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STATUS OF THE AGS POLARIZED NEGATIVE ION SOURCE*

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Summary

Development of an intense polarized H^- source for the AGS continues at Brookhaven National Laboratory. Initial tests with about one milliampere, 40 keV pulsed neutral cesium beam, colliding with more than two milliampere polarized hydrogen atoms, produced about one-half microampere polarized negative ions, extracted at 20 keV. A new pulsed cesium source with an anticipated output of 5-15 mA and an improved neutralizer are under construction.

Description

The colliding atomic beam principle, developed at the University of Wisconsin in Madison,[1] converts polarized thermal hydrogen atoms into polarized negative hydrogen ions by colinear interaction with an energetic neutral cesium beam. Figure 1 shows the principle of this method. The system consists of a molecular hydrogen dissociator, sextupole magnets, rf induced transition units and a cesium beam ionizer.

The polarized neutral hydrogen beam is obtained in a conventional ground state atomic beam apparatus, which makes use of rf dissociation of the hydrogen molecules, and focusing and electron polarization of the atomic hydrogen beam by sextupole magnets. Nuclear polarization is obtained by rf induced transitions. The molecular hydrogen dissociator nozzle is cooled by a closed-cycle helium refrigerator to improve the acceptance of the beam in the sextupole magnets. The gas feed is pulsed. Typical H° and H_2 pulses, detected with a residual gas analyzer are shown in Figure 2. So far, polarized densities of the order of 10^{11} atoms cm^{-3} have been measured near the interaction region and we expect further improvement by a factor of 2 to 3 by optimization of the various components.

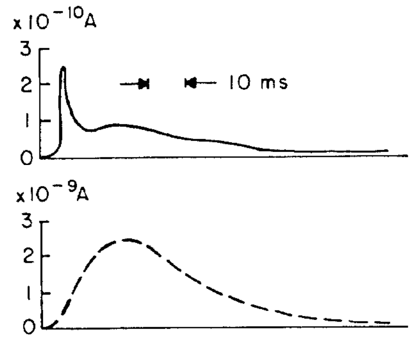

Figure 2 - Traces of typical atomic and molecular hydrogen pulses near the interaction region. —— (H); ---- (H_2).

A major thrust of the development effort has been toward the realization of a 5 to 10 mA, pulsed neutral cesium beam transported one meter downstream into the 1.5 cm diameter interaction region. The ANL cesium source was modified to accept an 3/4" diameter spherical porous tungsten surface ionizer and cesium boiler. The radius of curvature of the tungsten button and the inter-electrode spacings were chosen to be the same as those used at Wisconsin and a fourth electrode was added. Figure 3 shows the essential parts of the Cs source and the electrode voltage pulsing scheme. A spherical ball joint was added for mechanical beam steering.

Porous tungsten ionizers normally are used for d.c. cesium ion beams. However, in this application we require only 0.5 ms beam pulses, which may offer advantages in terms of increased reliability (less cesium contamination, sputtering and outgassing of

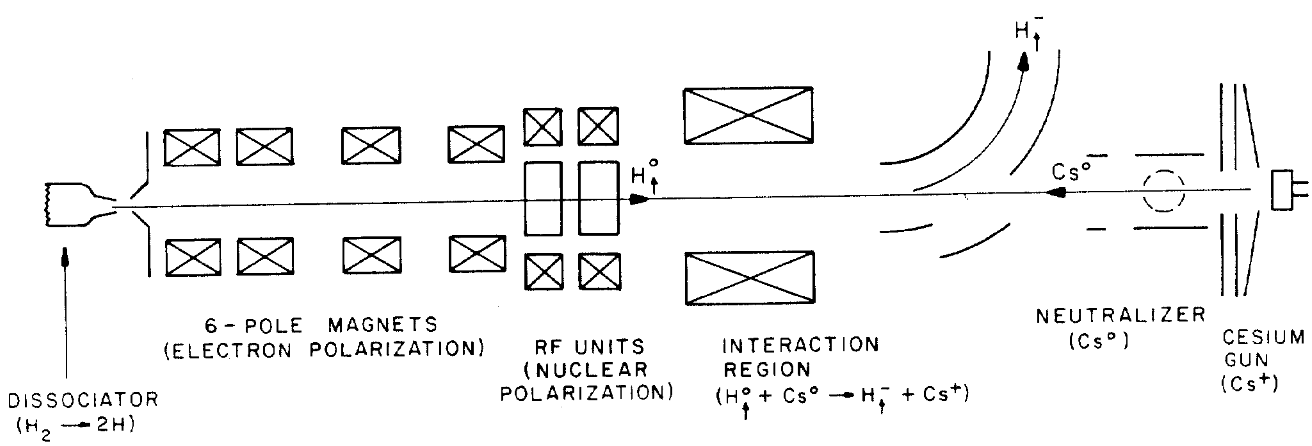

Figure 1 - Schematic diagram of the $H^-_\uparrow$ source. The functions of the various parts are indicated.

