THE COMPASS POLARIZED TARGET

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The major goal of the COMPASS muon program will be the measurement of the gluon contribition $\Delta G/G$ to the spin of the nucleon. This will be done by observing open charm neutral mesons produced by the scattering of longitudinally polarized muons off a longitudinally polarized solid state target. The polarized target will be a further development of the one used for the measurement of the proton and neutron structure functions g_1^p and g_1^n by the SMC collaboration. ^{6}LiD and NH_3 will be used as the polarized target materials, both are superior in terms of the figure of merit.

1 General Description

The existing SMC polarized target[1] can be used for the COMPASS muon program, but has to be modified in some details. A larger superconducting magnet was constructed to allow for a sufficiently large angle under which the produced hadrons emerge from the target. This demand also requires modifications to the dilution refrigerator, mainly concerning the geometry of the target cells and the microwave cavity[a].

The fundamental operation of the target stays the same: The target nuclei will be polarized by the method of dynamical nuclear polarization (DNP)[2] in a homogeneous magnetic field of 2.5 T under a temperature of 200 - 300 mK. Microwaves with frequencies slightly above and below the Larmor frequency of the paramagnetic centers, implanted in the diamagnetic target materials during the preparation process, transfer the high electron polarization present under these conditions to the nuclei.

In the case of the measurements with longitudinal spin orientations the target will be operated in the polarizing mode also during data taking to obtain the highest possible average polarization. In the transverse case the target must be switched to the 'frozen spin' mode after finishing the polarization mode. The microwave irradiation is stopped, the cryostat cooled down to its base temperature of 50 mK and the polarization is maintained by a vertical holding field of 0.5 T. Under these conditions the nuclear relaxation time is of

[a] A drawing of the COMPASS polarized target lay-out can be found in the article of H. Fischer about 'COMPASS, The Future Spin Physics at CERN' in these proceedings.

the order of several hundred hours.

Like in the SMC case, the target holder consists of two parts with the material polarized in opposite directions. The polarized μ^+-beam, which is produced via the decay of secondary pions, will have an energy of 100 - 200 GeV and an intensity of $2 \cdot 10^8$ particles within a spill of 2 sec every 14.4 sec. In order to achieve a luminosity of 10^{31} to $10^{32}\,1/\mathrm{cm}^2\mathrm{sec}$, it is thus necessary to use long target cells (2 x 60 cm in length) each having a diameter of 3 cm. They are separated by a microwave stopper, which ensures the correct microwave frequency to be present in each cell.

2 Target Materials

The gluon spin content will be extracted from the asymmetry of D_0, $\bar{D}_0$ production in the scattering of polarized muons off polarized nucleons. The experimentally observable asymmetry is weighted by the beam polarization as well as by the effective target polarization, namely the nuclear polarization times the dilution factor, which is the number of polarizable nucleons divided by the number of all nucleons present in the target. The latter two numbers define the quality of a polarized target material. Seen under this point of view, Ammonia (NH_3), which has been already used for the 1996 SMC data taking period, and ^{6}LiD[3] are the best materials available. Especially ^{6}LiD offers the highest dilution factor of all polarizable target materials. A recent three-body $(\alpha+n+p)$ calculation[4] of the ^{6}Li nucleus came to valence nucleon polarizations in excess of 92 % with respect to the ^{6}Li polarization.

Similar to NH_3 the production procedure of ^{6}LiD also includes an irradiation with 20 MeV electrons in order to create the above mentioned paramagnetic centers, which are necessary for the DNP process. In the case of ^{6}LiD these centers are called 'F-centers'. The correct choice of the temperature, under which this treatment has to take place, is the most crucial parameter for the polarizability of this compound. For the 850 cm^3 of material needed for one filling of the COMPASS target, a new irradiation cryostat was constructed and has recently started operation.

The equal spin temperature (EST) theory predicts a considerable dependence of the achievable maximum polarization on the width of the EPR resonance line, which is given by hyperfine interaction of the F-center electron with the surrounding nuclear moments. Thus it is essential to use the purest material (especially in terms of the residual ^{7}Li content) available. In order to minimize the ^{7}Li content, the whole amount of material will be synthesized from 95 % enriched ^{6}Li metal[b] and pure deuterium gas (2.7).

[b]Kindly placed to our disposal by G. Baum of the University of Bielefeld.

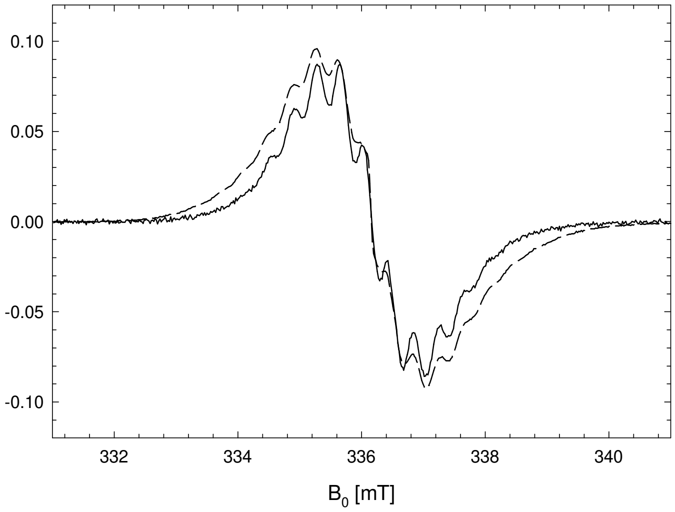

Figure 1: EPR spectra of electron irradiated ^{6}LiD: Solid curve taken from material with about 7 % ^{7}Li, dashed curve from material with 10-15 % ^{7}Li content.

Figure 1 compares the EPR of the F-center in two ^{6}LiD samples with different ^{7}Li content. It can be clearly seen, that the signal observed in the material with less ^{7}Li content is considerably smaller, especially in the tails. Furthermore the EPR lines exhibit a partially resolved hyperfine splitting, which belongs to the F-center interaction with the six nearest ^{6}Li neighbours and determines the overall width of the resonance. Similar hyperfine lines could be also observed in the isotopic compositions ^{7}LiD and ^{7}LiH, whereas in ^{6}LiH the hyperfine interaction is unresolvable, but nevertheless responsible for the width of the EPR envelope. The observation of the F-electron interaction with its environment for the first time opens up the possibility to understand in which way the variation of the irradiation parameters manifests in the nature of the paramagnetic structure well suited for the DNP process.

References

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