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BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

ACCELERATOR DEPARTMENT
Informal Report

SUGGESTIONS FOR FUTURE WORK ON HIGH INTENSITY NEGATIVE HYDROGEN SOURCES

K. Prelec

June 27, 1973

ABSTRACT

A few suggestions are given on how to proceed in the development of a high intensity negative hydrogen source. They include use of a neutral gas jet in the discharge, adaptation of the Ixion plasma device and development of a multiaperture source.

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Introduction of hollow discharge duoplasmatrons and cold cathode magnetrons can be considered as a breakthrough in the development of intense negative hydrogen sources with direct extraction. Beam currents of up to 20 mA have been achieved with these new designs,[1,2] which is an order of magnitude higher than before. If still higher intensities are desirable, and this will be the case especially if an application in fusion research is contemplated, substantially improved or new sources of negative hydrogen ions should be developed. As an alternative to the standard indirect way of producing intense beams of negative ions via charge exchange of protons, a few suggestions will be given about possible ways to achieve this by using direct extraction method. However, only a more detailed study can show which ones, if any, among them are really feasible.

a) Problem of the Gas Flow Through the Extraction Aperture

The neutral gas flowing through the extraction aperture may limit the available current of negative ions. The effects of neutral gas in the extraction gap are a decreased breakdown voltage and a loss of negative ions in collisions with molecules. This has especially been observed in Penning and magnetron sources where the slit width is limited to about 1 mm. Part of the problem might be solved by using as the medium for the discharge a neutral gas jet flowing in the direction opposite to the motion of extracted particles. Gas would be injected into the source in the vicinity of the extraction aperture, through one or several small nozzles (such small multiple nozzles are commercially available). The unused (i.e., not ionized) part of the jet would have to be caught at the open rear end of the source and pumped out there by a separate pump. Gas consumption in such a system would, of course, be much higher, but a larger extraction aperture and the availability of neutral molecules in its vicinity might more than offset this disadvantage. One can envisage the application of this idea in a Penning type of source (the part of the anode wall opposite the extraction aperture would have to be replaced by a transparent mesh) or even in a source with axial extraction (duoplasmatrons, large area arcs).

b) Ixion Geometry

In the original report by Belchenko et al.[3] on the magnetron source the authors have explained high negative ion yields by an improved electric field distribution and a more favorable electron velocity distribution in a crossed field discharge (radial E, axial B fields). Similarly, in an Ixion device a rotating plasma is created in crossed E and B fields. The central rod at the cathode potential, whose presence is essential for a magnetron discharge, has been in the Ixion device replaced by the so-called plasma rod. Cathodes in the Ixion are two hollow cylinders, covered on the outside by insulating sleeves; the end flat parts of the discharge chamber (anode) are also covered by insulators. Once the discharge has started, a plasma region extends from one cathode to another, at the cathode potential (plasma in a Penning discharge has a potential close to the anode potential). A very strong radial electric field exists in the discharge and plasma as a whole rotates due to the E x B drift. Advantages of such a discharge compared with a magnetron are the use of an air core pulsed magnet (mirror configuration of the magnetic field), smaller currents drawn from the plasma and possibility of using a gas jet as described above. Addition of some Cs into the source might facilitate the initial breakdown and improve its characteristics as a negative ion source. The extraction would preferably be done perpendicularly to the magnetic field.

c) Complex Hollow Discharges

Highest proton currents are nowadays obtained from large area, multiple aperture sources. Single units have been built yielding up to 15 A of pulsed proton currents (Berkeley source). It might be worthwhile to explore the idea of applying the hollow discharge principle in such a source and to try to convert it into an intense negative ion source. It would be necessary to determine first, e.g. by scaling down the anode space of the present hollow discharge duoplasmatron, how small the obstacle (rod, tube) and the discharge surrounding it can be. The conversion of a large area proton source into an H^- source would be done by using an array of shor., properly biased rods, one behind each extraction aperture (or plates in the case of rectangular extraction slits). The idea of using directed gas flow would be applicable in this case, too.

References

1. Th. Sluyters and K. Prelec, Nucl. Instrum. & Methods, (to be published).
2. K. Prelec and Th. Sluyters, Rev. Sci. Instrum., (to be published).
3. Iu.I. Bel'chenko et al., Novosibirsk Rep. 66-72.

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