Deep-hole State in ^{6}He and its Di-triton Cluster Structure

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Quasifree scattering is one of the most direct ways of investigating both the single-particle properties in a nucleus and the nature of the strong interaction in the nuclear medium. In spite of a lot of experimental efforts via quasifree nucleon knockout reactions as well as pick-up reactions, only the macroscopic structures like separation energies (E_{sep}) and total widths (Γ) were obtained for deep-hole states. Detailed structures and fragmentation mechanisms of deep-hole states have been little known even for light nuclei until now.

In the previous E110/E148 experiments, decay particles from the s-hole states in ^{11}B and ^{15}N were measured in coincidence with the quasifree ^{12}C$(p,2p)$ and ^{16}O$(p,2p)$ reactions [1]. Triton-decay was found to be larger than α-decay for both s-hole states in ^{11}B and ^{15}N despite its smaller Q-value than that of α-decay. This supports the selection rule predicted by the microscopic SU(3)-model calculations [2]. However, the statistical decay process competes with or is larger than the direct decay from the doorway s-hole states in ^{11}B and ^{15}N.

In the case of ^{6}He, the ratio of the mean free path of an s-hole to the nuclear radius is about 4 and, therefore, the direct decay process is expected to be dominant. The ^{6}He(s-hole) is more suitable to study its microscopic structure through the partial fragmentation widths. The threshold energies of decay from ^{6}He to the channels $\alpha+2n$, ^{5}He$+n$, and $t+t$ are 0.973, 1.77, and 12.3 MeV, respectively. Thus, the simple shell-model calculation predicts that decay with neutron(s) is predominant for the s-hole state.

Since ^{6}He is the lightest so-called "skin" nuclei, it has recently received considerable attention. Its high excitation states have, however, not been understood well. If the ground state of ^{7}Li is described by the $\alpha+t$ cluster state, the term "s-hole" dose not mean the naive $(s)^3(p)^3$ shell-model configuration, but suggests the $t+t$ structure after one proton is knocked out from the α-cluster. No discussion has ever made on the relation between the s-hole state and the di-triton cluster structure.

The experiment (E204) was carried out at RCNP, by using a 392 MeV proton beam. The quasifree $(p,2p)$ reaction was measured with the dual spectrometer system consisting of the high resolution spectrometer Grand Raiden (GR) and the large acceptance spectrometer (LAS). GR was set at 25.5° and the laboratory angle of LAS and the magnetic fields of two spectrometers were determined to satisfy the zero-recoil momentum condition at the central energy of the $s_{1/2}$-knockout bump, Charged particle decay of the s-hole state was measured with fifteen telescopes of ΔE-E Si solid-state detectors (SSD) in coincidence with the quasifree $(p,2p)$ reactions. Particle identification of decay particles is mainly made by means of the time-of-flight (TOF) method with the flight length of 25 cm. In order to reduce the energy losses of the emitted particles, we used thin ^{7}Li targets (1.5 mg/cm^2).

Excitation energy spectrum of the hole-states obtained by the ^{7}Li$(p,2p)^6$He reaction is shown in Fig. 1(a). A bump corresponding to the s-hole state is strongly excited around 15 MeV. Two-dimensional and coincidence spectra with decay charged particles are shown in Figs. 1(b) and (c), respectively. Our result shows that the ^{6}He(s-hole) state dominantly decay to the t+t channel. Its branching ratio is above 70%, which suggests the "s-hole" state has the di-triton cluster structure.

In the recent measurement of the ^{6}Li(^{7}Li,^{7}Be) reaction, a resonance with large binary triton decay was found at $E_x(^6\mathrm{He})\approx$ 18 MeV [3]. It is, however, not clear if this resonance has the same origin as the s-hole state because the peak energy of the resonance is about 3 MeV higher than the central energy of the s-hole state. The analysis of the recoil momentum dependence and analyzing power for the ^{7}Li$(p,2p)^6$He* reaction is in progress to elucidate more precisely the relevance between the di-triton cluster structure and the s-hole state.

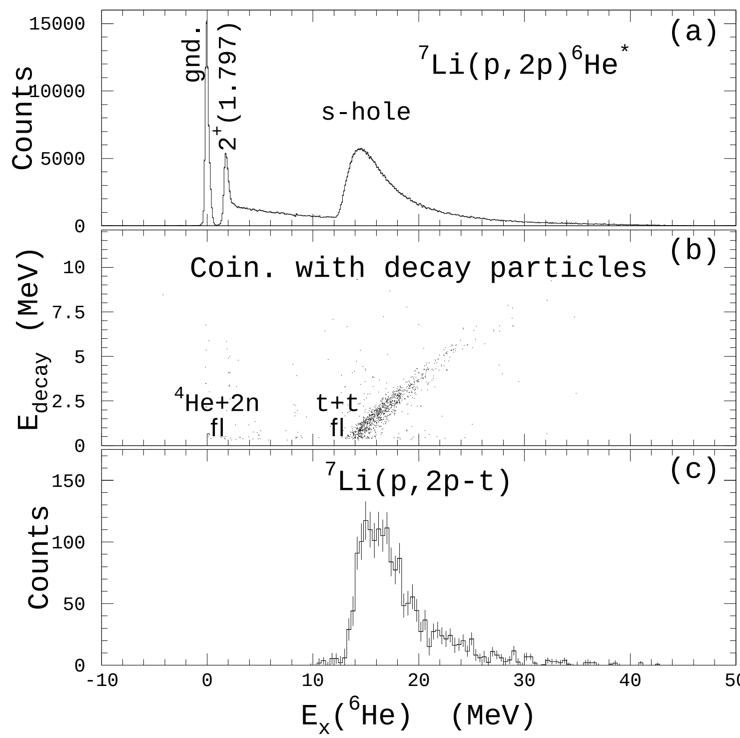

Figure 1: (a) Excitation spectrum of ^{6}He produced by the ^{7}Li$(p,2p)^6$He* reaction at E_p = 392 MeV. (b) Two-dimensional plot of the energies of the decay particles versus the excitation energy of ^{6}He. The locus corresponding to t+t two-body decay is clearly seen. (c) Coincidence spectrum for the ^{7}Li$(p,2p$-$t)$ reaction.

References

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