CERN-TH.95-51

THE πNN COUPLING FROM HIGH PRECISION np CHARGE EXCHANGE

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FBXV
5-9 June 1995
Peniscola, Spain

CERN-TH.95-51
March 1995

At the Few Body Conference in Adelaide two years ago the panel discussion on the πNN coupling constant concluded that there was an urgent need for a direct determination of this quantity [1]. Neutron-proton charge exchange reactions at intermediate energies are very suitable for extrapolation to the charged pion pole. In particular, both the CM unpolarized cross section as well as polarization transfer one are incoherent combinations of 5 amplitudes:

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}(q^2) = 1/2(|a|^2 + |b|^2 + |c|^2 + |d|^2 + |e|^2);$$

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}(q^2)\ (1 - C_{nn00}) = |b|^2 + |c|^2,$$

where q^2 is the squared momentum transfer from the proton to the neutron. Only the amplitudes b and d contain the pion pole at $q^2 + m_\pi^2 = 0$. The characteristic shape and magnitude of these terms are illustrated for the Paris model in fig. 1a. In the Born approximation the amplitude b corresponds mainly to a spin-spin interaction and d to a tensor one. These amplitudes contain the pion pole and are crucial to the extrapolation. The model independent determination of the coupling constant g^2 requires accurate single-energy data with absolute normalization of the unpolarized differential cross section. The error is proportional to $\sqrt{N}$, where N is the normalization and this whether polarization data are used or not.

We exemplify our approach using the precision data at 162 MeV from the recent Uppsala experiments [2,3], which represent a new generation of np scattering measurements, with higher relative and absolute precision than was previously possible. Besides the problem of a reliable experimental normalization, the main other difficulty is to control the systematic effects in the extrapolation procedure on a level of % or better. For this we have generated computer simulations of the data corresponding to the analyzed experiments from the Paris and Nijmegen models with exactly known coupling and analyzed these using different methods. The analysis is based on the quantity $x^2 \times \frac{\mathrm{d}\sigma}{\mathrm{dq}^2}$ extrapolated in the variable $x = q^2 + m_\pi^2$ under different conditions using power series expansions of n terms. This determines the systematic shifts explicitly. Our most accurate results obtained using the Difference method [3] are illustrated in Fig. 1b, where the *difference* between the functions $y(x)$ proportional to $x^2 \times \frac{\mathrm{d}\sigma}{\Omega}(q^2)$ for the Nijmegen potential pseudodata and our data at 162 MeV is extrapolated to the pion pole.

We deduce $g^2 = 14.62 \pm 0.06 \pm 0.30$ where the first error is statistical and the dominant second one stems from the uncertainty in the normalization. The present result does not support the low value for g^2 advocated by the Nijmegen group [4]. A normalizaton improved to the 1% level would provide a much stronger constraint. We presently apply the same type of analysis to data at different energies as well as to antiproton charge exchange [5].

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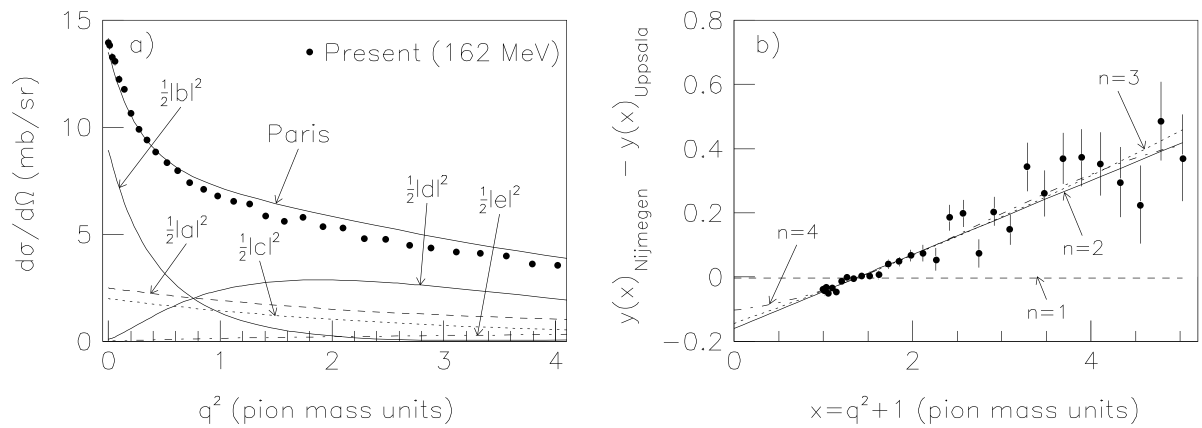
a)
• Present (162 MeV)
dσ/dΩ (mb/sr)
q² (pion mass units)
Paris
½|b|²
½|a|²
½|c|²
½|d|²
½|e|²
b)
y(x)Nijmegen − y(x)Uppsala
x=q²+1 (pion mass units)
n=1
n=2
n=3
n=4