An ion beam extraction grid using nets of fine Tungsten wires for the lamb shift source

Autor(en): **Isoya, A. / Nakamura, H.**

Objekttyp: **Article**

Zeitschrift: **Helvetica Physica Acta**

Band (Jahr): **59 (1986)**

Heft 4

PDF erstellt am: **09.08.2024**

Persistenter Link: https://doi.org/10.5169/seals-115727

Helvetica Physica Acta
Vol. 59, 1986 636-637

018-0238/86/040636-02$1.50+0.20/0

AN ION BEAM EXTRACTION GRID USING NETS OF FINE TUNGSTEN WIRES FOR THE LAMB SHIFT SOURCE

A. Isoya* and H. Nakamura

Tandem Laboratory, Faculty of Science
Kyushu University, Fukuoka, Japan

ABSTRACT

An ion beam extraction system using nets of fine tungsten wires as the grids was developed for extracting a wide H^+ ion beam for the use with the Lamb shift source. Results of computer calculations of the ion trajectories for both a system presently used and that of improved design (half divergent angle $\lesssim 1°$) are presented.

Fig. 1 shows the construction of an accel-decel extraction grid system consisted of networks of thin parallel wires of tungsten (0.1 ∿ 0.15 mm in dia.), which is used in the Lamb shift source of the Kyushu University tandem Laboratory. Ions from the exit hole of a quartz capillary tube of the ion source are spread over the grid of 40 mm in dia. with a tolerably good uniformity of current density (within ± 10%).

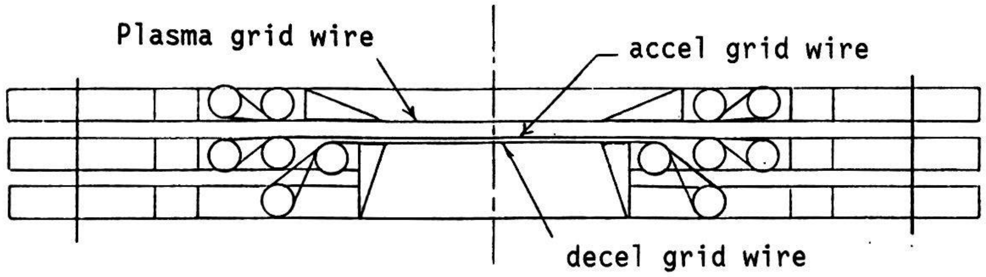


Fig.1 Construction of an accel-decel extraction grid

Recently optical properties of this extraction grid system has been investigated by computer calculations.** Some results are shown in Fig. 2 (Strong accel-decel mode). We had so far considered that the lens action is not so important since thin wires are arranged with small spacing (1 and/or 0.5 mm) and hence accel and decel electric fields between the grids are nearly parallel to the beam axis. Distances of the plasma to accel grids and the accel to decel grids were determined assuming a parallel beam in a strong accel-decel mode. But the above calculation indicated that this assumption was wrong and the performance obtained was not so good as expected.

---

* Now at Institute of Ressearch and Development, Tokai University, Kanagawa-ken, Japan

** We thank Dr.T.Katagawa of ULVAC Corp. for these calculations.

(strong accel decel mode)

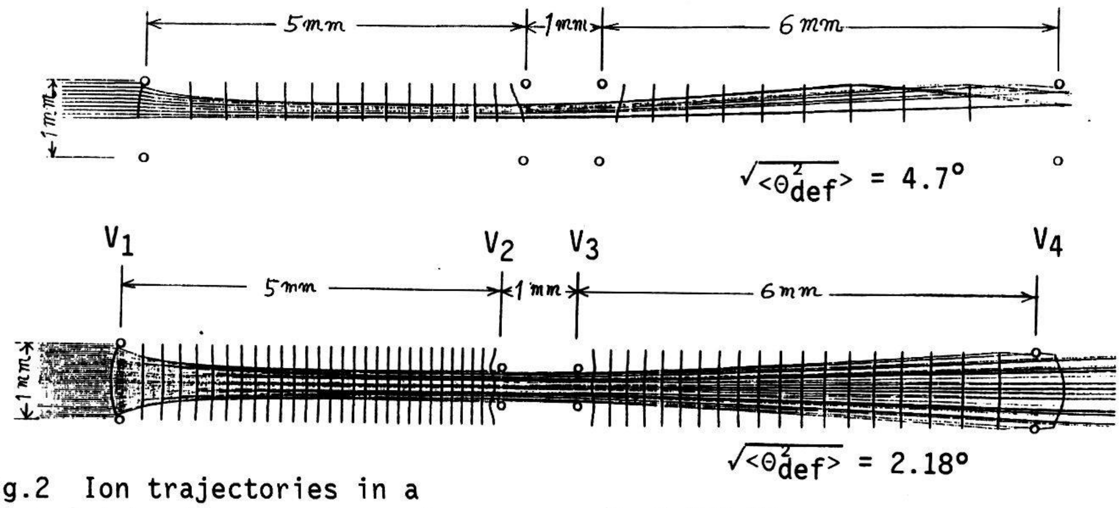
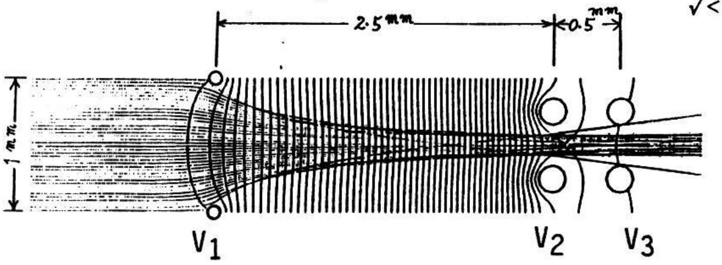


