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STATUS OF THE AGS POLARIZED H^- SOURCE*

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ABSTRACT

Development of a polarized H^- source for the AGS polarized proton project, initially begun at Argonne National Laboratory in 1979, has been continuing at Brookhaven National Laboratory since early 1982. A description of the source is given and the status of the project is reviewed.

INTRODUCTION

The source employs a conventional ground state atomic beam stage for the production of polarized H^0 at thermal energy. Subsequent collision with a fast neutral cesium beam leads to polarized H^- formation through the reaction[1]

$$H^0_{\uparrow} + Cs^0(\text{ 40 keV}) \rightarrow H^-_{\uparrow} + Cs^+$$

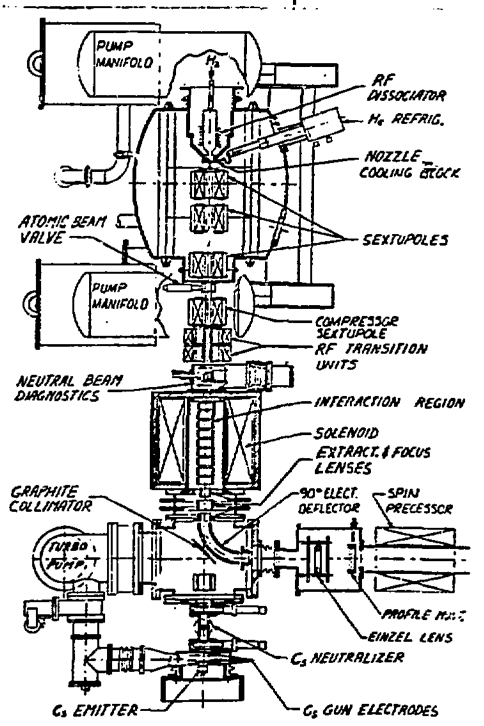

Fig. 1. AGS Polarized H^- Source.

The cesium beam is obtained by neutralizing a 40 keV Cs^+ beam in Cs vapor. The H^0 and Cs beams collide head-on in a region where the magnetic field is ~1.5 kG. The H^- ions produced are accelerated to 20 keV and extracted through a 90° electrostatic deflector. A schematic diagram of the source is given in Figure 1.

Initial development plans were presented by D.R. Moffett et al.[2] at the Lausanne meeting. The subsequent decision to use an RFQ[3] instead of a Cockroft-Walton generator as the 750 keV pre-accelerator has considerably simplified certain design objectives. The source will now be on the floor at ground potential.

In the following sections we shall briefly review individual subsystems and the status of the project.

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ATOMIC BEAM STAGE

The polarized hydrogen atomic beam stage is a commercially available model[4] that has been modified to incorporate nozzle cooling and rf and gas pulsing of the dissociator. These features produced a 5-fold increase in the H^+ intensity from the ZGS polarized H^+ source.[5] Cooling is effected by a closed-cycle helium refrigerator which cools the copper block surrounding the nozzle to approximately 30 K.

Velocity distribution measurements of the H^o beam made on the ZGS source showed that the most probable velocity of the beam is 1.7 x 10^5 cm s^{-1} for the conditions stated above, which corresponds to a Maxwellian temperature of 110 K. From Figure 2, which shows the results of a typical run, we see that the velocity distribution agrees better with supersonic than with effusive flow.[6]

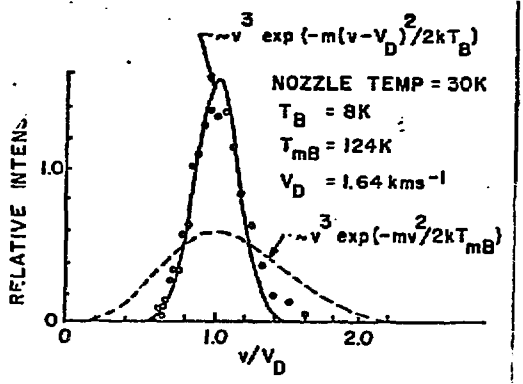

Fig. 2. Measured velocity distribution of the atomic hydrogen beam (o) and theoretical fits: Maxwellian (---) and supersonic (——).

The density of the H^o beam of the AGS source near the interaction region was measured with a quadrupole mass analyser to be about 1 x 10^{11} atoms cm^{-3}. Hence the flux of H^o through the interaction region is ~2 x 10^{16} atoms cm^{-2} s^{-1}, which is typical for such sources.

