A POLARIZED TARGET FOR SPIN TRANSFER MEASUREMENTS ON THE REACTION $\bar{p}p \to \bar{\Lambda}\Lambda$

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The use of the Bonn Frozen Spin Target at the experiment PS185/3 at the antiproton accelerator LEAR (CERN) allows the determination of the depolarization D_{nn} and of the spin transfer K_{on} of the reaction $\bar{p}p^{\uparrow} \to \bar{\Lambda}\Lambda$. The data of the spin transfer from the polarized target proton to the final state Λ hyperon should distinguish between proposed $\bar{s}s$ production scenarios, which will also provide new experimental input to the question of the strange quarks/antiquarks as carriers of a part of the spin of the nucleon.

Data has been taken at three different antiproton momenta between 1525 MeV/c and 1800 MeV/c with an average antiproton beam intensity of 500000 $\bar{p}$/sec. The average target polarization was 64 %, maintained in the frozen spin mode by an internal superconducting holding coil. A tiny butanol block target (vol = 0.25 cm^3) was employed to take account of the small beam spot and to maximize the filling factor. Dynamic proton polarization in butanol was enabled by the chemical dopant TEMPO.

1 Introduction

Early experiments in the seventies and more recent systematic studies of the PS185 collaboration at LEAR turned out, that measurements of $\bar{\Lambda}\Lambda$ production in antiptroton-proton reactions have been proven as a powerful tool to study the dynamics of the $\bar{q}q$ annihilation and production mechanisms. QCD inspired quark-gluon models as well as meson exchange models were used to describe angular distributions of cross sections, polarizations and spin correlations on the reaction $\bar{p}p \to \bar{\Lambda}\Lambda$. The main features of the data, especially near reaction threshold, can be described reasonably well in both quark-gluon and meson exchange models. The results crucially depend on the choice of the $\bar{\Lambda}\Lambda$ final state interaction. Usually the parameters of the $\bar{\Lambda}\Lambda$ interaction are adjusted to fit the $\bar{\Lambda}\Lambda$ production data. Especially the polarization and spin correlations are very sensitive to the explicit choice of the $\bar{\Lambda}\Lambda$ interaction. The measurement of quantities like spinflip and non-spinflip amplitudes serves big restrictions in the $\bar{s}s$ production process. The present models support the meson exchange scenarios, if spinflip transitions take the major part of the reaction. Otherwise the constituent quark model is better.

Polarization and spin correlations have been measured by the PS185 [1] collaboration using the self-analysing decay of the $\Lambda(\bar{\Lambda})$ into the charged decay products p and π^- ($\bar{p}$ and π^+). The polarisation of the Λ and $\bar{\Lambda}$ particles are measured simultaneously and it was found that the antihyperon-hyperon pair is always produced in a spin triplet state, especially near threshold. The PS185 decay spectrometer together with a polarized proton target is perfectly suited to measure the spin transfer to the emitted Λ-hyperon. According to the conservation of the spin momentum the tensor transition $\Delta L = 2$ needs a spinflip of both particles. To distinguish between the different transition scenarios the measurement of the depolarization parameter D_{nn} has been done with a target perpendiculary (vertically) polarized to the beam axis.

During two months of measurement data have been taken at momenta of 1525 MeV/c, 1633 MeV/c and 1800 MeV/c.

2 The Frozen Spin Target

A frozen spin target[2] has been in operation in Bonn for many years. Polarized solid state targets work on the principle of dynamic nuclear polarization (DNP) in which the high electron polarization of some paramagnetic centers is transferred via microwave induced transitions to the nucleon spin system. The nucleon spins are aligned either parallel or antiparallel to a external magnetic field up to 6.5 T applied by a superconducting polarizing magnet (solenoid). The field homogeneity fulfills the stringent requirement $\Delta B/B = \leq 5 \times 10^{-5}$ across the target area. The magnet warm bore of about 95 mm encloses completely the lower part of the dilution refrigerator, where the target material is located. After reaching the maximum polarization the microwaves are switched off to stop the DNP process. The temperature in the refrigerator is lowered down to 60 mK in about 25 minutes and the nucleon spins are 'frozen'.

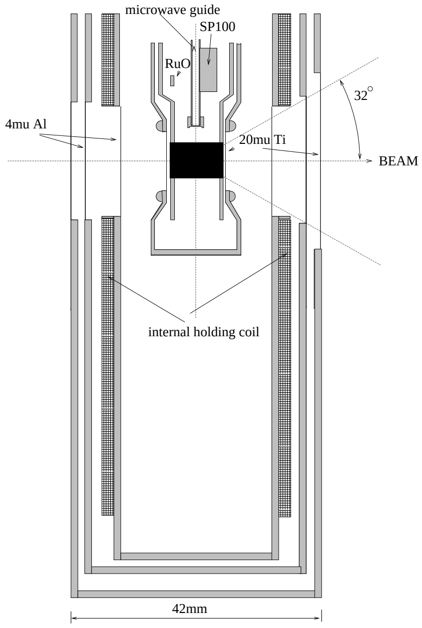

Figure 1: The lower part of the dilution refrigerator with target block, NMR coil and super conducting holding coil.

The degree of the nuclear polarization is measured with the continuous wave nuclear magnetic resonance technique (NMR)[4]. The area of the enhanced signal is compared with the area of the thermal equilibrium - signal, which is taken at a known temperature (T=1K) and a known magnetic field (B=3.5T).

The general idea is to utilize the very long relaxation time of the nucleon polarization for temperatures below 70 mK. Subsequently the polarization can be maintained by a substantially lower magnetic field of 0.3–0.5 T provided by a so-called internal holding coil.

The Bonn Frozen Spin Target [3] was modified [Figure1] in order to adapt the existing vertical dilution refrigerator to the experimental requirements. The target region was minimized to ensure that the uncharged $\lambda(\bar{\lambda})$ pass the veto counter before their decay into $p\pi^-(p\bar{\pi}^+)$.

In order to maximize the luminosity a one block butanol target was used. The alcohol was doped with TEMPO to implant the paramagnetic centers, which are required to achieve a high nuclear polarization via the DNP process. One of the major modifications, which was a inalienable requirement in order to make this experiment possible, was the internal holding magnet. This magnet consists of two coils with a gap of 20mm. The split pair configuration was wound on the inner radiation shield, which was connected to the still of the refrigerator. Each coil had 15 layers and 6250 windings. The maximum operation field was 0.48T at a current of 8.2A. The fringe field was very small, consequently the influence on the microstrip counters, which were positioned very close to the outer vacuum jacket, was negligible.

3 Measurements and results

The DNP and the polarization measurements were performed in a magnetic field of 3.5 T, using an Impatt diode as the microwave source. The average target start-up polarization was 70 % and the average polarization during the data taking was 64 %. The error $\Delta P/P$ is put together by the error in the NMR measurement and by the inhomogeneous relaxation. The latter caused by the inhomogeniety of the holding field and by the depolarization produced by the beam. The error in the determination of the polarization is given to $\Delta P/P \leq 4.5\%$.

References

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