Fig.2 Ion trajectories in a beamlet by the computer calculation for the wire grid arrangement so far used.

V_1=0.500 KV
V_2=-1.000KV
V_3=-1.000KV
V_4=0.000 KV

J =12.5 MA/CM^2
TE =1.0 EV
A/Z=1.0

(weak accel decel mode)



$\sqrt{<\Theta^2_{def}>}$ = 1.64°

V_1=0.500 KV
V_2=-0.020KV
V_3=0.000 KV

J =8.00 MA/CM^2
TE =1.0 EV
A/Z=1.0

Fig.3 Ion trajectories in a beamlet by the computer calculations for the optimized wire grid arrangement

In Fig. 3 is shown the best arrangement of the wire grids obtained by the calculation, where the extraction is performed by a week accel-decel mode taking lens action into account. Fractions of extracted ions accepted within the deflection angle of 1° and 0.5° are 0.81 and 0.49, respectively (Corresponding emittance: 2 cm x Θ_{def} rad x $\sqrt{500}$ (ev)$^{1/2}$ = 0.78 and 0.39 cm rad (ev)$^{1/2}$, respectively)

An important assumption in this calculation is that thermal energy of the ions is taken to be zero. This is not unreasonable because the thermal energy in the lateral direction is cooled very effectively during the ions travel from the exit hole to the extraction grid along abruptly expanding flux of magnetic field. A theoretical estimation indicates that the lateral energy can be decreased by a factor which equals to that of reduction of the magnetic field strength i.e., about two orders of magnitude. However it is important that residual gas pressure in the expansion cup should be reduced low enough ($\lesssim 10^{-4}$ Torr) so that atomic collisions with residual gas molecules can be ignored.

Helvetica Physica Acta
Vol. 59, 1986 638-640

018-0238/86/040638-03$1.50+0.20/0

QUENCHING OF METASTABLE ATOMS H(2S) BY THE ATOMIC ELECTRIC FIELD OF CS IONS AND A PROPOSED DESIGN OF THE CS-CELL ACCEPTABLE OF HIGH INTENSITY H^+ ION BEAMS

A. Isoya*

Tandem Laboratory, Faculty of Science
Kyushu University, Fukuoka, Japan

ABSTRACT

Degree of quenching of H(2S) atoms due to the atomic field of Cs^+ ions is estimated. It indicates that the quenching by this cause is becoming serious in the present Lamb shift source of Kyushu University. A plan of a high intensity Lamb shift source is proposed using a Cs-cell designed on the base of this evaluation.

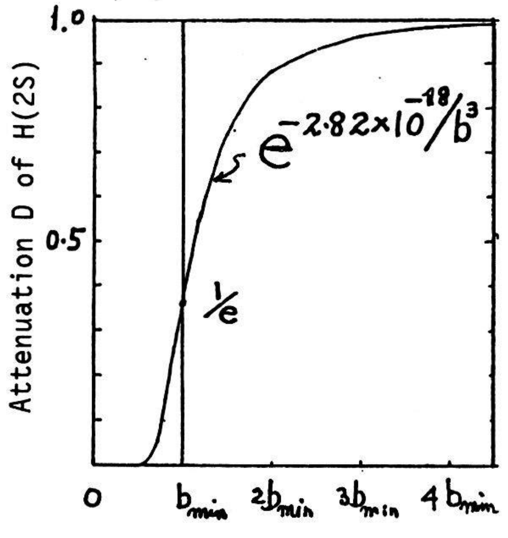
In the Cs-cell, incident H^+ ions are neutralized by charge exchange collisions at a very high rate, leaving Cs ions of a very high density in the cell. This density $n(Cs^+)$ is estimated in the case of a Lamb shift source of Kyushu University at about 2×10^{10} cm^{-3} for the incident beam current of 10 mA. Here it is assumed that baffle plates of 6 cm in length are mounted in the Cs-cell in parallel to the beam direction with a spacing of 1 cm, and half of the incident H^+ ions are neutralized in passing through the cell. Resulting Cs^+ ions diffuse out with the same thermal energy as before the ionization, and are lost at the baffle plates.

