working group #6: Baryon Spectroscopy

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Goal: Proposal for the measurement of polarization observables in pseudo scalar (η) photoproduction off the nucleon with the Crystal Barrel/TAPS experiment at ELSA.

Photons are able to excite atoms as well as their nuclear constituents, protons and neutrons, even if the needed energies are more than 10 million times larger for the later case. Obviously the proton and neutron are not elementary. Assuming that they are made out of three quarks with similar masses and using an appropriate potential, quark models describe the spectrum of such excited states, the baryon resonance spectrum, quite well — at least in the energy regime below a center of mass energy of $W = 1800\,\text{MeV}$. For higher energies the number of predicted states exceeds the number of experimentally observed states by far and one can doubt if all of these states really exist.

Unfortunately, the theory of the strong force between the quarks, Quantum Chromodynamics (QCD), is not solvable in the energy regime of light baryons. Here, the expansion in a perturbative series does not converge due to the large coupling constant and quarks are confined in hadrons. Lattice QCD provides a possibility to extend QCD into this non-perturbative regime, but to this day certain approximations are inevitable. So far, lattice calculations confirm the rich spectrum predicted by quark models. Therefore one of the main tasks of hadron spectroscopy is to identify the effective degrees of freedom and forces in the regime of non perturbative (strong) QCD.

Baryon spectroscopy is complicated by the fact that the excited states are broad and overlap with one another, which is why polarization experiments are needed to disentangle unambiguously the contributing resonances in the different reaction channels with various final states. The much improved Crystal Barrel/TAPS experiment started again taking data in 2017 with linear or circular polarized and/or longitudinal and transversal polarized proton or deuteron target allowing the measurement of all single polarization observables and all double polarization observables accessible with beam and target polarization.

In this working group you will learn something about scattering theory, quark models, partial-wave analysis, polarization observables and complete experiments, detection of photons and charge particle identification.