The Nuclear Polarization of Molecules from Recombined Polarized Hydrogen and Deuterium Gas Atoms – New Measurements in the Framework of an International Science and Technology Center Project

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During the past decade, polarized atomic H and D gas targets have been successfully applied at storage rings. In order to increase the target thickness over that obtained with an atomic jet, the beam from a polarized atomic beam source is directed into an open storage-cell tube in which the atoms make several hundred collisions before they escape from the target tube [1]. However, a fraction of the polarized atoms recombines in the wall collisions. The nuclear polarization, of the molecules is not directly accessible with a Breit-Rabi polarimeter (as used at HERMES), only the polarization of the atoms extracted from the cell can be measured. In order to overcome the resulting systematic uncertainty in the total overall nuclear polarization of the target gas, in an earlier measurement [2] the nuclear tensor polarization in recombined D_2 molecules in spite of the high statistical uncertainty was found to be retained partially (fraction 0.81 ± 0.31). The nuclear polarization of recombined H_2 molecules was recently studied in a separate experiment [3, 4]. A high value has been found for a strong external magnetic holding field.

In the framework of an ISTC project [5, 6], additional investigations of polarized hydrogen and new studies of polarized deuterium molecules are being prepared. The scheme of the set-up, which is developed, built, and tested in Gatchina and then will be transferred to Jülich, is shown in

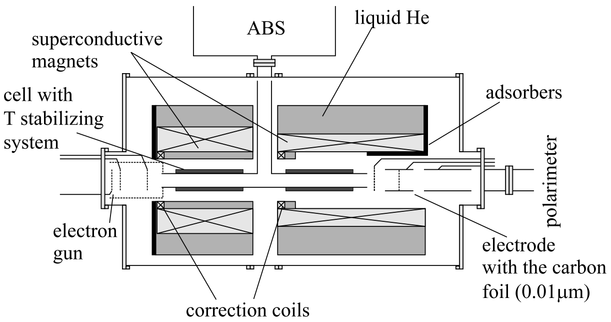

Fig. 1: Schematic drawing of the set-up, being developed in Gatchina in the framework of the ISTC project, in its position between the polarized atomic beam source and the Lamb-shift polarimeter after the transfer to Jülich.

Fig. 1. The storage cell will be fed by the H or D beam from the polarized atomic beam source (ABS, [7]), built for the polarized gas target of the ANKE/COSY spectrometer and to be used for the present studies between the beam times. Following a suggestion by W. Haeberli [8], $H(D)^+$ and $H(D)_2^+$ ions are produced from atoms and molecules in the storage-cell by electron bombardment, which are then accelerated to 50 keV a the strong longitudinal magnetic holding field (up to 5 T) onto a thin carbon foil. There, still in the strong field, the $H(D)_2^+$ ions are stripped, leaving two protons of 25 keV each, contrary to the protons from atomic hydrogen whose energy is 50 keV. Appropriate choice of the electric potentials of the electron gun, the cell, and the electrode supporting the carbon foil yields either protons from gas atoms or protons from gas molecules of 500 eV required for the analysis by the Lamb-shift polarimeter. In the first mode the protons from molecular dissociation cannot reach the polarimeter, in the second case the protons from atomic hydrogen of about 25 keV cross the polarimeter essentially without interaction in the Cs charge-exchange region of the Lamb-shift polarimeter. The polarimeter has been developed, built, and tested at the Universität zu Köln [9, 10]. For the final commissioning it has been installed at the polarized atomic beam source for ANKE.

The studies will focus the dependence of the nuclear polarization, maintained in the recombined molecules, on the cell-wall material and temperature and on the strength of the magnetic field on the cell. Effects from variation of the average number of wall collisions can be studied by changing of the cell dimensions. Most important will be to investigate the difference in the recombination process for $\vec{H}$ and $\vec{D}$. For hydrogen the lowest ortho-molecular state is the J=1 rotational state, whereas for deuterium it is the J=0 rotational ground state. The present status of the project is described in ref. [11].

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References:

[1] W. Haeberli, in: Free and Stored Beams as Internal Targets, AIP Conf. Proc. **128** (AIP, New York, 1984), p. 251.
[2] J.F.J. van den Brand et al., Phys. Rev. Lett. **78**, 1235 (1997).
[3] T. Wise et al., Phys. Rev. Lett. **87**, 042701 (2001).
[4] T. Wise et al., contribution to the present report.
[5] International Science and Technology Center, project no. 1861.
[6] Information to the ISTC initiative is found under www.istc.ru.
[7] M. Mikirtytchiants et al., contr. to the present report.
[8] Private communication.
[9] R. Engels, PhD thesis, Universität zu Köln (2002).
[10] R. Engels et al., contribution to the present report.
[11] Internal report on the 3[rd] project meeting December 19 and 20, 2001. Available from the ANKE ABS group.

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