The space charge of Cs^+ ions is considered to be nearly completely neutralized by swarm electrons in the beam plasma. The corresponding Debye length is estimated at 5×10^{-5}cm, assuming the electron temperature of 1 eV. The density of Cs^+ ions may be decreased if the Cs^+ ions are assumed to drift along the electric field generated by the space charge of Cs^+ ions. But a meaningfully large field could not be generated in the plasma and hence the situation may not be changed so much.

When a H(2s) atom passes by a Cs^+ ion, it is deexcited by the electric field around the Cs^+ ion. Since the mean life of a metastable atom in the electric field E is known as $\tau[sec] = 3.72 \times 10^{-4}/E^2[volt/cm]$, we can calculate the attenuation D as a function of the collision parameter b (Fig. 1. The value of b at which D is equal to $e^{-1}(b(min)=1.41 \times 10^{-6}$ cm) is much smaller than the Debye length above mentioned. Therefore the above estimation which ignores the screening effect of the swarm electrons can be justified. Putting the cross section for deexcitation to be b (min), we get
$D = \exp(-\Pi b^2(min)N(cs^+)1) = 0.68$, where 1 is an effective length of baffles.

---

*Now at Institute of Research and Development, Tokai University, Kanagawa-ken, Japan



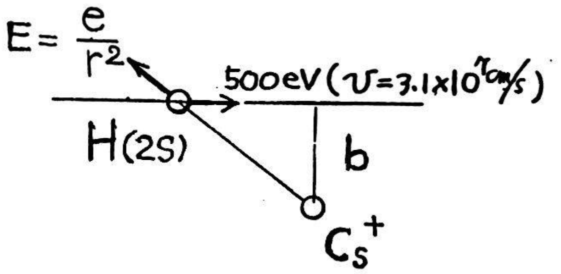


Fig.1 Attenuation D of H(2S) atoms passing through the atomic electric field of a Cs ion as a function of collision parameter b (b min = 1.41 x 10^{-6} cm).

The above calculation indicates that the current intensity of H^+ ion beam in our present Lamb shift source is already close to the allowable upper limit. A large step increase of polarized ion beam current can be obtained only by using baffle plates of the smaller spacing. The density of Cs^+ ions can be reduced in proportion to the length of spacing.

Fig. 2 shows a proposed design of the Cs-cell in which the length of spacing is 3 mm instead of 1.2 cm at the present cell. Cs vapor is supplied to the center of narrow gaps of baffle plates from an oven located under the cell. Short baffle plates set at the entrance and exit portions of the cell are kept cold to trap Cs vapor and to return condensed Cs to the oven.

Fig. 3 shows a proposed design of the Lamb shift source, using a Cs-cell of the new design. The Cs-cell is placed just behind the extraction grid and the distance from the Cs-cell to the argon-cell is chosen as short as possible to increase the output intensity of polarized ions. The primary positive ion source and the extraction grid are of an improved design presented in separate articles. With this source we may expect an increase of the output intensity by one order, i.e. about 30 μA per hyperfine state.