CESIUM GUN AND NEUTRALIZER

The principal components of the gun are indicated in Figure 3. The cesium emitter and electrode (1) are maintained at the desired Cs^+ accelerating potential relative to the grounded electrode. Electrode (2) is biased positive relative to (1) to prevent cesium emission, except for the duration of ~0.6 ms, when it is pulsed to an intermediate potential to facilitate emission. Typical waveforms for pulsed operation of the gun are shown in Figure 4. The Cs^+ beam current was measured with a Faraday cup.

The emitter contains a zeolite pellet that releases Cs^+ ions when properly biased and heated.[7] At room temperature the material is inert, thus eliminating special handling requirements typical of cesium dispensers. We have experimented with commercially produced emitters[8] as well as several that were developed at ANL and BNL. To date, we have obtained up to 10 mA of Cs^+ from 3 cm^2 of emitter area.

Beam profile measurements indicate that presently only about 25% of the cesium beam can be expected to overlap with the hydrogen in the interaction region. A modified electrode design and/or additional focusing elements between the gun and the neutralizer will have to be considered . Also, it might be beneficial to reach higher voltages than the 40 kV that is marginally attainable with the existing structure, since the space-charge limited current grows as $V^{3/2}$, as long as the temperature dependent emission limit of the zeolite has not been reached. The maximum safe operating temperature of the emitters used by us was about 1150°C.

In a lifetime study at 6x the normal pulse width and 4x the normal pulse repetition rate, a decline in emission current from 4 mA to 1.5 mA was observed after emission of 0.25 C. However, the current recovered to within 5% of its initial value, when the normal operating conditions (0.6 ms/0.5 pps) were restored. This phenomenon requires further examination.

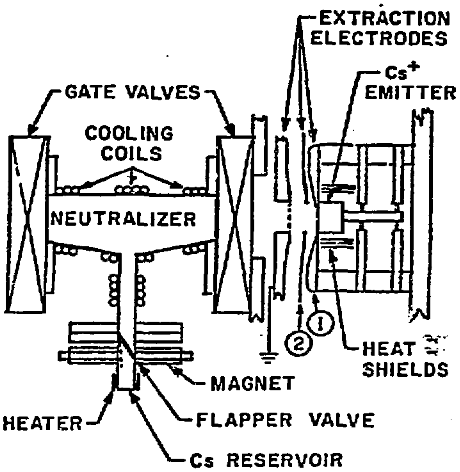

Fig. 3. Cs^+ Gun and Neutralizer

The neutralizer is also shown in Figure 3. The reservoir can be loaded in an argon purged glove box with up to 10 g of cesium. The gate valves facilitate its transfer to the source and isolate the neutralizer in the event of an accidental loss of vacuum. Ninety percent neutralization of a 20 keV Cs^+ beam has been achieved. Loss rates of a few mg/h have been measured, which are sensitive to the temperatures of the reservoir and the horizontal channel.

INTERACTION REGION

In the interaction region H^0 is ionized to H^- in collisions with Cs. The H^- is extracted in an average electric field of approximately 1 V/cm and is then accelerated to 20 keV in the gap between the ionizer and 90° deflector.

PROTON POLARIMETER

A polarimeter to measure the proton polarization of the 20 keV H^- beam is under development. This instrument is based on beam foil atomic spectroscopy techniques,[9] and involves the measurement of circular polarization of Lyman α light. Up to the present the polarization of proton beams has only been measured at higher energies through nuclear or nucleon scattering.

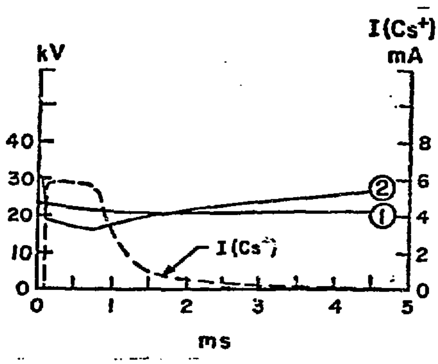

Fig. 4. Typical waveforms for pulsed operation of the Cs gun. Potentials of gun electrodes 1 and 2 are shown together with the Cs^+ current pulse.

STATUS AND OUTLOOK

Recently our group has been joined by colleagues from BNL and Michigan. A commercial low intensity Cs gun[10] using a porous tungsten emitter is being used temporarily to check out the overall operation of the source, while further development of Cs guns proceeds. In order to achieve 10 μA of polarized H^- a Cs beam current of 10 mA will be required in the interaction region if complete overlap of the H^0 and Cs beams can be achieved, and substantially more if the present gun optics is not significantly improved.

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