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8.16 The Polarized Heavy Ion Source at the Heidelberg MP-Tandem*)

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The present status of the polarized heavy ion source at the Heidelberg MP tandem postaccelerator combination is described. A schematic view of the source[1)] is shown in Fig. 1. A thermal atomic beam of ^{7}Li oder ^{23}Na (both with spin I=3/2 is formed by an oven and a system of collimators. Optical pumping by circularly polarized D1-light is applied before the beam enters the Stern-Gerlach magnet. A weak guiding field is provied parallel to the laser beam. The hyperfine splitting between F=2 and F=1 of the ground state (^{7}Li and ^{23}Na) is so large that the laser can pump only the F=2 multiplet. The remaining F=1 components are removed from the beam by the quadrupole magnet which has a 1 cm aperture and is 44 cm long. Thus an atomic beam in one single Zeeman-level $|F,m_F\rangle=|2,2\rangle$ is obtained with an intensity about one quarter of the oven intensity, into the acceptance angle of the 4-pole magnet. For fast switching to other Zeeman-levels $|2,m_F\rangle$ an adiabatic medium field transition[2)] (MFT) is installed behind the quadrupole. The atomic beam polarization can be analyzed by observing Laser Induced Fluorescence[3)] (LIF) of the D1-transition in a strong magnetic field. LIF gives the (relative) population of each Zeeman level and thus complete information on the nuclear polarization of the atomic beam. This facilitates efficient adjustment of the pumping laser system and the very sensitive parameters of the MFT.

Positive ions are produced on a hot tungsten strip. It is operated in a strong magnetic field (0.2T) to preserve polarization. In addition the surface temperature has to be high enough (1700 to 1800 K) to avoid depolarization by relaxation on the surface. In order to generate negative ions, the positive ions are accelerated to 5 keV for lithium or 18 keV for sodium and focussed into a cesium charge exchange cell (overall efficiency about 3%. The charge exchange is followed by a Wien-filter which enables the nuclear spins to be rotated into any desired direction.

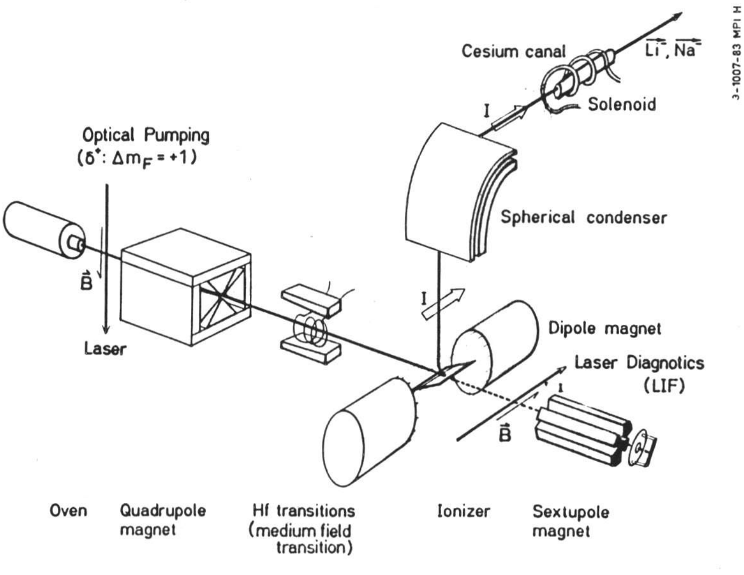

Fig. 1: Schematic view of the source for polarized heavy ions

The source is mounted on a high voltage platform. Negative ions are preaccelerated to about 150 keV and transported by an electrostatic system to the MP tandem. Beam currents achieved are listed in Table 1. A comparison of the currents from the source and after acceleration shows that the source emittance is presently too large and a study is underway to improve the beam quality by modifying the extraction optics. It should be noted that the very low efficiency for the Na^{9+} beams is partly due to the low stripping efficiency of about 2% for the 9^+ charge state of Na at 12 MeV.

One essential part of the new source is the laser system which consist of a COHERENT INNOVA 90-5 Argon laser (5W) and a COHERENT CR-599-21 dye laser. As a major request reliable operation with little attention by the operator has to be achieved. Frequency stability to better than 20 MHz are obtained by the usual phase sensitive locking of the frequency to the atomic beam fluorescence maximum. Mode hoping is avoided by the same technique locking the thin ethalon tilt angle to the laser power maximum. Both feedback loops result in reliable single mode operation for several days.

One major drawback of the present pumping scheme is the loss of a large fraction of the atomic beam. Pumping of both hyperfine levels F=1 and 2 simultaneously would result in a larger flux. Two possible solutions to this problem are described in another contribution to this conference[4].

In conclusion it can be stated that a conventional source for $\vec{Li}$ and $\vec{Na}$ beams equipped additionally with a laser system produces negative ion beams with a large fraction (>90%) in a single selectable m_I substate ($-3/2<m_I<3/2$). Their acceleration and determination of nuclear polarization as well as the question of depolarization of incompletely stripped polarized Na beams are discussed in other contributions to the conference[5,6].

Table 1: Ion currents and alignment on target with optical pumping (terminal voltage of the tandem about 12 MV)

Ion current			Alignment t_{20}
from ionizer	source exit	accelerated	accelerated
Li^+: 15 μA	Li^-: 0.3 μA	Li^{3+}: 80 nA	± 0.8
Na^+: 65 μA	Na^-: 1.5 μA	Na^{9+}: 30 nA	± 0.4

References

1) D. Krämer et al., Nucl. Instr. & Meth. 220 (1984) 123.
2) W. Dreves et al., Phys. Rev. Lett. 50 (1983) 1759.
3) H. Jänsch et al., J. Phys. D: Appl. Phys. 17 (1984) 231.
4) H. Bechtel and D. Fick, this Conference
5) G. Tungate et al., this Conference
6) H. Jänsch et al., this Conference