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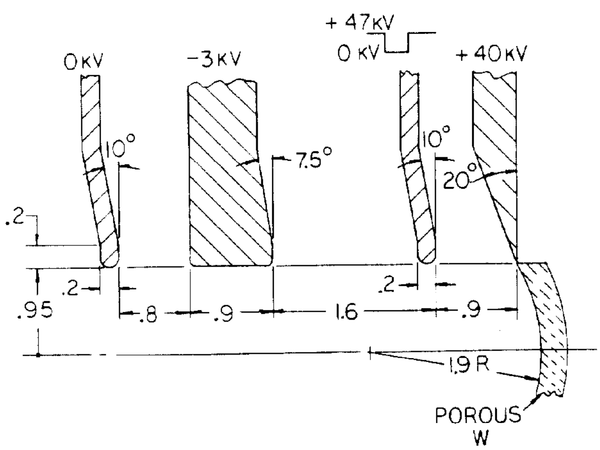

Figure 3 - The essential parts of the cesium source and the voltages on the electrodes.

downstream surfaces). The operation of the tungsten button in the pulsed mode has been achieved by operating the tungsten button and beam-forming electrode forming electrode at approximately +40 kV, while the extraction electrode is held at approximately +45 kV and pulsed to ground. This backbias prevents cesium ions from leaving the surface between pulses. The extracted ion current density is determined by the ion evaporation rate, which depends on the surface coverage reached between pulses and the button temperature.[2] As the surface coverage changes due to the ion extraction, the ion evaporation rate and the pulse shape change as well. Beam currents of up to 12 mA and sufficient pulse width have been obtained from a 3 cm^2 tungsten ionizer with a button temperature of about 950° C and a boiler temperature less than 70° C.

Special attention has been paid to the beam optics. Space charge effects of the ion beam are significant. It takes typically 0.5 to 1 ms for the beam to become space charge neutralized and well focused. As expected, this phenomena was not seen for the Cs° beam, which could be well focused even at the start of the pulse. The beam becomes very divergent due to space chage forces when the third electrode, normally biased negative to prevent backstreaming electrons, is grounded. The beam optics was in good agreement with computer calculations using the SLAC Electron Trajectory Program.[3] With this modified source we are able to get approximately 50% of a 6 mA cesium beam through the interaction region.[4] A new cesium source is presently under construction, which will supply (in principle) cesium beams of 10-15 mA into the interaction region without significant beam losses.

The cesium neutralizer operates with a magnetically pulsed flapper valve in the cesium supply line in order to minimize the cesium loss rate at the open ends. Figure 4 shows the principle of this neutralizer. The loss rate was measured to be 0.23 mg/hour for the temperatures shown and a 2% duty cycle.

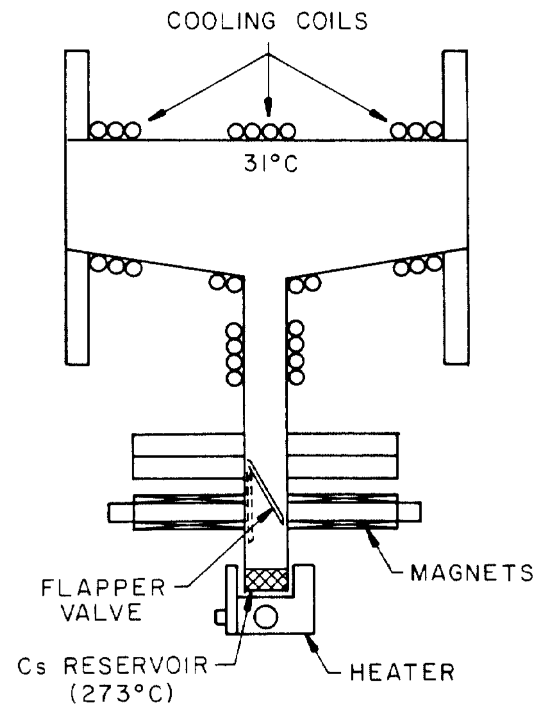

Figure 4 - Schematic diagram of the neutralizer with typical operating temperatures.

Preliminary operation of the overall system has shown a polarized H^- output of 0.5 μA per milliampere of neutral cesium beam. We expect a much higher efficiency when all components, in particular the atomic beam components, are properly optimized.

References

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