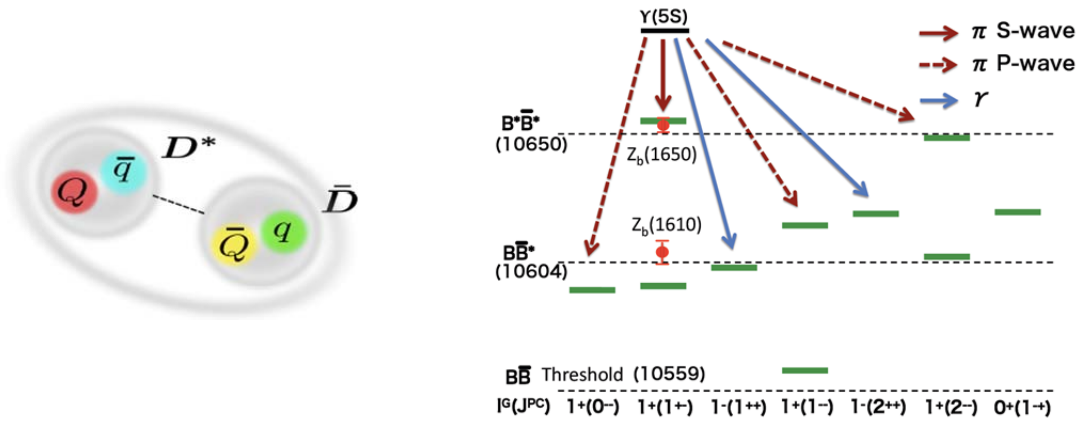


Fig.1 (Left) Molecular picture of heavy mesons and (Right) Predicted states (green bars) and decays from the Υ(5S) bottomonium.

(2) An elaborated coupled channel method, called the ANL-Osaka/EBAC approach, has been extended [2] to study the light-quark meson spectrum with the data of existing and future experiments at GlueX@JLab and COMPASS, Fig. 2. The formalism accommodates the elementary (intrinsic) components of resonances with suitable scattering dynamics, which provides a complete analysis of scattering amplitudes. The method has also been applied to neutrino reactions [3].

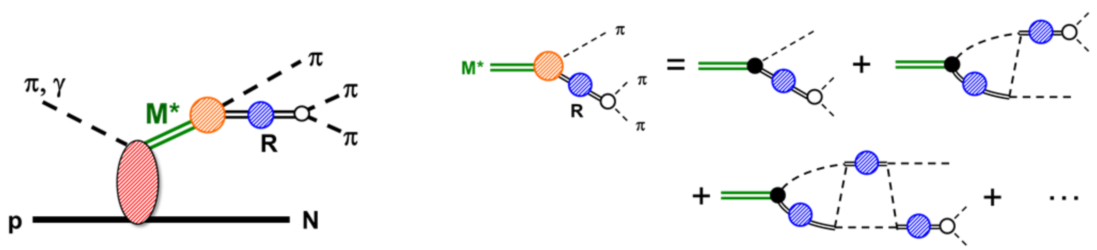
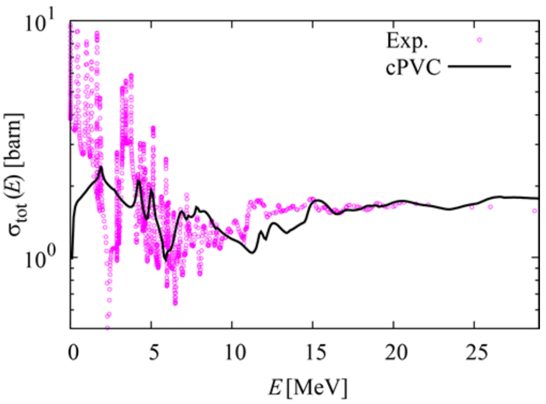


Fig. 2 (Left) Reactions for meson spectroscopy at COMPASS and JLab, where the meson M* could be hybrid. (Right) Three-pion decay of M*. In the ANL-Osaka approach, the three-body unitarity in the decay process are fully maintained.

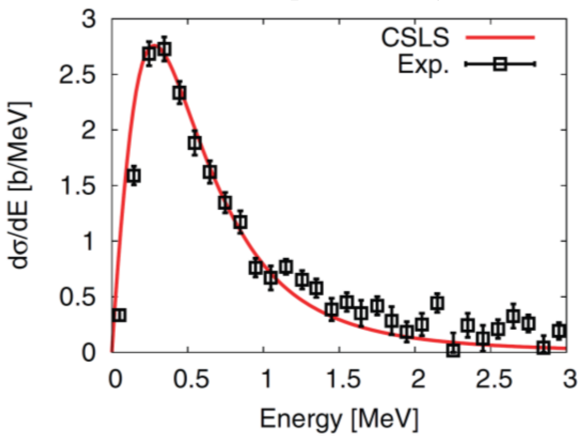
Nuclear Physics:

In nuclear physics, we have proceeded with the Triune Nuclear Physics (TNP), i.e., nuclear physics based on a *trinity* of nuclear structure, nuclear reaction, and effective interaction studies. An achievement to be highlighted is the fully microscopic description of *n*-^{16}O scattering at low energies with the continuum Particle-Vibration Coupling (cPVC) method [4]. The cPVC method treats the neutron motion (scattering) and the collective vibration of the ^{16}O core due to various types of phonon in a unified manner. The absorption of neutron, which is usually described by a phenomenological or microscopic imaginary potential, is treated within a coupled-channel formalism. In other words, the model space of the cPVC method includes all the non-elastic channels explicitly, i.e., there is no flux *loss* out of the model space. The left figure shows the total cross section of the *n*-^{16}O scattering compared with experimental data.



A distinguished feature is some narrow peaks (doorway states) are described well. It is found that more than 80% of the total reaction cross section is reproduced by the cPVC method with no free parameters.

Another important publication is the description of Coulomb breakup of ^{11}Li within a *n*+*n*+^{9}Li three-body model taking account of the core excitation of ^{9}Li due to 2p-2h correlations [5]. The right figure shows the breakup cross section compared with experimental data. This is the first work that explains beautifully well the data without free adjustable parameters. Through this study the importance of the 2p-2h excitation of ^{9}Li has definitely been confirmed.



Some other reaction studies such as ^{8}B(*p*,γ)^{9}C [6] and ^{208}Pb(^{15}C, ^{14}C+*n*) have been performed. TNP for unbound states/nuclei will be a possible next step of our study.

[1] S. Ohkoda, Y. Yamaguchi, S. Yasui, K. Sudoh and A. Hosaka, PRD86 014004 (2012)

[2] S.X. Nakamura, H. Kamano, T.-S. H. Lee, and T. Sato, PRD86 114012 (2012)

[3] H. Kamano, S.X. Nakamura, T.-S. H. Lee, and T. Sato, PRD86 097503 (2012)

[4] K. Mizuyama and K. Ogata, PRC86 041603(R) (2012).

[5] Y. Kikuchi, T. Myo, K. Kato, and K. Ikeda, PRC87 034606 (2013).

[6] T. Fukui, K. Ogata, K. Minomo, and M. Yahiro, PRC86 022801(R) (2013).