XYZ Resonances at Belle

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Discoveries of the X, Y and Z states, which are the quarkonium-like exotic hadron candidates, opened the new field of hadron spectroscopy to spot still unrevealed aspects of the QCD. With numerous efforts from both experimental and theoretical sides, quite plausible interpretations have become common for some states and such progresses drive further extensions and new ideas. The recent results and understandings about these exotic candidate states are reviewed.

KEYWORDS: Hadron spectroscopy, Exotic hadrons, Quarkonium-like states

1. Introduction

In hadron physics, one of the most important issues would be identifying the effective degree-of-freedom to form hadrons from quarks and gluons especially for excited states. In order to come up with the answer to this question, looking for and studying properties of the exotic hadrons play an important role. Here, the exotic hadrons are the composite system comprised by quarks and gluons possessing extraordinary structure beyond usual baryons (qqq constituent) and mesons ($q\bar{q}$ constituent), such as multiquarks, hadron-hadron molecule and so on. In the exotic hadron cases, reaching a convincing interpretation directly gives us the corresponding understanding for effective degree-of-freedom of the discussed state.

Thanks to the world-highest luminosity provided by the KEKB asymmetric-energy e^+e^- collider [1] and the Belle detector [2] that is a high-resolution 4π general purpose magnetic spectrometer with an excellent particle identification capability, the possibilities to access following items are in our hand; (1) various production mechanisms recorded, and (2) various decay modes. Since each physics process has preferred quantum numbers to produce a hadron, the former is essential to get chances to look for variety of the states and the latter is the key to reveal structure of the found states. These two key features make possible to have the interplay among several approaches and it is very effective to reach comprehensive understanding.

Here, the most recent results and understanding about the X, Y and Z states [3] and the future prospect for the heavy-flavored hadron spectroscopy at the Belle II experiment are to be discussed.

2. Recorded data and accessible physics processes in Belle experiment

The KEKB asymmetric-energy e^+e^- collider reached the peak luminosity of 2.1×10^{34} cm^{-2}s^{-1} and the Belle detector accumulated the high statistics data corresponding to the integrated luminosity more than 1 ab^{-1} in total. Out of these, 711 fb^{-1} was accumulated on the $\Upsilon(4S)$ resonance, it contains 772 million $B\overline{B}$ pairs. Next largest data sample is the runs taken on $\Upsilon(10860)$, 121 fb^{-1}. In these datasets, following reactions are recorded; (1) B meson decays, (2) initial state radiation (ISR), (3) double $c\bar{c}$ prodeuction, (4) two photon collisions, (5) bottomonium decays and (6) other e^+e^- annihilation-originated processes such as continuum handron production and τ pair events. From (1)