An intense optically pumped H^- ion source

L.Buchmann, R.Burge,C.D.P.Levy, M.McDonald, R.Ruegg, P.W.Schmor
TRIUMF, 4004 Wesbrook Mall, Vancouver B.C., Canada V6T 2A3
A.Belov,V.G.Polushkin,A.Zelinskii
INR, Moscow

Abstract

An optically pumped polarized ion source producing a DC H^- current of $20\mu A$ with a polarization in excess of 50% has been developed at TRIUMF. A 28 GHz Electron Cyclotron Resonance (ECR) source is used to provide an initial proton beam. A significant increase in polarized beam current was obtained using multihole extraction electrodes in an accel-accel mode. Three dye lasers were used to polarize the sodium charge exchange target. Recent laser optimization has significantly increased the power from the dye lasers. The sodium target has been lengthened from 10 to 23 cm and immersed in a 2.1 T longitudinal field to increase the H^- polarization at the higher currents. The source design and recent pumping results are presented.

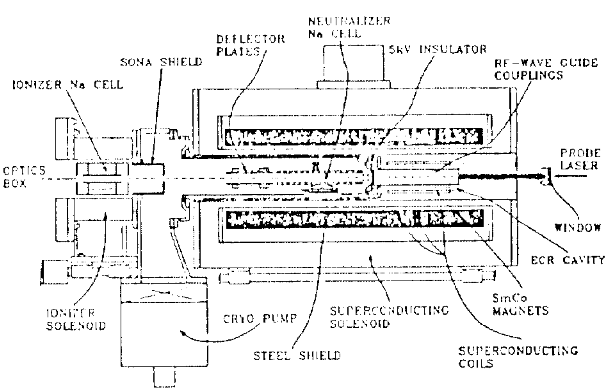

Figure 1: Overview of the optically pumped ion source at TRIUMF

An optically pumped H^- ion source based on the proposal of Anderson [1] has been installed in a 300 keV terminal and recently reconstructed within a superconducting solenoid [2,3]. The source is displayed in figure [1]. It has provided 5 μA of proton beam with over 50% polarization extracted from the TRIUMF cyclotron.

During the development of the proton ECR, which is driven with 28 GHz RF at about 850 W in two different source configurations (normal or superconducting generated magnetic ECR/neutralizer fields), several types of extraction systems have been explored. Among the different kinds of extraction electrodes a three electrode, small hole grid system driven in an accel-accel mode as displayed in figure [2] has been found advantageous in providing stable operation with a maximum of beam at a very specific setting.

To stabilize the second electrode against plasma shorts a balast resistor of 100 $k\Omega$ is used. Figure [3] shows the H^- current measured at an internal Faraday cup, the current drawn out of the cavity for a constant volt-

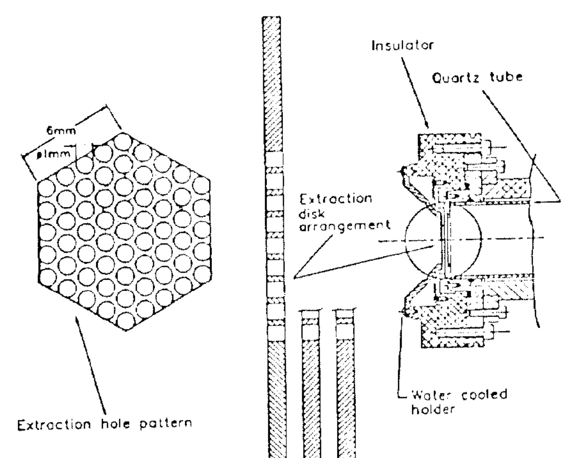

Figure 2: The ECR source extraction system as driven in an accel-accel mode

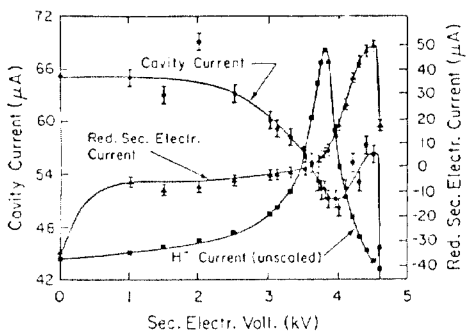

Figure 3: The H^- current, the cavity current, the reduced second electrode current versus the second electrode potential

age of 4.6 kV and the reduced second electrode current (i.e. the current derived by the subtraction of the resistor current) against the varied second electrode potential.

The laser system as shown in figure [4] consists of three rhodamin 6G dye lasers driven by a 20 W argon laser and giving a total output of up to 3 W at the pumping frequency. Very recent work on high power pumping of dye laseres has resulted in 10 W of dye laser power within a 3 GHz bandwidth, using two argon lasers to drive two dye lasers.

A Na polarization of less than 70% has been achieved for a Na thickness of $3 \cdot 10^{13}$ $atoms/cm^2$, considerably lower than expected (90%) with 2.5 W laser pump power. Radiation trapping calculation indicate that the reason may be a too wide Na cell diameter and insufficient laser power to penetrate through the cell [4].

Even though the polarization transfer in the high magnetic field of the superconducting solenoid (2T) is measured to exceed 90%, the final proton polarization is lowered by various kinds of degradation: Most significant is a strong unpolarized background beam from protons neutralized by hydrogen coming from the ECR source. In addition, there are polarization losses due to the presence of the proton beam in the optically pumped Na vapour.

The backgound beam has been energetically analysed in a narrow-slit magnetic-analysing system. By applying a voltage to the snout and the Na neutralizer cell simultaneously as well as independently it has been found [4] that the background beam most likeley originates in the snout/entrance region of the Na cell. However, biasing this cell causes severe disturbances to the beam by changing the space charge compensation. Unfortunately with a biased cell the resulting H^- beam is considerably lowered and the background beam/ Na induced beam ratio in fact increases.

Faraday rotation measurements show that the density of the Na vapour decreases as the proton beam increases (up to a factor 2 under normal operational conditions). This can be reasonably explained by elastic scattering of Na [3,4] asuming scattering cross sections in the 10^{-15} cm^2 range. However, the sodium electronic polarization is similar to the one of the thick (no beam) region. Calculations are underway to understand this phenomenon [4].

At the moment a nuclear polarimeter is under construction, based on the known analysing power of the $^6Li(p,^3He)\alpha$ reaction, to be used in the 300 keV injection line without the cyclotron. To calibrate this polarimeter it is planned to use the known polarization of the TRIUMF Lamb shift ion source.

In order to incease the polarization of the source it is planned for this fall to replace sodium with rubidium, taking advantage of the more effective Ti/Sapphire lasers for optical pumping.

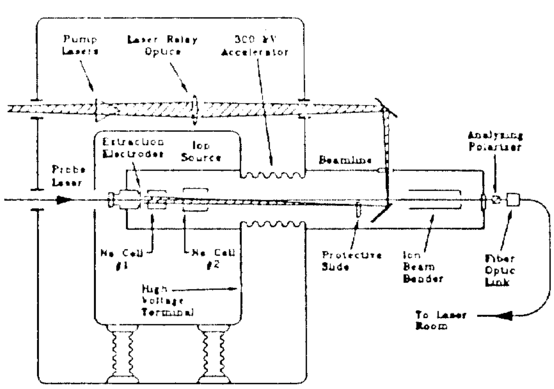

Figure 4: The laser system for the optically pumped source

References

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