Abstract

The excitation spectrum is one of the fundamental properties of every spatially extended system. The excitations of the building blocks of normal matter, i.e., protons and neutrons (nucleons), play an important role in our understanding of the low energy regime of the strong interaction. Due to the large coupling, perturbative solutions of quantum chromodynamics (QCD) are not appropriate to calculate long-range phenomena of hadrons. For many years, constituent quark models were used to understand the excitation spectra. Recently, calculations in lattice QCD make first connections between excited nucleons and the fundamental field quanta (quarks and gluons). Due to their short lifetime and large decay width, excited nucleons appear as resonances in scattering processes like pion nucleon scattering or meson photoproduction. In order to disentangle individual resonances with definite spin and parity in experimental data, partial wave analyses are necessary. Unique solutions in these analyses can only be expected if sufficient empirical information about spin degrees of freedom is available. The measurement of spin observables in pion photoproduction is the focus of this thesis. The polarized electron beam of the Mainz Mictrotron (MAMI) was used to produce high-intensity, polarized photon beams with tagged energies up to 1.47 GeV. A frozen-spin Butanol target in combination with an almost 4π detector setup consisting of the Crystal Ball and the TAPS calorimeters allowed the precise determination of the helicity dependence of the $\gamma p \rightarrow \pi^0 p$ reaction. In this thesis, as an improvement of the target setup, an internal polarizing solenoid has been constructed and tested. A magnetic field of 2.32 T and homogeneity of 1.22×10^{-3} in the target volume have been achieved. The helicity asymmetry E, i.e., the difference of events with total helicity 1/2 and 3/2 divided by the sum, was determined from data taken in the years 2013-14. Subtraction of background events arising from nucleons bound in Carbon and Oxygen was an important part of the analysis. The results for the asymmetry E are compared to existing data and predictions from various models. The results show a reasonable agreement to the models in the energy region of the Δ(1232)-resonance but large discrepancies are observed for energy above 600 MeV. The expansion of the present data in terms of Legendre polynomials, shows the sensitivity of the data to partial wave amplitudes up to F-waves. Additionally, a first, preliminary multipole analysis of the present data together with other results from the Crystal Ball experiment has been performed.