Design and Simulation of a Polarized $^6Li^{3+}$ Ion Source

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Nuclear spin-isospin excitations show rich and characteristic features in various nuclei. One of key points to study such excitations is to use probes which are selective for the reactions relevant to the physics of interest. In this paper we will briefly report on design and simulation of a planned polarized $^6Li^{3+}$ ion source for feasibility tests. The source will enable us to study, for example, spin dipole resonances (SDRs) in nuclei involving information on spin degrees of freedom at a beam energy of 100 MeV/A.

In our plan, a ^{6}Li atomic beam is produced by a Li oven and collimators. The ^{6}Li nuclei in the atomic beam are polarized by an optical pumping method. The atoms are, then, injected to an ECR ionizer directory or after ionization to 1+ by a surface ionizer (see Fig. 1) for producing 3+ ions. The part before the ECR is based on the ion source developed at Florida Sate University [1].

One of the critical points to be tested is the amount of depolarization in processes in the ECR. Several depolarization processes have been pointed out: 1) depolarization due to the inhomogeneous magnetic field, 2) depolarization in each elementary process in the plasma, *e.g.* ionization, charge-exchange (electron capture), and excitation of the ions, 3) electron spin-flip due to the electron cyclotron resonances induced by radio-frequency (RF) power, etc.

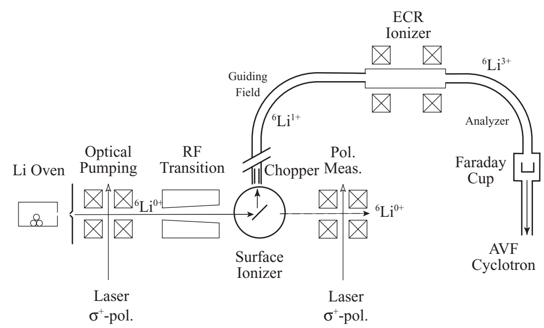

Figure 1. Schematic diagram of the planned polarized $^6Li^{3+}$ ion source in the case of 1+ ion injection to the ECR ionizer (not to scale).

We have performed simulations of the depolarization processes. We assumed a plasma condition which was estimated from a basic study on the 14.5 GHz ECR ionizer (SHIVA) at Univ. of Tsukuba [2]: *e.g.* a uniform electron (ion) temperature of 580 (5) eV with Boltzmann distribution, and a neutral gas (electron) density of 1.4×10^{10} (2.2×10^{11}) cm^{-3}. Ionization rates, charge exchange rates, excitation rates were calculated from fitted parameters reported in literatures [3]. One of the critical parameters was the confinement time (τ) of the ions in the plasma. We assumed a proportional relation of τ to the ion charge and 1 ms for $^6Li^{3+}$. Later we measured time structure of extracted ions from an 18G Hz superconducting ECR ionizer at RIKEN [4] by a laser ablation method and from the analysis of the data we obtained a reasonably consistent value of 0.6 ms for $^7Li^{2+}$.

After analytically solving a network calculation, we obtained depolarizations of 1) 30-40%, 2) 6-30% and 3) less than 0.2% for each depolarization process. The number depends on the polarization mode to be used. Details are described in Ref. 5. Some of depolarization processes possibly have significant effects. The detailed numbers largely depends on the assumed plasma condition, confinement time, and tuning of the ion source. Thus feasibility tests of the depolarization effects are indispensable.

As a part of the injector cyclotron upgrade project, an 18 GHz superconducting ECR ionizer will be installed at RCNP. Combining with this project, we will install a polarized ^{6}Li ion source and a Wien-filter for controlling the spin axis for feasibility tests of polarized $^6Li^{3+}$ ions. The design procedure is in progress.

References

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