The Polarized Internal Gas Target for ANKE - Status and Future Developments[1]

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An atomic beam source (ABS) for polarized hydrogen and deuterium is under development which will be utilized to feed the storage-cell of the gas target to be installed at the magnetic spectrometer ANKE. The assembling of the ABS has been completed. This contribution presents the essential constructional elements of the ABS complementing an earlier report [1], it gives the results of the first beam studies, and lists the future steps to establish the polarized gas target at ANKE.

Layout of the ABS

The layout of the ABS is shown in Fig. 1. Due to space restrictions at the ANKE target area, only a vertical installation is possible. The slight tilting by about 6^o may be required in order to avoid sputtering material from the discharge in the dissociator (**1**) to drizzle into the storage cell (**7**). Laboratory test runs will show, whether the inclination is needed. A powerful pumping system provides the necessary vacua in the chambers **I** to **IV**. Two Pfeiffer TPH2200 turbopumps (combined H_2 pumping speed 5600 ℓ/s) are mounted on chamber **I**, each followed by a Pfeiffer TMH260 turbopump. The two TMH260 are backed by a common third-stage TMH260 and finally by two Pfeiffer MD8 diaphragm pumps. The smaller gas load in chamber **II** is pumped by a single set of TPH2200-TMH260-MD8. Two Leybold Coolvac 3000 cryopumps (each of 3000 ℓ/s H_2 pumping speed and of 28 barℓ H_2 capacity at 10^{-6} mbar) are installed at the chambers **III** and **IV**. This pumping system (14400 ℓ/s in total) at a primary H_2 inlet flow of 1.5 mbarℓ/s yields pressures of about 10^{-4}, 10^{-6}, 10^{-7}, and $5 \cdot 10^{-8}$ mbar in chamber **I**, **II**, **III**, and **IV**, respectively.

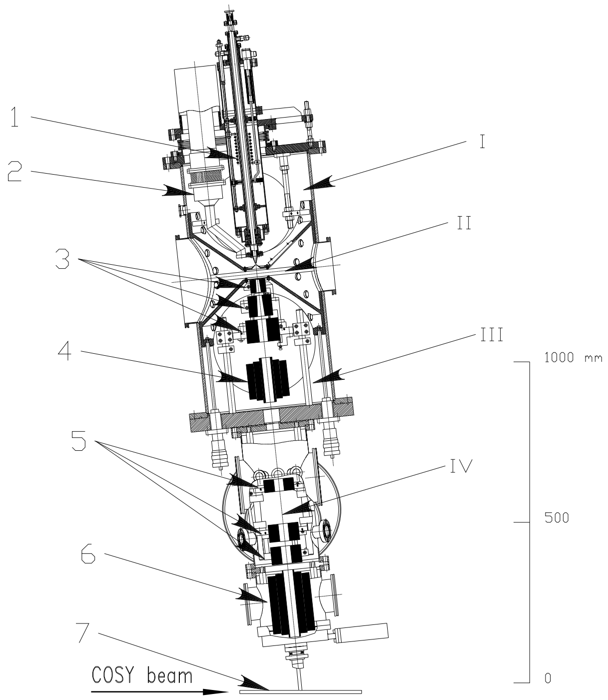

Figure 1: The atomic beam source for ANKE (bold face numbers in the text refer to those in the figure).

The plasma discharge in the dissociator (**1**) is maintained by inductive coupling of 13.56 MHz from a rf-power supply and an adapter network. The inner discharge tube (Duran 8330 glass of 14 mm outer diameter and 1.5 mm wall thickness) is cooled by a coaxial water flow. The nozzle at the lower end of the dissociator can be cooled down to about 40 K by a Leybold RGS120 1-stage cryocooler (**2**) via a flexible connection by either a Cu heat bridge or a Ne heat pipe. The details at the lower end of the dissociator are shown in Fig. 2. The transition from the cold nozzle to the outer dissociator tube avoids any force on the discharge glass tube. Thermal contact to the lower part of the discharge tube is provided by a modified sliding rf connector. This special construction allows to extract and reinstall the glass tubes and the rf-generating elements without disassembling of the heat bridge and nozzle. The design considerations for the set of permanent sextupole magnets (two groups, **3** and **5**) and the results of the field distribution measurements are described in a recent publicationr [2]. To protect the magnets from hydrogen, they were enclosed in stainless steel cans with inner tubes of 0.2 mm thickness in order to maximize the free magnet apertures.

