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Colliding-Beams Polarized Ion Source

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This ion source was to be purchased from ANAC, Inc., a New Zealand-based supplier of beam optics hardware and atomic beam polarized ion sources in December, 1982. Shortly before scheduled delivery ANAC went into receivership. During 1983 little work was done on the project as various steps were taken by us, first to get the ion source completed at ANAC, and then, failing that, to obtain the existing parts. In early 1984 we began work to finish the ion source in Seattle. The project is nearly complete, and this article presents progress to date.

Description

Many design details of this source are derived from the Wisconsin colliding-beams source.[1] The general principle has been described by Haeberli.[2] A polarized, thermal, atomic hydrogen beam is ionized by collision with a fast neutral cesium beam in a region at elevated potential. The resulting negative hydrogen ions are accelerated to ground, transported through a spin precessor and on to the accelerator beam line.

The cesium beam is produced by a cesium gun mounted in reentrant fashion on a large ceramic tube. The gun runs conservatively at +45 kV and can be biased to +60 kV. Positive cesium beam is produced by a 1.9 cm ϕ tungsten ionizer at about 1150° C. With 15 mA of cesium beam the cesium oven temperature is about 310° C. An extraction electrode at -10 kV is followed by a ground electrode, both with 1.9 cm apertures and roughly 1 cm spacings.

The cesium source, with its vacuum vessel and cryopump, is mounted on a gimbal which permits fine motorized angle adjustment in the vertical plane. The beam passes through a small-angle dipole magnet, which permits fine angle adjustment in the horizontal plane, and a magnetic quadrupole triplet which matches the cesium beam into the ionizer volume.

The neutralizer region is very similar to that in the Wisconsin source. The neutralizer, carbon baffle, deflector, and first inflector are mounted on a table referenced to the ionizer solenoid and enclosed in a large ported spool. The ionizer solenoid is a standard ANAC model designed for an electron bombardment ionizer. An axial electric field (~ 1-2 V/cm) is provided inside the solenoid by a set of ten cylinders biased at graded potentials with respect to a common -50 kV.

The hydrogen atomic beam, entering the solenoid from one end, is produced by an ANAC model 2101 source. Between the compressor sixpole and the ionizer solenoid is a 35 cm region containing two strong and one weak field rf transitions and a calorimeter for the cesium beam.

Polarized negative hydrogen ions created in the ionizer solenoid (at about 2 kG and 50 kV) are accelerated to ground at the cesium beam end and then bent through two 90° inflectors with an intervening einzel lens. The beam passes through a spin precessor with two co-rotating quadrupole doublets. Two more 90° inflectors bring the beam onto the tandem axis.

Special Features

A unique feature of this source is the magnetic beam transport between the cesium source and neutralizer. The quadrupole triplet lens decouples the problem of extracting an intense metal ion beam from the problem of producing a waist in that beam which properly matches the acceptance of the ionizer solenoid. The first waist (object) in the cesium beam occurs about 10 cm from the cesium source ground electrode. The quadrupole lens produces a second waist (image) at the ionizer center, 150 cm further downstream. Besides proper matching the lens greatly reduces cesium beam wander in the ionizer solenoid region caused by slow changes in the cesium source because this source is so close to the lens object point.

Source components are mounted on two carriages running on rails which are mounted atop a steel frame containing four low-profile electronics racks. The atomic beam source is fixed to the floor and to the steel frame. The cesium source, beam transport, and one cover flange for the neutralizer spool are on a single carriage. A second carriage holds the ionizer solenoid and neutralizer spool plus contents. Carriages and rails are sufficiently massive that mechanical stability is excellent. This arrangement permits rapid access to all components.

Pumping for cesium gun and neutralizer spool is by a pair of 15cm cryopumps. Roughing is achieved with sorption pumps and supplemented by a venturi pump for the neutralizer spool.

Source parameters are controlled with three microprocessors and a modular interface system produced by ANAC. This system has advantages for quick startup, since it saves parameter values, but presents difficulties with regard to lack of flexibility in a developmental apparatus.

Results

The cesium gun produces more than 15 mA positive cesium beam with energies at or above 40 keV. The beam is easily visible, and a waist is formed 10-15 cm downstream from the ionizer button with a waist diameter of 1-1.5 mm. The second waist, formed in the neutralizer spool, is also visible, with a 2-3 mm diameter. This dimension agrees with the size of the incandescent spot on the carbon baffle and the size of holes sputtered in the baffle. The corresponding emittance is apparently 2-3 times better than expected and insures good flexibility in matching the cesium beam to the hydrogen beam profile in the ionizer. The source is easy to turn on and cycles to atmosphere (argon) repeatedly without deteriorating.

The AB source performance is another matter. Measured output is presently 10-100 times smaller than specified, and the source, purchased as a supposedly working unit from ANAC in 1982, suffers from a number of engineering problems. Our main effort now is to bring this source up to proper performance and complete the remainder of the negative beam transport system (inflectors 3 and 4).

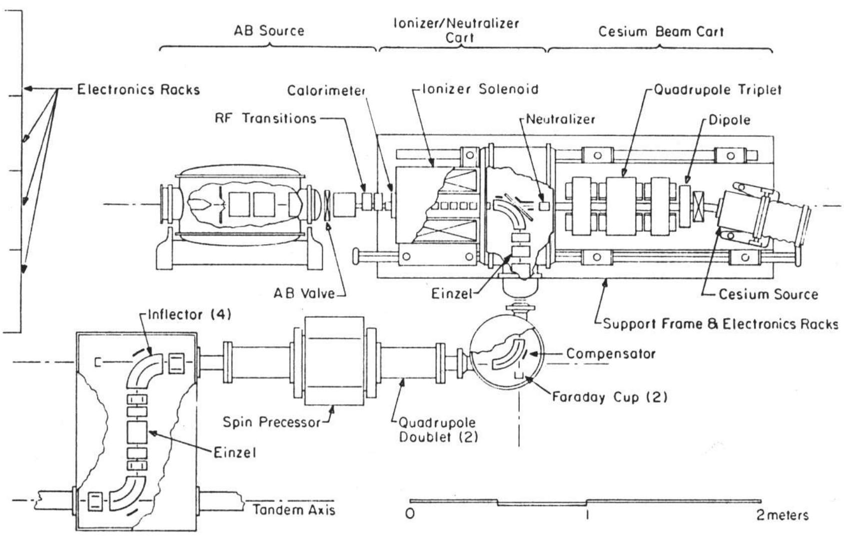

Fig. 1. Colliding-Beam Polarized Ion Source

References

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2) W. Haeberli: Nucl. Instrum. & Methods 62 (1968) 355.