2 - 24 Breakup Reaction of ^{9}Li

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The studies of nuclear cluster structure play an important role in understanding of nuclear structure properties. There are lots of works have been done[1−6] to study the nuclear cluster structure properties.. It is a very important method to investigate the nuclear cluster structure through analyzing the breakup reaction of the interesting nucleus.

The experimental study of the cluster structure of ^{9}Li through analyzing its breakup fragments was performed at Radioactive Ions Beam Line in Lanzhou (RIBLL). The light charged particles were measured by a ΔE-E telescope array. Also the energy distribution of the fragments have been measured in this experiment.

The experiment was carried out at RIBLL. The primary beam is 53.7 MeV/u ^{12}C delivered by the Heavy Ion Research Facility of Lanzhou (HIRFL). The RIBs were produced by bombarding the production target. Be with a thickness of 3 038 μm, and analyzed and delivered to the secondary reaction chamber at the second focal point by RIBLL. In order to improve the purity of the selected secondary RIBs, a 2 153 μm thick Al wedge was used as a degrader at the first focal plane of RIBLL. Two 50 μm plastic scintillation detectors, installed at two focal points of RIBLL with a distance of 17 m, were used as time of flight detectors to identify the radioactive beams combining with the magnetic rigidity and the energy losses detector, a 325 μm silicon detector. For the same magnet set for ^{9}Li, the contaminants of ^{8}Li, ^{7}Li, ^{6}He, ^{4}He and ^{3}H ions were also delivered. In the secondary reaction chamber, three position-sensitive Parallel-Plate Avalanche Counters (PPACs), developed at the Institute of Modern Physics, Chinese Academy of Sciences[7], provide the position of the incoming beams with a position resolution better than 1 mm. Each PPAC had 51 gold-plated tungsten wires in both X and Y directions and a sensitive area of 50 mm×50 mm. The distances of PPAC1, PPAC2 and PPAC3 from the secondary target were 1 386.5, 996.5 and 91.5 mm, respectively. The position and incident angle of the beam particles at the target were determined by extrapolating the position information provided by the PPAC1, PPAC2 and PPAC3 event-by-event.

The Pb target was a self-supported foil with a thickness of 526.9 mg/cm^2. A ΔE-E telescope array covers the polar angles -10 ° to 10 ° in the laboratory frame. A detailed description of this telescope array can be found in Ref. [8]. The telescope array consisted of two ΔE detectors. They are double-sided silicon strip detectors (DSSDs) with the thickness of 523 μm for the DSSD 1 and 527 μm for the DSSD 2 and an sensitive area of 49 mm×49 mm which is divided into 16 strips with the width of 3 mm and the interval of 0.1 mm between each two of them in each side. The two DSSDs were also applied to determine the position of the outgoing particles with a position resolution better than 3 mm. The E detector is a CsI(Tl) crystal array which is composed of 8×8 CsI(Tl) crystals, produced and fabricated at the Institute Modern of Physics (IMP), CAS[9]. The active area of each crystal unit is 21 mm×21 mm for the front side and 23 mm×23 mm for the back side. The length of each crystal is 50 mm. A light guide is used to couple the crystal and PMT (photo-multiple-tube, Hamamatsu R1213 type with a gain of $\sim 6.7\times10^{5}$) by an optical glue.

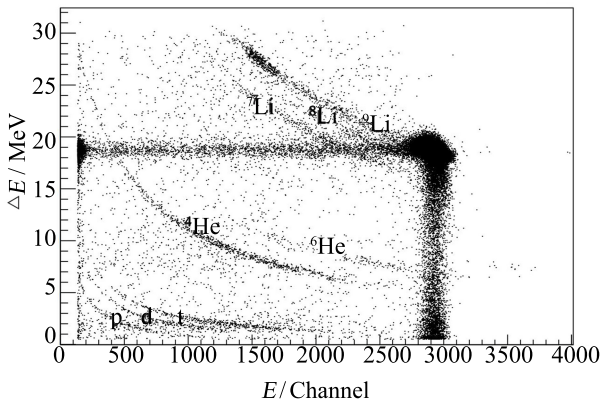

Fig. 1 Typical $\Delta E-E$ particle identification spectrum.

A typical ΔE-E particle identification spectrum obtained in the telescope array is shown in Fig. 1 after cutting the contaminants of RIBs for the relative pure ^{9}Li. ΔE is the energy losses from the ΔE detector DSSD2 and E is the residue energy deposited in the CsI(Tl) crystal. A clear separation of different nucleus is obtained. The shown nuclei p (proton), d (deuterium), t (tritium), ^{8}Li, ^{7}Li, ^{6}He and ^{4}He are all the breakup fragments from ^{9}Li on Pb target. In present investigation, we mainly take into account the α+t+n+n structure of ^{9}Li via its breakup reaction on Pb target. Through analyzing the ΔE-E telescope array, the coincident charged particles α and t were identified and investigated. In Fig. 2, it is the ΔE-E spectrum of coincident charged t and α in breakup reaction from ^{9}Li. And the energy sum spectra of the coincidence of charged t and α is demonstrated by Fig. 3. The existence of the α+t+n+n structure of ^{9}Li possibly be determined by these coincident charged particles α and t from the breakup reaction of ^{9}Li on Pb target.