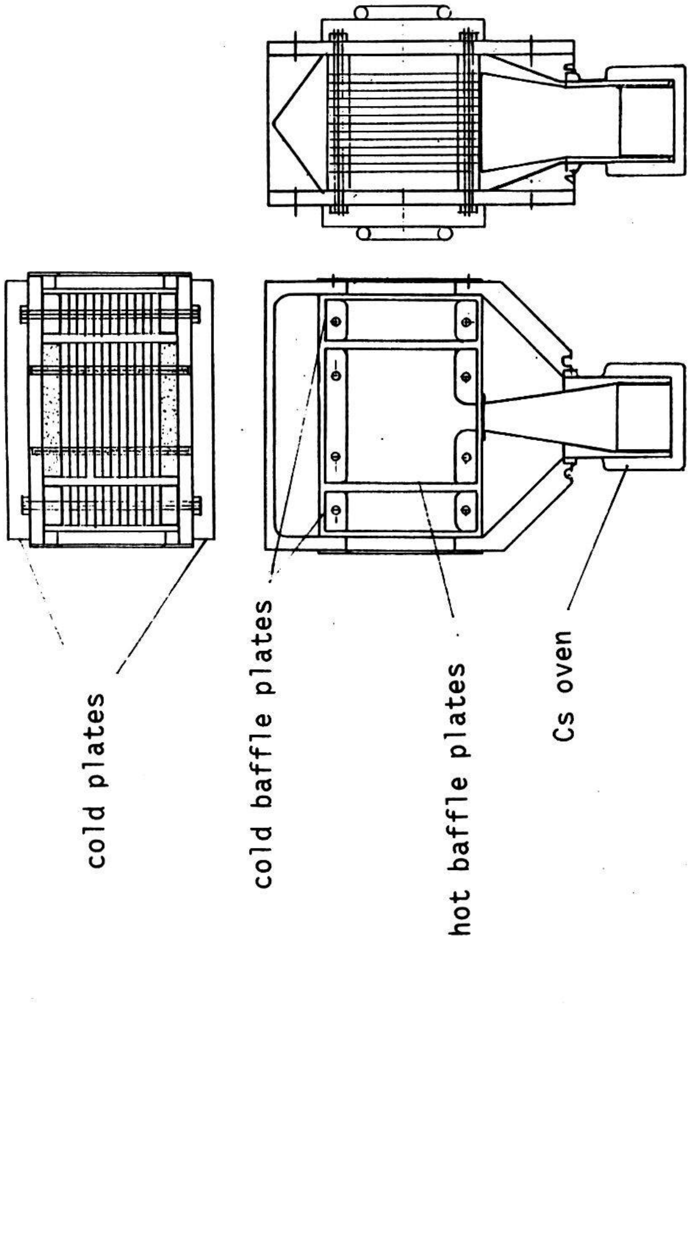


Fig.2 Proposed design of the Cs-cell

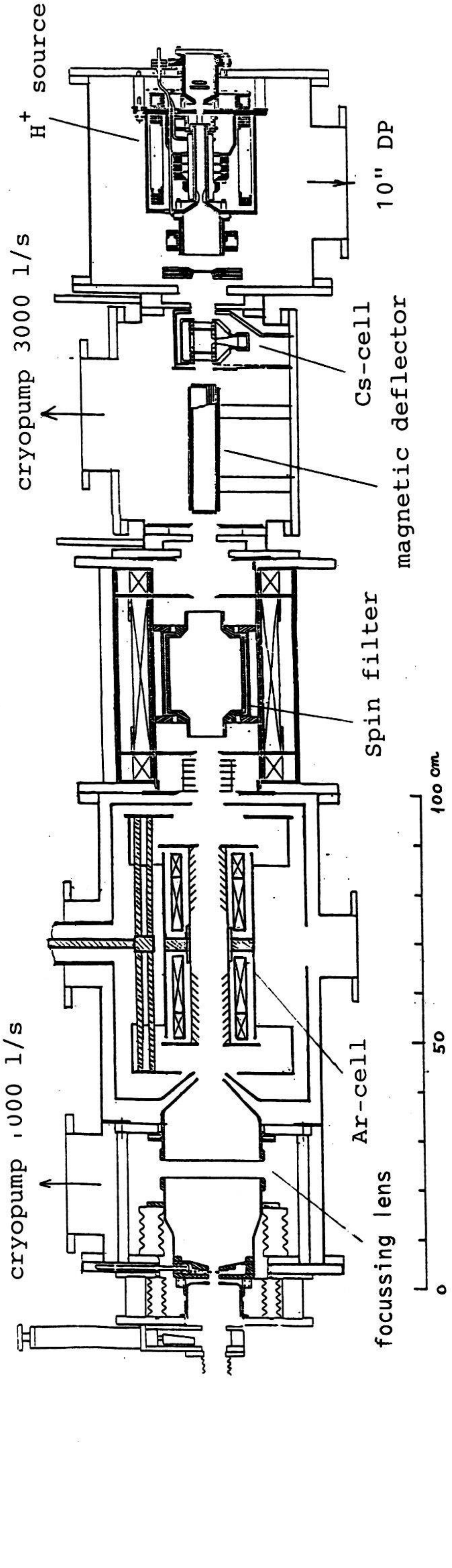


Fig.3 A proposed design of the Lamb shift source, using a Cs-cell of the new design