POSSIBILITY TO OBTAIN A HIGH DENSITY POLARIZED ORTHO-HYDROGEN GAS TARGET.

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The novel high intensity source of a polarized molecular hydrogen which is based on the classical Stern-Gerlach separation scheme is discussed. It consists of the capillary beam formation system cooled down to 10 K and superconducting 12-pole magnet with a magnetic poletip field up to 5 T. The computer calculations show that $1 * 10^{17}$ polarized molecules per second could be injected into the cold (10K) storage cell, yielding a target thickness of about $10^{15} mol./cm^2$. The expected degree of nuclear polarization is about 0.7.

Introduction

There is a strong interest in nuclear physics for a dense, highly polarized hydrogen witch is used as an internal gas target in polarized scattering experiments. Different techniques of gas target preparations and their advantages are widely known [1,2].

We suggest to obtain a polarized molecular hydrogen by use a cold capillary beam formation system in combination with a superconducting 12-pole magnet for a nuclear spin separation.

Description of the source of polarized hydrogen

A schematic view of the source and target arrangement is shown in Figure 1. A cold (10K) molecular beam is produced by high transparency microporous membrane. In this way the peak intensity could be increased by a factor of about 100 compared to a cosine law source for the same total flow. Regular microporous membrane with pores of $0.3\mu m$ in diameter and $30\mu m$ thickness have a geometrical transparency up to 70% and could be fabricated by deep X-ray lithography [3]. Membrane has a ring shape with 17.7 cm inner diameter and 19.7 cm outer diameter in perpendicular layer of the beam axis.

Peaked molecules enter into the superconducting 12-pole magnet through a ring aperture near by inner surface of the magnet. The accepted beam solid angle and thus the flux of the selected particles is proportional to poletip field B_0. The greatest poletip field might be obtained in a superconducting magnet. At the same time the cold surface of the wall of the magnet might be used

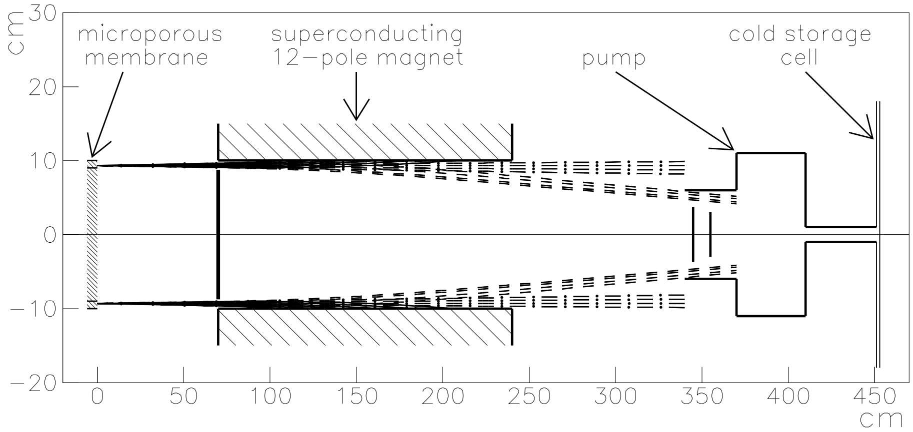

Figure 1: Schematic view of the molecular beam source and calculated trajectories of hydrogen molecules in different energy states (dashed lines – A, B, C states; dot-dashed lines – D, E, F states; solid lines – G, K, L states.)

as a cryopump to get good vacuum conditions along the beam axis. Having some experience in construction and operation with superconducting sextupole magnets [4] we suppose that superconducting 12-pole magnet with aperture of 20 cm in diameter and poletip field up to 5 T might be manufactured.

The Zeeman structure of molecular hydrogen is shown in Figure 2. Each energy state is defined by a nuclear spin projection m_I and projection of a orbital angular momentum m_J. The molecules in A, B and C energy states are focused by a magnetic field of the superconducting 12-pole magnet as illustrated in Figure 1 (dashed lines). The molecules in G, K and L states are defocused and pumped by inner surface of the magnet (solid lines). The molecules in D, E and F energy states pass through the magnet without deflections (dot-dashed lines) and also are pumped. The focused polarized molecules are collected by pump and transported into the storage cell. To decrease a depolarization due to wall collisions a magnetic field up to 0.4 T of strength should be applied. To increase a target density the storage sell should be cooled down to 10 K.

Results of the calculations

The results of ray tracing calculations for the most probable velocity ($3 \times 10^4 cm/sec$) of moleculer hydrogen are illustrated in Figure 1. The calcu-

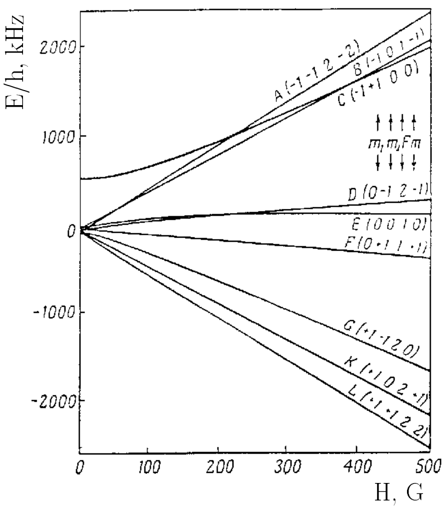

Figure 2: The energy of H_2 states versus a magnetic field. $F = I + J$, $m = m_I + m_J$ – total angular momentum and its projection.

lations show that about 10^{17} polarized molecules per second could be held by pump and injected into a cold storage cell, yielding a target thickness of about $10^{15} mol./cm^2$. The first experimental results from NIKHEF show that molecules retain polarization inside the storage cell for a long time [5]. The decision of the Shroedinger equation for a polarized molecular hydrogen experiencing wall collisions in the presence of a 0.4 T magnetic field gave us $P_z = 0.65$ after 500 wall bounces (initial $P_z = 1.0$). A simple quantum model was taken into account and it predicts a lower limit for nuclear polarization.

References

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