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POSSIBILITY OF BUILDING A POLARIZED TARGET OF ^{6}LiD

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^{6}LiD has been proposed[1-2] as a promising material for polarized targets, because of its high content of polarizable nucleons. As far as the nuclear spin polarization is concerned, the ground state of ^{6}Li can be described as :

$$^6\mathrm{Li} \sim {}^2\mathrm{D} + {}^4\mathrm{He} ,$$

so that ^{6}LiD appears in fact as two deuterons (both polarizable) and one ^{4}He (with no spin). This high density of deuteron, or "effective deuteron" (10^{23} per cm^3) is particularly interesting when one needs a target of polarized neutrons : since free neutrons do not exist in matter, one has to resort to polarized deuterons (the deuteron is a weakly bound structure wich can be described with a reasonable accuracy as a neutron and a proton with parallel spins and no orbital moment). Let us remark that ^{6}LiD can make also a suitable target of polarized protons, and more generally of polarized nucleons, for all cases where it is not harmful to have protons and neutrons simultaneously polarized. Furthermore, some experience has been acquired during the past five years in polarizing ^{7}LiF [3] and ^{7}LiH[4] which are chemically very near. Roughly speaking, one could hope for a polarization of ^{6}Li in ^{6}LiD comparable to that of ^{7}Li in ^{7}LiH, i.e. of the order of 80%.

As a test, a small sample of ^{6}LiD was prepared and polarized, using the same techniques as in [4]. These include :

1) Creation of F-centers by irradiation with 3MeV electrons, in a cold loops using liquid Argon[5]. The conditions of the irradiation were :

incident current : $10 \mu A/cm^2$
" energy : 3MeV
duration: 1 hour.

The resulting dose received amounts to 2×10^{17} $e\ell/cm^2$ and the concentration of F-centers is $1.3\times10^{19} cm^{-3}$.

2) Dynamic nuclear polarization in a magnetic field of 6.5 Tesla, using a 182 GHz carcinotron and a dilution refrigerator.

The result obtained is a polarization of ^{6}Li and ^{2}D nuclei of about 70%, which proves the potential worth of ^{6}LiD as a polarized target material. Let us examine now the three outstanding problems that have to be solved for building an operational target.

1. MAGNETIC FIELD.

The field of 6.5 Tesla was obtained with a high homogeneity, split-pair superconducting magnet built for neutron diffraction studies of nuclear antiferromagnetism[6]. We have also used a 2.5 Tesla electromagnet, in which case the nuclear polarization obtained was of only 40%. In the present "state of the art", one must choose between large access and high polarization.

2. POLARIZATION TIME.

The limiting polarizations were obtained in a time of 20 to 40 hours, which is appreciably longer than in standard target materials, and may be inconvenient. The possibility of reversing the polarization by the NMR technique of "fast passage" was tested and found to be unsatisfactory (yield of 75% only, at 2.5 Tesla and 50mK). For fast reversal of the polarization the only possibilities left are : either a double target with opposite polarizations, or a considerable improvement in the sample preparation, to shorten the polarization times.

3. SIZE OF THE SAMPLE.

The dimensions of the sample (which is composed of sintered material) were 5×5×0.5mm. The maximum thickness is limited to about 1mm because of the small penetration of the 3MeV electrons, and also the necessity of cooling efficiently the sample during the DNP. A large target such as those used in high energy experiments should then be realized by piling up a large number of small samples, each one being irradiated separately with 3MeV electrons. It is thus absolutely necessary to improve the reproducibility of the irradiation (which is not very satisfactory at present). This is believed to depend upon a better control of the temperature of the sample during irradiation. A new cooling system is now under study for that purpose.

In conclusion ^{6}LiD has proven to be a possible choice for a polarized target material. A large amount of development work still remains to be done, and this lies now in the hands of high energy and target development physicists if they consider that the advantages of ^{6}LiD warrant the effort.

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ABSTRACT

Polarizations exceeding 70% for the nuclear spins of lithium and deuterium have been obtained in a small sample of ^{6}LiD. These results make ^{6}LiD a polarized target material which outperforms all others tried so far. We outline briefly the problems that have to be solved for building an operational target.