Research and development of Boron ion source for nuclear responses for double beta neutrinos and double spin isospin resonances

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Double beta decays are of current interest in view of particle, astro and nuclear physics[1-5]. Neutrino-less double beta decays ($0\nu\beta\beta$), which require the neutrino helicity mixing, are sensitive to the Majorana masses of light and heavy neutrinos, right-left mixings of weak currents, and to SUSY-neutrino couplings. Therefore, the findings of the neutrino-less double beta decays provide difinite evidence for the unified theories beyond the standard theory. Finite ν-masses give contributions to non-baryonic hot dark matters in the universe.

Nucleon (quark) sectors of double beta decays include double isospin-flip and double isospin flip nuclear weak responses. The nuclear isospin symmetry operator τ leads to the sharp isobaric analog state (IAS) and double IAS. On the other hand, the nuclear spin- isospin operator $\sigma\tau$ results in the broad GT (Gamow Teller 1^+) resonance and double GT ones. These GT resonances at the high excitation region exhaust most of the transition strengths and leave a small fraction of the isospin-spin strength at the low excitation region[6]. Recently, $\beta\beta - \nu$ responses have been analyzed in terms of couplings of single particle-hole GT states and GT giant resonance (GTR). Here double GT resonances play crucial roles for the $\beta\beta - \nu$ responses.

Double giant resonances are of great interest to see resonance features at high excitation energy regions[6-14]. At present moment, some new giant resonances standing on the excited resonances are found experimentally. Double isobaric analogue resonances, and double isobaric dipole resonances have been studied using pion probes at LAMPF. Double dipole resonances standing on the single dipole resonances are also found via the heavy ion-heavy ion collision with the great advantage of the strong Coulomb excitation. Double GT resonances standing on the GTR, however, have not well studied. It is shown that nuclear weak responses relevant to the isospin and isospin-spin mode are investigated by studying strong processes of charge-exchange(isospin-flip) spin-flip nuclear reaction. Actually, charge-exchange (^{3}He,t) reactions with E(^{3}He) = 450MeV are used to study isospin spin responses for $\beta\beta$-nuclei. The charge-exchange reactions at the intermediate energy excite preferentially the isospin spin modes.

The present proposal aims at studies of double spin-isospin responses in view of the $\beta\beta - \nu$ decays. The double isospin spin giant resonances are investigated by means of double charge-exchange nuclear reactions. The experimental results will directly provide the information on nuclear double-weak responses, which are crucial in getting the physics quantities beyond the standard theory. So far, double charge-exchange reactions with double isospin flips of $\Delta T_z = \pm 2$ have been studied by double pion exchange reactions. Pion reactions, however, are rather complicated because they include isobars and many other processes. The (^{11}B,^{11}Li) double charge exchange reaction is one of the possible reaction. But, there is no experience of Boron beam by Ring-cyclotron. The figure 1 shows schematic diagrams for $2\nu\beta\beta$ double beta decay processes compared with heavy ion double charge exchange reactions to be studied in this proposal.

Research and development of ^{11}B ion source was done. NEOMAFIOS[15] is the ECR ion source of 10GHz RF frequency for non-polarized light and medium ion. This ion source is used a permanent magnet (Fe-Nd-B) as a mirror magnet instead of solenoidal coil and was developed at CEA(Centre d'Etudes Nucle'aires de Grenoble, France). We were tested some material such as ,the mono lattice rod of Boron ,H_2BO_4, $Li_2B_4O_7$, RnB_6, BN ,as Boron ion source. The parameter seach was done such as some kinds of support gas , the flow rate of the support gas, the sending velocity of the material, RF power of the NEOMAFIOS. We have researched about intensity and stability of the Boron beams.

The result, the ^{11}B ions were produced by using of the mono lattice rod and He support gas. The size of this lattice rod was 4mm$\phi\times$60mm. Boron rod is moved 0.15 mm/h by stepping motor control system to direction to the NEOMAFIOS ECR central region as spattering source. The melting point of lattice Boron is 2300 degree. The Ta sheet was covered with inside chamber to prevent for damage of inner chamber. The RF power was 650W. The typical vacuum is 4×10^{-7}Torr at extraction region of the NEOMAFIOS. The He support gas flow was controlled by feed back system to monitored the drain current of the accelerator power supply. The typical intensity of $^{11}B^{4+}$ was 3 μA at the FARADAY-CUP placed at the out of ion source point after analyzed by magnetic dipole field.

At the present, ^{11}B(E=780MeV) and 5nA beam by RING-cyclotron was available. Therefore, (^{11}B,^{11}Li) double charge exchange reaction is possible. The energy of 70 MeV/A is enough to selectively excite the isospin and spin modes. The beam intensity is required to be the order of 5nA.

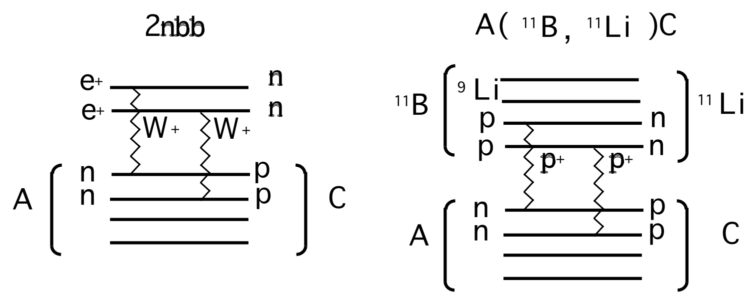

Figure 1: The schematic diagrams for $2\nu\beta\beta$ double beta decay processes(left side) compared with heavy ion double charge exchange reactions(right side) to be studied in this proposal.

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