Charged particle decay from excitation energy regions of dipole resonance analogs in the α clusters of ^{6}Li and ^{7}Li

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In a series of singles experiments we searched for the intrinsic excitation of the α clusters in ^{6}Li and ^{7}Li and found dipole resonances (DR's) in ^{6}Li and ^{7}Li via the (p,p'), in ^{6,7}He via the ^{6,7}Li(^{7}Li,^{7}Be) and in ^{6,7}Be via the ^{6,7}Li(^{3}He,t) reactions at Q~-27 MeV [1, 2]. The excitation energies for the DR's are much higher than the well known isovector giant dipole resonance (GDR) in ^{6}Li and ^{7}Li. Based on the comparison of the resonance shapes, excitation energies, and cross sections for the DR's with those reported in the photoreactions and in the ^{4}He(p,p') reaction [3, 4] we suggested that the DR's are consistent with the DR's consisted of the GDR's and spin dipole resonances (SDR's) in the α cluster of ^{6,7}Li and their analogs [1, 2]. Since the idea for the excitation of the α clusters is not yet well established, it is very important to confirm this interpretation from different viewpoints.

In the present work, we investigated the ^{6,7}Li(^{7}Li,^{7}Be x) reactions by using the 455-MeV ^{7}Li beams from RCNP [5, 6] to determine the branching ratios for charged particle decay from the excitation regions of the high-lying DR's in ^{6}He and ^{7}He at E_x~24 and 18 MeV, respectively. The resonances had been observed and interpreted in our previous work as the candidates for the analogs of the giant dipole resonances in the α clusters in ^{6}Li and ^{7}Li. The present study may also provide information on the microscopic structure of the DR's.

Noticeable events have been observed in the coincidence with x=d, t, and α in the ^{6}Li(^{7}Li,^{7}Be x) reaction, while coincidence events have been observed to be very small for p. On the other hand, in the ^{7}Li(^{7}Li,^{7}Be x) reaction coincidence events with x=t and α have been observed to be large, and those with p and d have been observed to be very small. The branching ratios in the DR region of ^{6}He, thus obtained for d+t+n and α+2n channels are found to be about 43% and 40%, respectively. Those in the DR region of ^{7}He for t+t+n and α+3n channels are found to be about 47% and 40%, respectively [7].

The specific feature of the observed large branching ratios for the d+t+n channel in ^{6}He and for the t+t+n channel in ^{7}He are qualitatively understood as follows: The ground states of ^{6}Li and ^{7}Li have the cluster structures of d+α and t+α, respectively. The DR's observed in ^{6}He and in ^{7}He at E_x=24 MeV and 17 MeV, respectively are excited via the reaction process in which the α clusters themselves are excited as $\alpha \rightarrow {}^4\mathrm{H}^*$ in both ^{6}Li and ^{7}Li. On the other hand, the d and t clusters in ^{6}Li and ^{7}Li, respectively remain as the spectators during the reaction process [8]. Since the produced ^{4}H* is the resonant system of t+n, the DR's would have the components of d+t+n and t+t+n for ^{6}He and ^{7}He, respectively. d and t from ^{6}He and t from ^{7}He can be emitted as the dominant decay products because the DR's are located above the thresholds. Considerable magnitude of branching ratios for the α decay may be due to come from the underlying continua in both ^{6}He and ^{7}He. This interpretation is very consistent with the idea of the α cluster excitation. Therefore, the present experimental results are a strong evidence for the DR's in ^{6}He and ^{7}He being the α cluster excitations.

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