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Laser Source of Polarized Protons and H^- Ions.

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A source of polarized protons and H^- ions based on polarized electrons capture has been developed for the Moscow Meson Factory. This approach, first proposed by Zavoiskii[1], has recently attracted a lot of interest, since the use of advanced dye lasers for optical orientation of electrons spins in a charge-exchange sodium target makes it possible to considerably increase the polarization efficiency[2,3].

Electrons capture by 5 keV protons is most likely to result in producing the hydrogen atoms in 2S and 2P states. To avoid depolarization because of the spin-orbital interaction the charge-exchange should proceed in a strong magnetic field of 10 - 20 kG[3,4]. Changing the charge state of the beam in the magnetic field of the solenoid is known to result in increasing the beam divergence which is caused by fringing fields. To overcome these difficulties Y. Mori et al[5] used an ECR proton source which was placed in the same magnetic field as the sodium cell.

The basic features of our scheme (see Fig.1) are: a) formation of an intense neutral hydrogen beam; b) its injection into the solenoid; c) ionization of the beam in an auxiliary helium cell (5). In this case the input and output beams are neutral and the emittance increase doesn't occur[6,7].

The protons produced in the cell (5) are retarded by a 1 kV voltage. This allows to eliminate a non-polarized component of the proton beam which is formed of atoms passed through the He-cell without ionization. A flash-lamp dye laser is used for optical pumping of sodium atoms. Pulse duration is 30 μs, a linewidth being 0.2 Å. A repetition rate of the current pulses (1 Hz) is restricted by a pulsed solenoid cooling system. Electron-spin polarization of hydrogen atoms is transferred to nuclear polarization by a Sona transition in a zero-crossing magnetic field. Then atoms are ionized in the second helium cell (9).

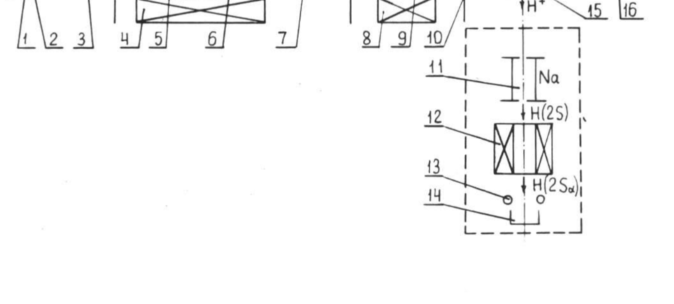

Fig. 1. Schematic layout of the source: 4) pulsed solenoid (B_1 up to 20 kG); 7) deflecting plates; 8) solenoid of ionizer (1.5 kG); 12) spin-filter; 13) detector of Lyman-alpha; 14) Faraday cup; 15) bending magnet; 16) laser system.

For polarization measurements the protons are transmitted through the sodium cell (11) and the populations of hyperfine structure sublevels are analyzed [7,8].

The results of the measurements are shown in Fig. 2. The output current of polarized protons amounts about 1 mA with polarization 65±3%. Without a retardation voltage the current increases up to 3 mA, the polarization falls down to 30%. The current of H^- ions about 0.06 mA is obtained in case of ionization in xenon. The normalized emittance of the beam doesn't exceed 0.1 π cm·mrad.

The dependence of the proton polarization on the magnetic field has been measured (Fig. 2). The polarization increases with the growth of the field strength, the current of polarized protons being practically constant.

The further improvements of the ion source, the retardation system and optimization of the installation geometry are still needed.

We believe that the development of this scheme would allow to achieve H^+ current of 10 mA and H^- current of 1 mA, with the emittance acceptable for high energy accelerators.

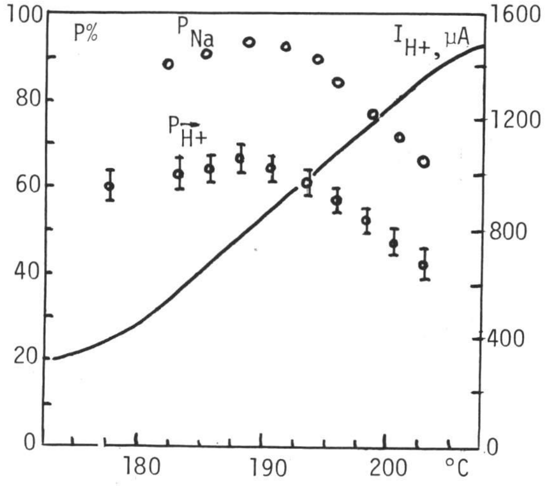

Fig. 2. Dependence of sodium and proton polarizations as well as polarized proton current on sodium cell temperature (B_1 = 15 kG)

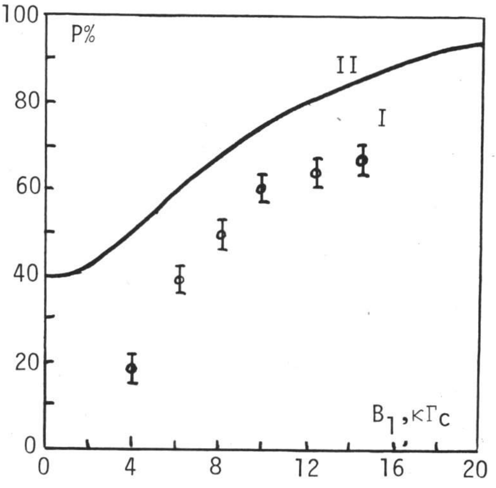

Fig. 3. Proton polarization vs the magnetic field strength (I), II - calculations of [9].

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