\( ^3\text{He} (\gamma, \pi^0) \rightarrow ^3\text{He} \) \(^3\text{He} \) as the nuclear probe

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Abstract. The state of polarization of the recoil nucleus in \( \gamma + ^3\text{He} \rightarrow \pi^0 \rightarrow ^3\text{He} \) as well as the asymmetry in the differential cross-section when the initial \(^3\text{He} \) is polarized are studied together with the differential cross-section taking into consideration the \( S, S' \) and \( D \)-state admixtures in the nuclear wavefunctions. In view of the considerable spin dependence in the photoproduction amplitudes these observables are found to be quite sensitive to the small admixtures of \( S', D \) states in the nuclear wavefunctions.

Keywords. Differential cross section; target asymmetry; recoil nucleus polarization; \( S, S' \), \( D \)-state admixtures in; \(^3\text{He} \) nuclear wavefunction; nuclear structure; multipole amplitudes.

1. Introduction

The study of the three-nucleon ground state has been pursued with renewed interest during the last decade. Following the extensive electron scattering studies made earlier as part of the saga of high energy electron scattering experiments, we have now several theoretical solutions of the dynamical equations for the three-nucleon ground state with realistic potentials (see for example Sick 1981; Payne 1981; Drechsel 1980 where extensive references to the literature can be found). However it has been found that (McCarthy et al 1977) there is no agreement between experiment and theory especially around \( Q^2 = 11 \text{ fm}^{-2} \) for the charge form factor. A recent study of the magnetic form factor (Riska 1980) with simple wavefunction models and taking into account the pion and \( p \)-meson exchange current effect shows that the single-nucleon current contribution depends strongly on the \( D \)-state probability. Since the new data (Arnold et al 1978; Riska 1980; Sick 1981) on the \(^3\text{He} \) form factors at large \( Q^2 \) indicate that the existing microscopic calculations of the wavefunctions are missing an important ingredient, it appears quite reasonable to use the wavefunctions for the nuclear systems following the traditional enumeration of Sachs (1953); Schiff (1964); Gibson and Schiff (1965), where free parameters can be adjusted in order to reproduce the experimental data. In fact this approach was used by Lazard and Maric (1973) in their discussions of photoproduction of charged pions on \(^3\text{He} \).

Here, the photoproduction of neutral pions on \(^3\text{He} \) is studied since the reaction offers several advantages as a tool to study the nuclear structure (i) corrections due to Coulomb interaction between the pions and the nucleus in the final state or between the target and the beam in the initial state are absent, (ii) the momentum transfers