IEEE Transactions on Nuclear Science, Vol.NS-24, No.3, June 1977

A QUICK CHANGE AXIAL COLD CATHODE ION SOURCE

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Summary

An axial cold cathode heavy ion source has been built and successfully operated on the Michigan State University Cyclotron. This ion source was designed to minimize the time to change cathodes and thereby increase the cyclotron efficiency. The ion source change time (i.e. the time to change the cathode and restrike the arc) can be less than 15 minutes. In particular, all source parts that need to be cleaned at the end of a source lifetime are easily removed and clean pieces substituted. No internal ion source vacuum and water seals are broken. The ion source operates at gas flows less than 1 cc/min. and typically at 1/2 cc/min. This reduced gas usage results in a good accelerating chamber pressure and small attenuation of the accelerated beam to the external beam stop. The external ion beam intensity for a given particle and charge state are comparable to the intensity obtained from Oak Ridge and Berkeley.

Introduction

Present cyclotron heavy ion sources are operated at power levels of ≈2 KW in order to produce high charge ions.[1] This high power operation mode results in rapid erosion of the ion source cathodes, hence necessitating frequent maintenance. This maintenance time represents an inefficiency in the acceleration operation, and attempts to decrease this ion source outage time has previously concentrated on use of various exotic cathode materials and on rotatable cathodes.[2] In this paper we report another approach at increasing the accelerator efficiency by minimizing the time to change the ion source cathodes. An axial cold cathode heavy ion source has been designed and is now operating in the Michigan State University (M.S.U.) cyclotron that has short ion source cathode maintenance time.

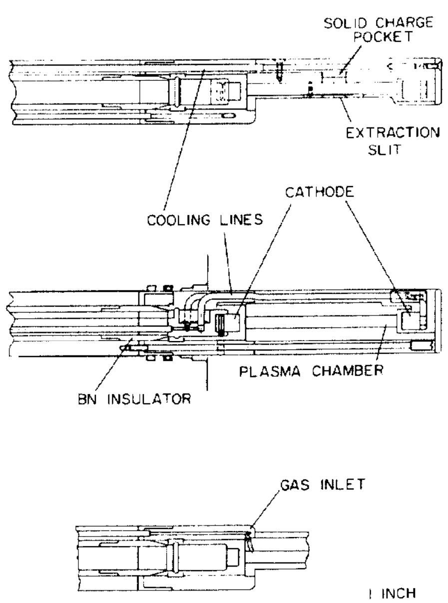

Figure 1.--The M.S.U. cold cathode axial heavy ion source is shown. The two cathodes are electrically connected by water cooled tubes. The ion source can be completely disassembled for maintenance without breaking any water and vacuum seals. A pocket for solid charge materials (e.g. for lithium beams) is provided directly behind the ion source extraction slit.

Ion Source Design

The axial cold cathode Penning ion source developed for the M.S.U. cyclotron is shown in figure 1. The ion source components that require maintenace (e.g. chimney and cathodes) can be easily disassembled without breaking water or vacuum seals. Duplicate and new ion source parts are substituted for the used pieces. The ion source is then reassembled and put back into operation.

Ion Source Operating Experience

The ion source has now operated since September 1976. A list of particle beams and their intensity extracted from the cyclotron is shown in Table 1. The measured intensities are comparable to the cyclotron extracted beam intensities of Oak Ridge and Berkeley. The ion source cathode lifetime is a strong function of accelerated ions. Lifetimes as long as 10 hours have been observed for a carbon beam where the ion source gas was CO. The ion source is maintained by the experimentalist and maintenance times of less than 15 minutes have been recorded.

The ion source gas usage is ≈.5 cc/min. Gas mixing[3] of xenon with oxygen for an O^{6+} beam has resulted in increased stability and intensity. The ion source has also been used for the production of proton beams. The gas usage for hydrogen is greater than 5 cc/min. The heavy ion beam has required improvements in the cooling of the cyclotron accelerating slit (puller). The beam power dissipated from heavy ions is larger than for light ions. Large beam attenuation, due to charge exchange with residual vacuum in the accelerating chamber (~5×10^{-6} torr), has been observed only with the argon beam.

TABLE I.—The M.S.U. Cyclotron Laboratory Heavy Ion Beams (1/24/77).

Particle	Max Energy	Intensity (e μA)
$^{6}Li^{2+}$	38	3.0
$^{6}Li^{3+}$	75	1.0
$^{7}Li^{3+}$	74	1.0
$^{11}B^{4+}$	85	.02
$^{12}C^{4+}$	77	10.0
$^{13}C^{4+}$	70	.003
$^{14}N^{5+}$	103	1.0
$^{16}O^{5+}$	90	1.0
$^{16}O^{6+}$	130	.5
$^{20}Ne^{4+}$	60	1.0
$^{40}Ar^{8+}$	92	.03

References

1. E.D. Hudson, et al., IEEE Trans. Nucl. Sci. NS-18, No. 3(1971)113.
2. M.L. Mallory, et al., IEEE Trans. Nucl. Sci. NS-22, No. 3(1975)1669.
3. E.D. Hudson, et al., Proceeding this conference.