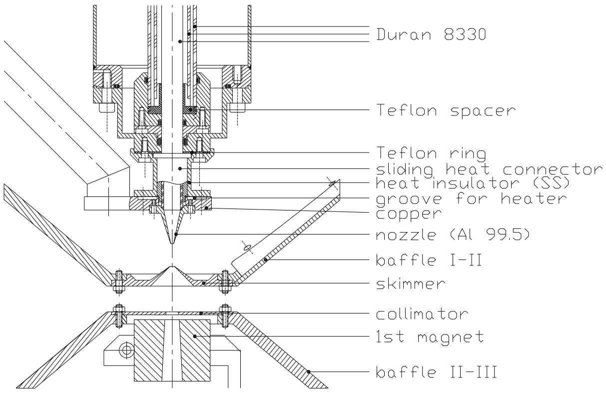

Figure 2: The region between the lower end of the dissociator and the first sextupole magnet (diameter of nozzle, skimmer, and collimator: 2, 3, and 8 mm, respectively; distance from skimmer entrance to first magnet 35 mm). Components not labeled are made from stainless steel (SS).

Both rf transition units to provide purely polarized H atoms with $m_I = \pm 1/2$ have been designed and built at Universität Erlangen [3]. The medium-field unit (**4**) has been installed, tested, and is ready for operation. The weak- and strong-field unit (**6**) will be installed as soon as the Lamb-shift polarimeter is available for beam-polarization studies.

Results of first ABS-beam studies

With a crossed-beam quadrupole mass spectrometer degrees of dissociation of the beam have been measured to be about 70% for a pure H_2 inlet flow of 1.0 mbarℓ/s. The ABS operation parameters have been determined by maximizing the atomic beam intensity into a compression tube. Its dimensions (10 mm diameter and 100 mm length) and its position (tube entrance 300 mm behind the last sextupole magnet) are those of the future storage-cell feeding tube. The resulting values of 1.3 mbarℓ/s for the H_2 inlet flow and 300 W for the rf power are close to those measured at other sources [4, 5, 6] of comparable geometry and aiming at high beam intensity, e.g. to feed a storage cell [4, 5].

With a fixed distance of 35 mm between skimmer entrance and first magnet, the optimum nozzle-to-skimmer distance was found to be 14.8 mm. With these values the H beam intensity into the compression tube has been measured as function of the temperature at the base of the nozzle. The results are shown in Fig. 3. The highest intensity of

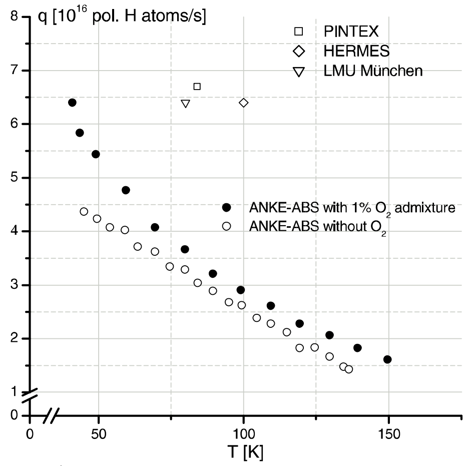

Figure 3: $\vec{H}$-beam intensity into the compression tube as function of the nozzle temperature compared with the values given for other sources in similar geometry (for PINTEX, HERMES, LMU München see refs. [4], [5], and [6], respectively).

$(6.4 \pm 0.3) \cdot 10^{16}$ is close to the best values published for other sources. However, it is obtained with a lower input flux. Measurements of the temperature distribution along the nozzle are underway. As suggested by Fig. 3, the beam intensity will be measured at lower nozzle temperatures possibly after installation of a 2-stage coldhead.

Future developments

A Lamb-shift polarimeter has been designed, built, and tested with unpolarized gas [7] at the Universität zu Köln [8]. It has been transferred to Jülich and it first will be used to study the nuclear polarization of the atomic beam, thus enabling a fine tuning of the rf transition units, and later to investigate the polarization of the gas in the storage cell. The slow control and interlock system is extended to control the various polarimeter components as well.

COSY-beam studies have been started with use of simple rectangular and elliptical diaphragms of 10 mm vertical and 30 mm horizontal width placed at the ANKE-target position. The first results demonstrate that additional beam-position monitors and vertical beam steerers near the ANKE target are required.

A new large target chamber is under development which will allow to extend the beam studies with storage-cell prototypes. The chamber will also house tailored beam- position monitors near the storage cell of the polarized gas target.

The nuclear polarization of the target gas in a storage cell can be determined by measuring polarization observables in the interaction of the target nuclei with the accelerator-beam projectiles, if polarization data exist. Otherwise a suitable polarimeter has to be used to analyze a subsample of the gas extracted from the target cell. However, such polarimeters (like the Lamb-shift polarimeter) are suited to measure the nuclear polarization of atoms and do not directly yield information on the nuclear polarization of recombined molecules in the target gas. In order to continue and to complete first measurements on the nuclear polarization in recombined H_2 and D_2 molecules at NIKHEF [9] and IUCF [10], a collaboration project with the PNPI has been started in the framework of the International Science and Technology Center (ISTC) initiative [11].

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