# Hyperon forward spin polarizabilty $\gamma_0$

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## Introduction

Compton scattering is a source of valuable information about baryons since it offers access to some of the more subtle aspects of baryon structure such as polarizabilities [1], which parameterize the response of the target to an external quasi-static electromagnetic field. The spin-dependent (SD) pieces of the forward scattering amplitude for real photons of energy $\omega$ and momentum $q$ is [2],

$$\epsilon_1^\mu \, \mathcal{M}_{\mu\nu}^{\rm SD} \, \epsilon_2^\nu = ie^2 \, \omega \, W^{(1)}(\omega) \, \vec{\sigma}\cdot(\vec{\epsilon}\times\vec{\epsilon}^*)+\ldots \quad (1)$$

From the theoretical perspective there is particular interest in the low energy limit of the amplitude:

$$e^2 W^{(1)}(\omega) = 4\,\pi\,(f_2(0) + \omega^2\,\gamma_0^N) + \ldots \quad (2)$$

where $\gamma_0$ is the forward spin polarizability.

The forward spin polarizability $\gamma_0^N$ has been calculated to $O(p^3)$ (LO) in the framework of HBChPT yielding, at lowest order in the chiral expansion,

$$\gamma_0^N = \frac{\alpha\, g_A^2}{24\,\pi^2\, F^2\, M_\pi^2} = 4.54 \times 10^{-4}\ {\rm fm}^4 \quad (3)$$

both for protons and neutrons.

While a rather a large amount of work has been devoted, both theoretically and experimentally, to the study of the nucleon polarizabilities, very little is known about *hyperon* polarizabilities. However, with the advent of hyperon beams at FNAL and CERN, the experimental situation is likely to change, and this possibility has triggered a number of theoretical investigations. Already, predictions for electric and magnetic polarizabilities have been made for low-lying octet baryons in the framework of HBChPT to LO [3], and in the context of several other models, yielding a broad spectrum of predictions. At present, no experimental data is available for the forward spin polarizabilty of the hyperons and no theoretical calculations have been published. Motivated by this situation, in the present work, we extend the analysis of SU(2) HBChPT to the SU(3) version in order to compute $\gamma_0$ for hyperons. This could serve as a test of low-energy structure of QCD in the three flavor sector.

In order to calculate the forward spin polarizabilities, we work in the Weyl (temporal) gauge $A_0 = 0$, which in the language of HBChPT means $v \cdot \epsilon = 0$, where $v_\mu = (1,0,0,0)$ is the baryon four-velocity. At $O(p^3)$ only the loop diagrams contribute to $\gamma_0$. To one loop, the hyperon polarizabilities are pure loop effects. Fig. 1 shows all the possible loop-diagrams, which contribute to $\gamma_0$ for $\Sigma^+$. Similarly for the other octet baryons the diagrams in Fig. 1 are the only ones which contribute to $\gamma_0$ (except that the incoming and outgoing particles are different).

The values of $\gamma_0$ are found from the calculation of $W^{(1)}(\omega)$ via [2],

$$\gamma_0 = \alpha\, \frac{\partial^2}{\partial\omega^2} W^{(1)}(\omega)\Big|_{\omega=0} \quad (4)$$

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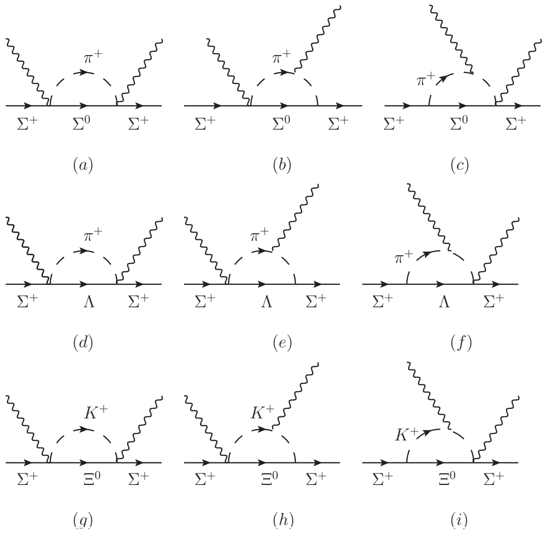


FIG. 1: The one loop diagrams contributing to forward Compton scattering of $\Sigma^+$ $\pi^+$ ($K^+$) at $O(p^3)$. Crossed diagrams are not shown.

The obtained results are listed in Table I.

TABLE I: The forward spin polarizablity $\gamma_0$ of octet baryons (in units of $10^{-4}$ fm$^4$)

| Baryon | present with $\pi$ loops | present with $\pi$ and $K$ loops | $O(p^3)$ [4] |
|---|---|---|---|
| $p$ | 4.50 | 4.86 | 4.5 |
| $n$ | 4.50 | 4.86 | 4.5 |
| $\Sigma^+$ | 1.20 | 1.38 | |
| $\Sigma^0$ | 0.60 | 0.70 | |
| $\Sigma^-$ | 1.20 | 1.22 | |
| $\Lambda$ | 0.60 | 0.70 | |
| $\Xi^-$ | 0.16 | 0.26 | |
| $\Xi^0$ | 0.16 | 0.43 | |

## Conclusions

We have presented the LO contribution to spin-dependent Compton scattering in the framework of HBChPT. In LO HBChPT, these contributions are all meson loop effects, with no counterterm or resonance exchange contribution and hence are a test for the chiral sector of three-flavor QCD. There is a small but finite contribution from kaon loops for $\gamma_0$ for all the low-lying octet baryons. The $\gamma_0$ of the proton and neutron reproduces the results of the LO calculation of SU(2) HBChPT when kaon loops are not considered.

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