Establishing mass spectrum of $S = -1$ hyperon resonances via a dynamical coupled-channels analysis of K^-p reactions

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The spectra and structure of the excited baryons with light valence quarks (u, d, s) contain the information for understanding the non-perturbative aspects, confinements and chiral symmetry breaking, of Quantum Chromodynamics.

The excited baryons are unstable and couple with meson-baryon continuum states to form nucleon resonances (N^*, Δ^*) with strangeness $S = 0$ and hyperon resonances $(Y^* = \Lambda^*, \Sigma^*)$ with $S = -1$. Thus the extraction of these baryon resonances from the data of hadron-, photon-, and electron-induced meson-production reactions has long been an important task in the hadron physics. However, the hyperon resonances are much less understood than the nucleon resonances. This can be seen, for example, from the fact that only the "highly model-dependent" Breit-Wigner masses and widths were listed for the Y^* resonances by the Particle Data Group before 2012 [1]. In contrast, the pole positions and residues of the N^* and Δ^* resonances, which are known to be model-independent quantities meaningful to compare, have been well determined by many analysis groups through detailed partial-wave analyses of πN and γN reactions.

In this situation, we have recently developed a dynamical coupled-channels model of K^-p reactions [2], aiming at (1) extracting the Y^* resonance parameters (mass spectrum and branching ratio etc.) defined by poles of scattering amplitudes and (2) providing the elementary antikaon-nucleon reaction amplitudes that can be used for investigating various phenomena in the strangeness sector such as the production of hypernuclei from kaon-nucleus reactions. The model consists of (a) meson-baryon (MB) potentials $v_{M'B',MB}$ derived from the phenomenological flavor SU(3) Lagrangian, and (b) vertex interactions Γ_{MB,Y^*} for describing the decays of the bare excited hyperon states (Y^*) into MB states. The model is defined in a channel space spanned by the two-body $\bar{K}N$, $\pi\Sigma$, $\pi\Lambda$, $\eta\Lambda$, and $K\Xi$ states and also the three-body $\pi\pi\Lambda$ and $\pi\bar{K}N$ states that have the resonant $\pi\Sigma^*$ and $\bar{K}^*N$ components, respectively. The resulting coupled-channels scattering equations satisfy the multichannel unitarity conditions and account for the dynamical effects arising from the off-shell rescattering processes. The model parameters are determined by fitting the available data of the unpolarized and polarized observables of the $K^-p \to \bar{K}N, \pi\Sigma, \pi\Lambda, \eta\Lambda, K\Xi$ reactions in the energy region from the threshold to invariant mass $W = 2.1$ GeV.

In this contribution, we will present the Y^* resonance mass spectrum extracted from our comprehensive analysis of K^-p reactions and demonstrate a possible existence of a new narrow $J^P = 3/2^+$ Λ resonance that couples strongly to the $\eta\Lambda$ channel. Future developments, including an extension of our model to K^-d reactions to study $\Lambda(1405)1/2^-$ and YY interactions, will also be discussed.

[1] J. Beringer et al. (Particle Data Group), Phys. Rev. D **86**, 010001 (2012).

[2] H. Kamano, S. X. Nakamura, T.-S. H. Lee, and T. Sato, Phys. Rev. C **90**, 065204 (2014).