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8.2 Production of a High Intensity Polarized Ion Beam from the Lamb Shift Source

A. Isoya, T.Nakashima, K. Sagara and H.Nakamura

Department of Physics, Kyushu University, Fukuoka 812, Japan

In the Kyushu University tandem laboratory various attempts have been made in the last several years to increase the output intensity of the Lamb shift source. Parts of these efforts have been reported on occasion at various places[1]. As the result the source performance could be greatly improved and it becomes possible in this laboratory to carry out the experiments of polarization transfer reactions. The design of this source is shown in Fig.1. The effort of improvement covers the whole system of the Lamb shift source and the associated devices. The most important point was concerned with the production of a primary positive ion beam with a good property. So far the Lamb shift sources have been well investigated in many laboratories and the design has been optimised in nearly all components of this device, but the primary positive ion source and the associated beam formation system had been left still in a poor situation, and then put limit on the source performance.

We have developed a powerful hydrogen atomic ion source which can produce a proton output of several hundreds mA with a very high proton percentage($\gtrsim$95%). This is a sort of magnetic ion source using a capillary arc in a narrow quartz tube. In this source the adjustment of the magnetic field strength along the tube axis from the cathode-anode region to the exit canal at the end of the quartz capillary tube is very critical. But once a good adjustment is made, this ion source can work very stably and powerfully.

Associated with this source, a special expansion cup is used. Hydrogen atomic ions, coming out of the quartz capillary tube, are pushed toward the axial direction along suddenly expanding lines of magnetic force, being cooled in the lateral thermal motion, when they travel from the exit canal of the quartz tube to the extraction grid. Owing to this effect, the emittance of the extracted ion beam is kept considerably low in spite of the fact that the beam diameter is quite large(40 mm) at the source point.

For obtaining an extremely parallel ion beam, matching a very stringent beam optics of the present Lamb shift source, a very carefully designed accel-decel extraction electrode system is required. After various trials we developed a system which is consisted of four net planes, made of fine tungsten wires(0.1 or 0.15 mm wide) accurately arranged with a pitch of 1 mm. For the accel electrode, two layers of net planes are used. A nearly parallel accel-decel field is produced between these net plane electrodes. Hence a very nice ion beam of low energy(500 eV for H^+) can be obtained.

Along with the use of a wide ion beam, a wide Cs-cell(40 mm in aperture) is used. The consumption rate of Cs is depressed to a level of 0.1~0.2 gr/hr by a wick action of fine SUS mesh lined on the wall of the entrance and exit portions of the cell. For compensating the optical property of the ion beam injected to the Cs-cell a weak magnetic lens of large aperture is placed in front of the Cs-cell.

For the space charge neutralization of the intense low energy ion beam, the use of a set of hot filaments dipped in the beam is indispensable. It was found that the location of these filaments should be as close as possible to the extraction grid. Fine control of potentials of various portions surrounding the ion beam is also very important to transmit an intense beam through the whole system of the Lamb shift source.

For sweeping charged particles after the Cs-cell a magnetic deflector is used. Usual electrostatic deflectors can not be used for the present case since it gives too much disturbance to the ion beam plasma which extends from the extraction grid to the Cs-cell by taking away swarm electrons from it.

In the original design of our Lamb shift source, for pumping argon gas from the Ar-cell, cryo-panels were equiped at the surrounding portions of the entrance and exit of the cell. These cryo-panels were found to be harmful by the reason why they were charged up by the scattered incident particles. In particular, the one at the entrance caused the quenching of H(2S) atoms. Therefore, it is now abolished.

In the last few years the output intensity of the polarized ion beam from our Lamb shift source has been increased gradually, corresponding to the steps of improvement of various components of the device. At this moment it reaches a level of 3 μA at the Faraday cup after the spin precessor with the degree of polarization of 80 % for the case of proton. More than a half of this beam intensity can be obtained on the target as an accelerated ion beam.

In the high level operating condition above mentioned, the H^+ ion beam injected into the Cs-cell is about 10 mA and the density of Cs^+ ions produced by the incident beam in the Cs-cell is estimated to become considerably high. Hence the quenching of H(2S) atoms passing by these Cs^+ ions should occur with a non-negligible strength(A rough estimste indicates a decaying factor of H(2S) of about 0.7). This effect puts the limit on the highest output intensity obtainable from the Lamb shift source. In the present system we use parallel plate baffles in the center of the Cs-cell to reduce the equilibirium density of Cs^+ ions. The observed degreee of polarization shows a trend to decrease gradually with the increase of the output intensity. However, this situation will be considerably changed by further improvements of the property of the H^+ ion beam injected into the Cs-cell. We can then expect a higher output intensity from our Lamb shift source without a serious loss of the degree of polarization.

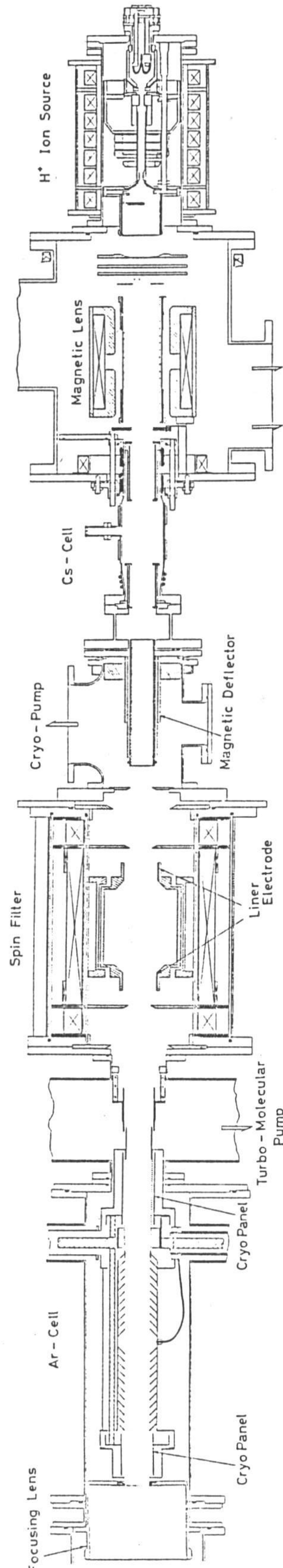

Fig.1.

Reference

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