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Coupled-channels analyses of meson production data and identification of nucleon resonances[1]

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An important challenge in hadron physics is to understand the structure of the nucleon in terms of Quantum Chromodynamics (QCD). Since the nucleon is a composite particle, its structure is closely related to the spectrum and structure of its excited states. Because the nucleon excited states show up as resonances in $\pi(\gamma)$-induced meson production reactions on the nucleon, their existence and their properties (mass, width, branching ratios, etc.) can be revealed by a careful partial wave analysis of the reaction data. Because several meson-baryon channels are strongly coupled in the reactions, the unitarity requires a coupled-channels analysis. The mass and width of a nucleon resonance are identified by real and imaginary parts of a pole position in the partial wave amplitude, and a partial width is calculated with the residue of the pole. Those extracted properties are to be understood with Lattice QCD and/or hadron structure models. Analysis methods can be classified into two classes: one of them is based on a dynamical model in which meson-baryon potentials are derived from a set of interaction Lagrangians, and a set of coupled-channels scattering equations is solved to calculate the scattering amplitude. The other approach is based on a parametrization of the amplitudes using the K-matrix. In this presentation, I will give an overview of those coupled-channels analyses of meson production data. Although there are several groups working on their coupled-channels analyses, I will mainly discuss an analysis done by the Excited Baryon Analysis Center (EBAC) in Jefferson Lab as a representative of the dynamical approach. For the parametrization approach, I will mainly review an analysis done by the Bonn-Gachina group. I explain their models, methods and database, and show the quality of description of the data with their models, and present resonance properties extracted from their models.

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