MEASUREMENTS OF ELECTRON-SPIN ORIENTED
SODIUM ATOMS FOR KEK POLARIZED H^- ION SOURCE

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The construction of the polarized H^- preinjector has been started since April in 1980. In this project, a new type polarized ion source (APOLON) which utilizes the charge-exchange reactions between fast protons and electron-spin oriented sodium atoms is to be employed.[1] The principle of this polarized ion source is shown in Fig.1. There are two ways to obtain the electron-spin oriented sodium atoms; Stern-Gerlach method with an inhomogeneous magnetic field[2] and optical pumping method with the circular polarized light.[3] The intensity of polarized H^- ion beam depends strongly on the density of electron-spin oriented sodium atoms. We have measured the density and the electron polarization of sodium atoms for both methods described above.

Experimental setup for the measurement of the density of sodium atoms which are oriented by passing through the 6-pole magnet is shown in Fig.2. The typical temperature of the oven was 480°C and the orifice diameter was 3 mm. The maximum edge field of the 6-pole magnet was about 8 K gauss. Sodium atoms were detected by the surface ionization detector placed at the exit of the magnet. In Fig.3 is shown a schematic set-up of this detector. The positive voltage was applied to the tungsten filament heated up to about 1500°C and the wall of the anode was cooled by a liquid freon. The distance between the filament and the anode was 5 mm.

Acceptance of the 6-magnet for the sodium atomic beam can be calculated analitically for each atomic state of $m_j = +1/2$ or $m_j = -1/2$[4] and the results are shown in Fig.4. In this figure η is the parameter concering for the atomic velocity:

$$\eta = (4kT/m)^{1/2}/v \quad , \qquad (1)$$

where v is the velocity of sodium atom, T the source temperature, m the atomic weight and k the Boltzmann constant. The number of atoms per second which leave an oven of pressure p and orifice radius R_s within the solid angle Ω is given by,

$$c\ \Omega\ \ p\pi\ R_s^2/(TM)^{1/2} \qquad (2)$$

where $c = 1.115 \times 10^{22}$ $(°K\ amu)^{1/2}/(Torr\ cm^2\ sr\ sec)$. Fig.5 shows the output current from the surface ionization detector as a function of the oven temperature. The saturated current was varied with an applied bias voltage because of the space charge effect. The measured sodium density was 5×10^{10} atoms/cm^3 at the temperature of 480°C and it was consistent with the value calculated from eq. (2).

In Fig.6 is shown a schematic sep-up for the polarization measurements of optically pumped sodium atoms. Sodium atoms flowing from the oven is exposed in the teflon coated cell to a circular polarized light whose wave length is 5896 Å as same as that of the D1 spectrum line in sodium atoms. Teflon coating prevents from depolarization induced by the collisions with the metal wall. The oriented sodium atoms are analyzed by the 6-pole magnet and the polarization is estimated in the following equation,

$$P = \frac{N_1 - N_2}{N_1 + N_2} \quad , \qquad (3)$$

where N_1 is the intensity of the sodium atomic beam pumped by a left circular light and N_2 by right circular light. The measurements are now in progress.

References

1) Y. Mori et al., Proc. of the 4'th Symp. on Ion Sources and Ion Application Technology, Tokyo (1980), 59.
2) G.J. Witteveen, Nucl. Inst. Meth., 158 (1979), 57.
3) L.W. Anderson, Nucl. Inst. Meth., 167 (1979), 363.
4) V.W. Hughes, et al., Phys. Rev. A., 5 (1972), 195.

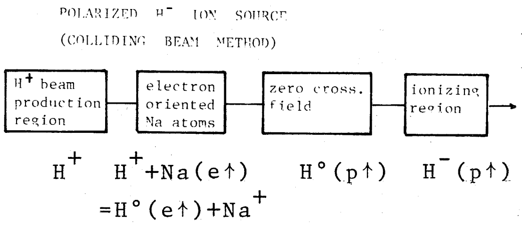

Fig.1 Block diagram of Pol. H^- ion-source

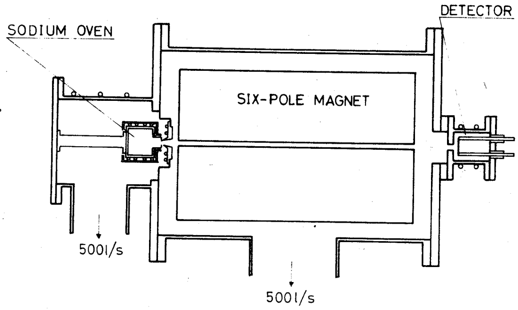

Fig.2 Experimental arrangement for Sodium atom density

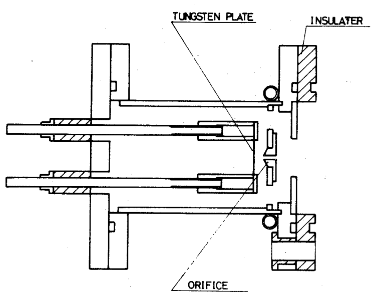

Fig.3 Surface ionization detector

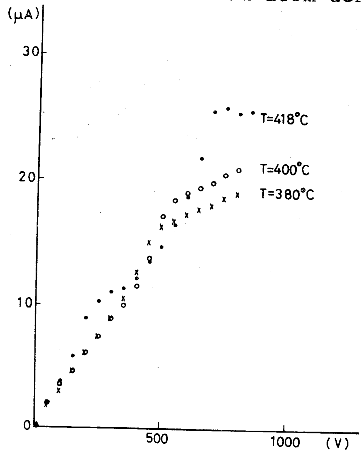

Fig.5 Output current from surface ionization detector

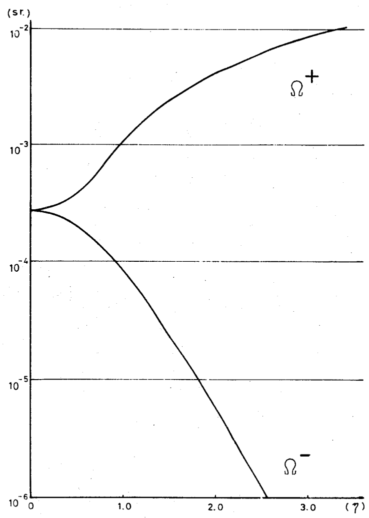

Fig.4 Acceptance 6-pole magnet

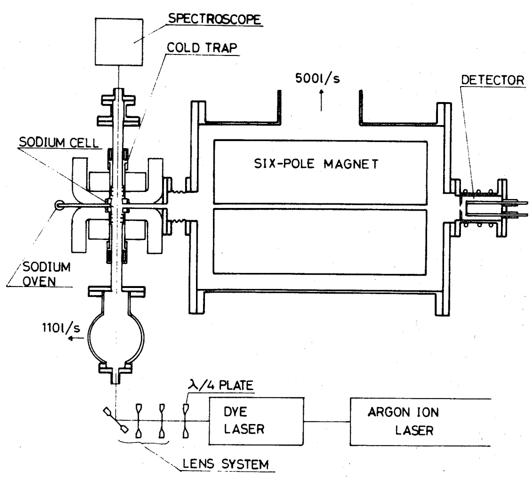

Fig.6 Experimental set-up for optical pumping method