Ionizer and Charge-Exchange Unit for the New Polarized Hydrogen Source ◇

A. Metz, K. El Abiary, R. Hertenberger , P. Schiemenz, S. Trieb, and G. Graw

The new ion source for intense polarized hydrogen beams is designed as injector for the Munich MP-Tandem. A Stern-Gerlach atomic beam source (ABS) produces intense neutral $\vec{H}$ or $\vec{D}$ beams, which will be first ionized in an electron-cyclotron-resonance-ionizer (ECR) and then negatively charged by pick-up of two electrons in a cesium gas-target of 10^{15} atoms/cm^2. This scheme seems to be a reasonable compromise in regard to efficiency and reliability in operation. Intensities of negative $\vec{H}$ and $\vec{D}$ beams of several μA and polarizations of 75% for $\vec{H}$ and 85% for $\vec{D}$ seem feasible [1]. Alternative schemes are ionization in electron beams with a smaller ionization efficiency or the direct negative charge exchange in a cesium beam. The latter is used at COSY in pulsed mode [2], but reliability for dc beams may be a problem. An interesting alternative has been recently discussed by Clegg, the resonant charge exchange of slow negative H or D beams on neutral $\vec{D}$ or $\vec{H}$ atoms, which are stored in a target cell similar to the HERMES storage target. A study of feasability is about to start at TUNL.

Our atomic-beam-source [3–5] is largely optimized. Over 3 periods of in total 40 hours it was running stable with an intensity of 6.2×10^{16} pol. H-atoms per sec.

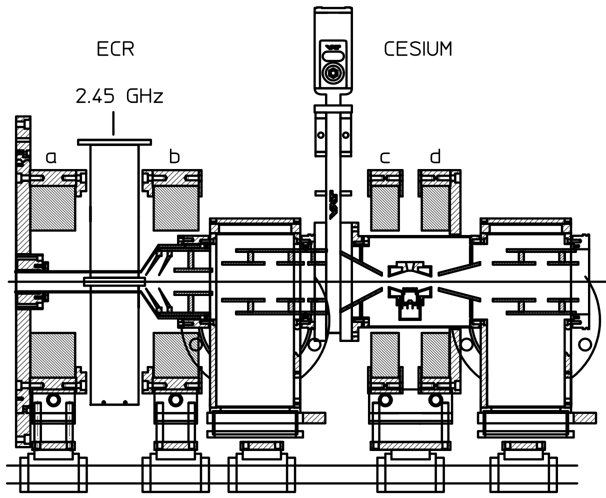

Fig. 1: Vertical section of ECR ionizer and cesium charge-exchange unit; the lens-system is given schematically.

Fig. 1 shows the design of the ECR-ionizer and the two-step charge exchange unit. Four pancake coils (a...d) provide an axial-symmetric magnetic field, which is shaped such that the first two coils create a magnetic bottle (250mT...80mT...120mT) for the ECR ionizer and the second two coils a holding field of about 100 mT to preserve nuclear polarization during electron pick-up by decoupling nuclear and electron spin.

A commercial wave-guide couples the rf-power of 2.45 GHz and 50 W to the ECR plasma. To maximize electron density and ionization probability we aim for a closed ellipsoidal resonant magnetic surface of 87.5 mT in the wave-guide, with a diameter approximately equivalent to that of the active beam area. Herefore, a sixpole field of strong FeNdB permanent magnets is overlaid to the axial mirror field.

The plasma potential will be defined by an electrode to 600 eV per nucleon. A grounded entrance aperture of 10 mm diameter is used to collimate the incoming neutral beam from the ABS. It also prevents spread of the plasma into the ABS region. The electrostatic lens system will be similar to that of our Lamb-Shift source (LSQ). We have to consider the presence of radial magnetic fields along beam transport. Charged particles pick up azimuthal angular momentum and in regions of stronger radial magnetic fields beam diameters have to be kept as small as possible.

Recently, we redesigned the cesium-oven of the Lamb-Shift source to have better collimation of the cesium vapour. Besides better recirculation of the cesium we observed an increase in beam intensity on target by at least 50 % to 220 nA. The design of the oven seems also applicable to provide the 20 times larger cesium vapour thickness needed at the new source. Two vacuum chambers with large openings enable the maintenance of the lens systems and the cesium region. Each of them will be pumped by one 500 l/sec turbomolecular pump and one 1500 l/sec cryo pump.

The status is as follows: The coupling of the 2.45 Ghz rf-power works on a test stand. Together with the pancake coils we are installing the wave-guide just now on the ABS plattform. In the next month we hope to light the ECR plasma. The vacuum chambers are designed. The lens system is under optimization, results from a ray-tracing simulation program [6] are forthcoming.

References

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◇ Supported in part by BMBF and DFG