The Lamb-Shift Polarimeter for the Polarized Internal Target at ANKE

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The Lamb-shift polarimeter (LSP, Ref. [1, 2]) is an instrument well suited to measure the nuclear polarization of the atomic hydrogen or deuterium beam produced by the polarized atomic beam source (ABS) developed for the polarized internal gas target of the magnet spectrometer ANKE in the COSY ring. With the full ABS beam intensity of 7.8×10^{16} $\vec{\mathrm{H}}$ atoms/s), entering the ionizer, the polarization is measured within 2 s with an accuracy better 1%.

A reduction of the error has been achieved with the new ionizer by the installation of non-evaporable getter modules [3] around the ionization volume. With this additional internal pumping speed of 2000 l/s, the background pressure in the ionizer is appreciably reduced to 10^{-9} mbar even if the ABS beam of full intensity reaches the ionizer. Especially the background of recombined H_2 molecules in the ionizer chamber is efficiently suppressed. This results in a strong reduction of proton production from recombined H_2 molecules reaching the ionization volume. Thus, their contribution to the peaks in the Lyman α spectrum, measured in the quench section, now is much lower. The correction factor, necessary to deduce the beam polarization and earlier dominating the error, is decreased by one order of magnitude by the internal pumping module.

The H_2 molecules in the ionization volume now predominantly come with the ABS beam. This allows one to measure the ratio of H atoms and H_2 molecules in the beam. The Wienfilter [4] is used to separate the mass 1 and 2 ions extracted from the ionizer. Fig. 1 shows the ion currents, measured in the Faraday cup behind the Wienfilter with the chopped ABS beam. The extremely low background, measured when the chopper is closed, demonstrates the quality of the achieved vacuum. With use of the electron-impact ionization cross section ratio for electrons of 10^3 eV, $\sigma_{H_2}/\sigma_H = 1.85 \pm 0.025$ [5], the H_2 admixture in the ABS beam results as (2.8±0.4)%.

Installed at the polarized internal storage-cell gas target (PIT) [6] of the ANKE spectrometer, the LSP will be used to measure the nuclear polarization of the hydrogen or deuterium cell gas. As done at the HERMES target [7], a small fraction of the cell gas is deduced by a polarization-sample tube and fed into the LSP ionizer. Compared to the intensity of the directed beam from the ABS, the intensity of the incomming atoms drops by about 4 orders of magnitude to $\approx 10^{13}$ atoms/s. To study the feasibility of these measurements, a test setup of feeding, storage, and sample tubes, all made from teflon, in a weak magnetic field was fed by the $\vec{\mathrm{H}}$ beam from the ABS. From the new ionizer the expected number of polarized protons (10^9 p/s ~ 0.1 nA) could be extracted. However, in spite of use of the getter module, the background by unpolarized protons, stemming from residual gas, was higher than expected. Further measurements are underway.

The installation at ANKE imposes a number of modification in the LSP setup:

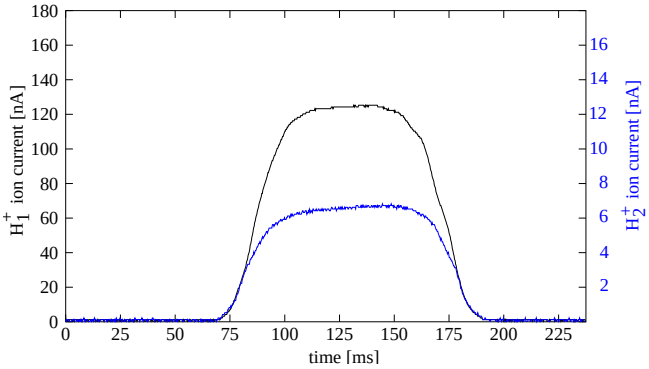

Fig. 1: The H_1^+ (upper curve, black, left-hand scale) and H_2^+ (lower curve, blue, right-hand scale) currents of ions extracted from the ionizer and separated by the Wienfilter, measured with a Faraday cup positioned behind the Wienfilter. The beam from the ABS was opened and closed by a rotating chopper in front of the ionizer.

- A shorter Wienfilter was built [4]. It allows to rotate the quantization axis of polarized deuterons by about 90° up to the highest LSP-beam energies. In first studies a transmisson of 25% was achieved, which should reach about 70% by a slight modification of the electric field plates.
- The space limitations at ANKE necessitate a 60° deflector for the ion beam. Having been design, built, and tested [4], it is ready for installation.
- The new LSP support system, which follows the movements of the ANKE-target chamber, has been designed and presently is under construction.
- The software extension of the Siemens Simatic S7 control system is finished and the hardware is established. Tests are planned for the near future.

References:

[1] R. Engels et al., Rev. Sci. Instrum., Vol. 74 (2003) 4607.
[2] R. Engels, PhD Thesis, Universität zu Köln (2002).
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[7] J. Stewart et al., Proc. Int. Workshop on Polarized beams and Targets, Köln 1995, Eds. H. Paetz gen. Schieck and L. Sydow (World Scietific, 1996), p. 408.

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