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PRODUCTION OF AN INTENSE DC POLARIZED BEAM WITH AN ECR IONIZER

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Résumé - L'intensité du faisceau polarisé du PSI a été fortement augmenté par l'installation d'un ioniseur de type ECR à la source polarisée. Les nouvelles performances du faisceau accéléré sont présentées.

Abstract - The intensity of the PSI polarized beam has been significantly increased by the installation of an ECR ionizer at the polarized ion source. The new performances of the accelerated beam are presented.

The last major progress discussed at this series of Conferences was the installation by Jaccard /1/ of a cold atomic beam stage in 1985. With this new component the accelerated beam intensity has been increased from 1-1.5 \(\mu\)A to a routine value of 3-4 \(\mu\)A. Beams of 5 \(\mu\)A have been observed under particularly favourable conditions. In the mean time, the refinement of the cold atomic beam technique using a nitrogen coated accomodator made it possible to produce very stable beams over periods exceeding one month.

To further improve the beam intensity, alternatives to the electron beam (EB) ionizer have been investigated. It was found that the technique used in ECR ion sources, i.e. ionization in a magnetically confined plasma heated by microwaves at the electron cyclotron resonance (ECR) frequency, has the potential to become the solution of choice for a polarized ion source.

Encouraged by the promising results of feasibility studies by Clegg et al./2/ a KfK/PSI collaboration was able to successfully test a prototype designed for operations at 2.45 GHz. While the results showed that, as expected, no depolarization occurs in the ECR field, it was also found that the design of the vacuum system is critical to reduce the contribution of unpolarized particles from the molecular background. In our case, an unperturbed passage of the atomic beam through the ionizer should be allowed by the use of an extraction system with very large aperture.

Based on the experience gained during this test, an ionizer suitable for the PSI polarized ion source was designed and installed in summer 1989. The new ionizer is shown on fig. 1. Like in the KfK/PSI prototype /3/ the Pyrex plasma chamber is surrounded by the microwave cavity located inside the sextupole magnet. New features are the absence of external parts at high voltage (the plasma potential is defined solely by the plasma electrode), an extraction system giving a better beam quality, solenoid coils with magnetic return designed to allow for operation of the ionizer at frequencies up to 6 GHz. The system is evacuated by a turbomolecular pump, a cryogenic pump and a titanium sublimator (total pumping speed 2300 l/s) to a basic pressure below 5 \(\times\) 10\(^{-8}\) mbar. The operating pressure with atomic beam and buffer gas is less than 2\(\times\)10\(^{-7}\) mbar. The ionizer is presently operated at 2.45 GHz with about 20 W of microwave power.
During the development work on the prototype ionizer large intensities (~1 mA) of 10 keV polarized deuterons could be extracted from the plasma, however beam forming was not satisfactory. Magnetic focussing may be a cure to this problem, but because of space limitations at the source it has not been considered yet. With the optimized arrangement the extracted current is smaller, but 300 μA, i.e. 80% of the beam focussed 90 cm downstream of the extraction, are within an emittance area of 600 mm mrad.

With the new ionizer, the proton intensities observed at the end target of the axial injection line have increased by more than a factor 2 between 5 and 13.5 keV injection energy.

Fig. 1 - The PSI ECR ionizer with the associated pumping chamber and electrostatic focussing system. The total height is 1220 mm.
The present status of the PSI polarized proton beam can be summarized as follows (the changes in performance compared to the electron beam "ANAC Superionizer" are given in parenthesis):

- Beam extracted from Philips Cyclotron (PC):
  - Intensities: 72 MeV, 17 MHz 12 μA (*3)
  - 72 MeV, 50 MHz 11 μA (*6)
  - 23 MeV 6 μA (*4)
  - 10 MeV 0.5 μA (*4)
  - Polarization: at full intensity 73% (*33)
  - at I = I/3 79% (*90)

- Beam accelerated to 580 Mev, on target
  (test with 9.5 μA) I(target) = I(PC) - 0.5 μA

The much lower energy spread of the beam extracted from the ECR ionizer results in a higher bunching factor when operating the PC in the third harmonic mode (50 MHz). The better beam quality allows for a better injection efficiency, especially at the lower energies. The achieved polarization is still below expectation. A large contribution (15%) of unpolarized particles arises from the ionization of the molecular hydrogen background in the ionizer. Further, the present operation at 2.45 GHz, i.e. at a low magnetic field, is unfavourable for a high proton polarization. The 79% polarization is obtained with a current in the coil at the entrance of the ionizer 10% higher than required for optimum beam intensity. A polarization exceeding 80% is expected after completion of the following improvements:

- increased pumping between the focusing electrodes
- reduction of the presently to large radial extension of the ionization volume
- operation at a frequency above 4 GHz, i.e. at larger values of the axial magnetic field

Experience with accelerated deuteron beams is missing yet, but the results obtained on the test bench /3/ where a tensor polarization of up to 85% has been observed are very promising.

In its short life since the first experimental test the ECR ionizer has proven its ability to improve the performance of the atomic beam polarized ion source by a significant factor and has already demonstrated its reliability under the routine operating conditions at the accelerator.

So far, the intensity of the PSI polarized beam has increased by almost one order of magnitude since the last Polarization Conference. This achievement would not have been possible without the work of S. Jaccard at PSI till 1986. The ECR ionizer is the result of a fruitful collaboration with L. Friedrich and E. Huttel from KfK. H. Einenkel and S. Drack are the main contributors to the successful installation and operation of the new ionizer at the PSI Philips Cyclotron.

REFERENCES


