FIRST RESULTS OF THE MEASUREMENT OF THE GDH SUM RULE AT MAMI

H. DUTZ

Physikalisches Institut der Universität Bonn, Nussallee 12, 53115 Bonn, Germany

on behalf of the GDH collaboration

The measurement of the Gerasimov-Drell-Hearn sum rule at the Mainz electron microtron MAMI has been started in May '98 by taking first data on the helicity dependence of total and partial photon nucleon cross sections using circularly polarized photons and longitudinally polarized nucleons in a frozen spin target. The outgoing particles have been detected by the large acceptance detector DAPHNE and additional forward components. First preliminary results from an analysis of a small subset of the data taken in the energy range from pion threshold up to 800 MeV are will be presented and discussed.

1 Introduction

The Gerasimov-Drell-Hearn sum rule relates the anomalous magnetic moment κ and the mass M of the nucleon with the helicity dependent total photoabsorption cross sections $\sigma_{3/2}$ and $\sigma_{1/2}$:

$$\int_0^\infty \frac{d\nu}{\nu}(\sigma_{3/2} - \sigma_{1/2}) = \frac{2\pi^2\alpha}{m^2}\kappa^2$$

The GDH sum rule is based on fundamental physics principles such as causality, unitarity, gauge invariance and Lorentz invariance. A derivation of the sum rule was first published in 1965, but more than thirty years passed before the demands for a direct experimental check could be fulfilled. Now in spring 1998 a first measurement for the GDH sum rule was performed at MAMI in Mainz for photons of energy up to 800 MeV. The test of the sum rule will be completed using a further measurement next year at the Bonn accelerator facility ELSA with electrons of energy between 550 MeV and 3400 MeV[1].

2 Experimental equipment

For an experimental check of the GDH sum rule the total cross section of circularly polarized photons on longitudinally polarized nucleons has to be measured. Circularly polarized photons are obtained by the bremsstrahlung process of longitudinally polarized electrons from a GaAs-source and energy tagged in the GEM-tagger of the A2-collaboration with a resolution of 2 MeV. The beam polarization is determined by a Møller polarimeter and the photon

flux is about 500 kHz.
As polarized target a frozen spin target has been used to prepare the longitudinal polarization of the nucleons. The system consists of a horizontal $^{3}He/^{4}He$ dilution refrigerator including an internal superconducting 'holding coil' [2] to maintain the polarization in the frozen spin mode and a horizontal superconducting polarization magnet. The dilution refrigerator was built by the Bonn polarized target group. The target material (Bochum) - butanol (C_4H_9OH) - was polarized using microwaves by means of the principle of Dynamic Nuclear Polarization (DNP). At a magnetic field of 2.5 Tesla and a temperature of 300 mK a nucleon polarization of $80-85\%$ has been obtained. During data taking the polarized target is switched into the so–called frozen spin mode. In this technique the nucleon polarization is preserved after the polarization process at a temperature of about 50-60 mK and a magnetic field of 0.4 Tesla with a relaxation time of more than one week (200 hours). This magnetic field is provided by a superconducting, internal holding coil that is integrated in the refrigerator. The homogeneity of the magnetic field over the target area ($< 5 \cdot 10^{-3}$) allows for the first time an online polarization measurement during 'frozen spin mode' (data taking), so that the systematic error of the polarization measurement is considerably lowered. The degree of the nucleon polarization is determined by the NMR technique with a systematic error of less than 2 %.
The DAPHNE detector represents the central part of the detector and covers 94 % of 4π. It is complemented in the forward region by microstrip detectors MIDAS (Pavia) and a forward wall consisting of the STAR-detector (Tübingen) and Showercounter. A Çerenkov detector (Gent) is used for the suppression of the electromagnetic background. DAPHNE is mainly a charged particle tracking detector with cylindrical symmetry. It consists of three laxers of multi-wire proportional chambers and 6 layers of plastic scintillators.

3 Preliminary results

Between May and August 1998 the GDH collaboration has taken data on the proton for more than 400 hours. The electron beam polarization was $70-75\%$, so that the photon polarization exceeded 50 % in the upper half of the bremsstrahlung spectrum. To use this energy range the experiment ran at three different electron energy settings: 850, 525, 300 MeV. The following preliminary result of the GDH-integral based on an analysis of a 10 % subset of the total data taken on the proton. The quality of the online data are shown in fig.1 where the missing energy for protons from the π°p-process detected in DAPHNE are plotted. Events from the polarized proton can be seen as a clear peak on a broad background from unpolarized carbon which is canceled out in the difference spectrum of the two helicity-states. This plot only containes the events of the difference of both helicity states. The preliminary data of the difference of the total photo absorption cross sections $\sigma_{3/2} - \sigma_{1/2}$ from 200 to 800 MeV are shown in fig.2. The cross section starts out negative due to the $E_{0+}^{n\pi^+}$ multipole and has a strong positive contribution from the M_{1+} multipole in the first resonance. The theoretical predictions for single pion photoproduction are plotted for comparison. The dotted line represents the VPI multipole analysis SAID (solution SP97K) and the solid line a dispersion analysis of Hanstein et al. [3] (HDT). With respect to the errors the preliminary data allow to calculate the integral for the GDH sum rule with a large uncertainty. In the energy range from 200 to 800 MeV the integral leads to a GDH-value of $(230 \pm 20)\mu b$. The missing low energy contribution according to HDT is $-30\mu b$ and the contribution above 800 MeV is about $25\mu b$. This leads to $(225 \pm 20)\mu b$, which is compatible with the theoretical value of the GDH sum rule of $204\mu b$ but is in disagreement with πN multipole analyses of Sandorfi et al. [4] and Hanstein et al. [3].

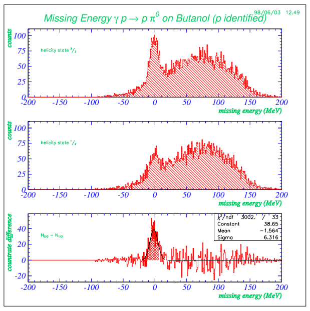

Fig.1 Missing energy spectra for the reaction $\gamma p \to \pi^\circ p$

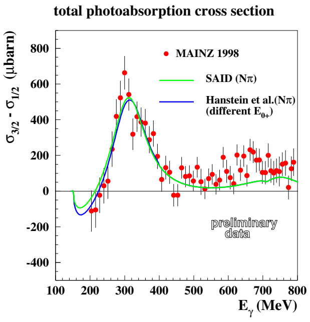

Fig.2 Total photoabsorption cross section difference $\sigma_{3/2} - \sigma_{1/2}$

References

1. J. Ahrends et al., Proposal to the PAC MAMI Mainz (1992).
   G. Anton et al., Proposal to the PAC ELSA Bonn (1992)
2. H. Dutz et al., NIM **A 340** (1994) 272
3. O. Hanstein et al., Nucl. Phys. **A 632**, (1998) 561
4. A. Sandorfi et al., Phys. Rev. **D 50**, (1994) R6681