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8.13 Polarized Lithium Ion Source for the Cyclotron U-240

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In order to experimentally investigate potentials, reaction mechanisms of heavy ions interacting with nuclei, to get the spectroscopic information on nuclear states, to study the cluster structure of lithium nuclei, to study peculiarities of interaction of aligned deformed and just spherical nuclei in dependence on the spatial orientation, and to solve other problems, the source for polarized lithium nuclei is under design at the Institute for Nuclear Research of the Ukrainian Academy of Sciences.

The source will be mounted on the isochronous cyclotron U-240 using axial injector. The maximum energy of accelerated ions with charge Z and mass A for U-240 equals $E=140\ Z^2/A$, i.e. 23.3 MeV for $^6Li^+$ and 20 MeV for $^7Li^+$. To widen the energy range of the accelerated beam it is supposed to obtain doubly charged ions and thus to accelerate ^6Li and ^7Li up to 93 and 80 Mev, respectively.

The source is based on the classical principle. The outline of the source is displayed in Fig.1. The main units are an oven (1), a separating magnet-polarizer (3), RF transitions (4 - 6), an ionizer (7), an accelerating tube (8), a stripping region $Li^+ \rightarrow Li^{++}$ (10), a system of Li^+ and Li^{++} beams splitting and input to the injector (11). The design of the source units from the oven to the ionizer is much alike as described in [1]. The stainless thermal stable steel oven has a nozzle 0.8 mm in diameter and handling at 900°C. Temperature dependence of the lithium atom flux intensity at 0° and directional patterns of the atomic beam at 6 values of the oven temperature were measured during laboratory test [2]. The atomic flux inside the solid angle of the magnet-polarizer ($2\cdot10^{-3}$ sr) is expected to be about $4\cdot10^{14}\ s^{-1}$ at above mentioned conditions of oven handling.

Atoms are separated with respect to m_j by passing an inhomogeneous magnetic field formed by a 6-pole magnetic system made of permanent magnets. Modules constitute the system; magnetic field distribution for 150 mm module with tapered poles is showed on Fig.1b.

The magnetic field for RF transitions is generated by electromagnets. It is provided to switch on 3 transitions to guarantee maximum achievable polarization for ^6Li $P_z=2/3$, $P_{zz}=1$; for ^7Li $P_z=1/2$, $P_{zz}=1$, $P_{zzz}=1/3$. Magnetic field distributions for RF transitions in weak and intermediate fields along the atomic beam axis are showed in Fig.1c.

The surface ionizer made of oxidized tungsten is situated in a strong magnetic field ($\sim$30 mT) formed by coils. Unitary charged Li^+ ions are extracted by the grid in the direction of the magnetic field, are accelerated and pass through the stripping carbon foil of $\lesssim$ 10 $\mu g\ cm^{-2}$. The ionizer unit is at positive potential to the ground and the foil is at negative potential. Passing the foil the Li^+ ion beam with energy 210 keV losses 18 keV; multiple scattering loss is unsignificant, energy struggling for the uniform foil is 1.2 keV. Evaluation of equilibrium charge distribution [3] for lithium beam with energy 200 keV gives: $F_0^\infty \simeq 23\%$, $F_1^\infty \simeq 66\%$, $F_2^\infty \simeq 10\%$, $F_3^\infty \simeq 0.1\%$. The electrostatic separator extracts the doubly charged beam. Potentials at various sections of the electrostatic separator are chosen to enable Li^{++} ions be focused into the axial injector (~10 keV).

The oven, the separation magnet and the RF transition system are arranged in a vacuum chamber; oil diffusion pumps guarantee vacuum $\sim 10^{-5}$ torr. Special transformers are used to supply power to the ionizer and the accelerating-moderating tube.

Expected intensities are 30 μA for unitary charged ions and 3 μA for doubly charged ions. For transmission rate through the injector-cyclotron system 0.01 the intensity of polarized lithium ions is expected to be 30 nA.

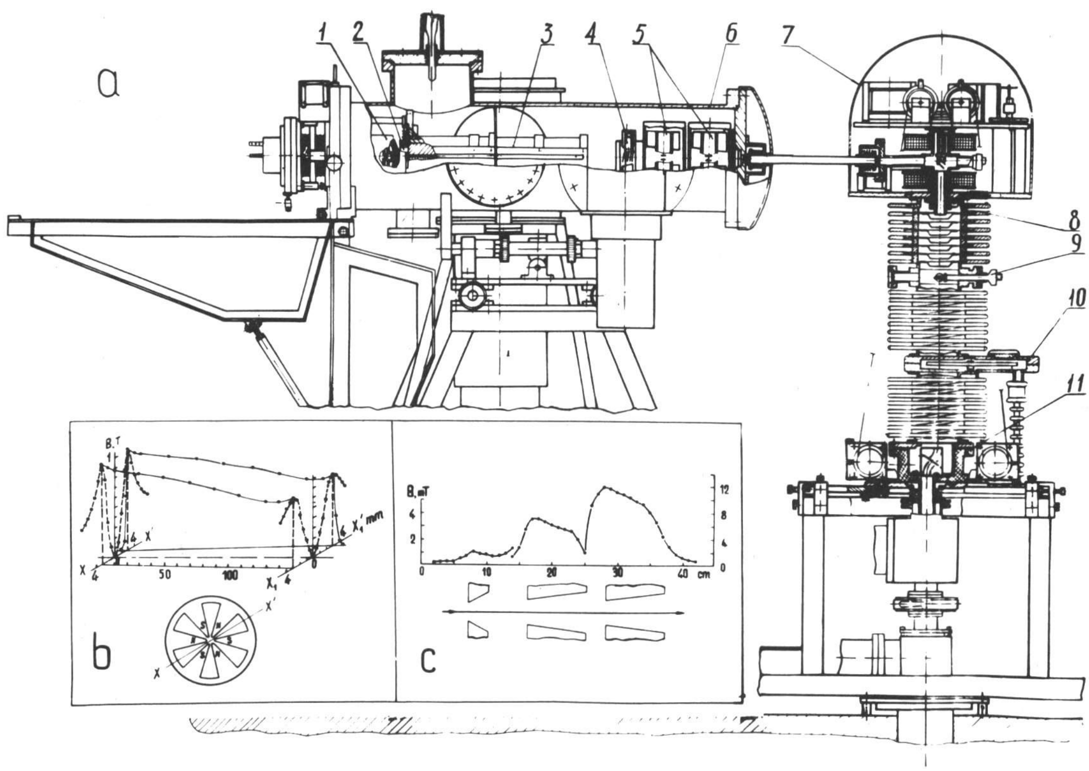

Fig.1. a)Scheme of the source for a polarized lithium beam. b)Magnetic field distribution longitudinally and transverse to the beam axis for the 6-pole magnet with tapered poles. c)Magnetic field distribution along the beam axis for the magnet system of RF transitions.

References

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