2 - 2 New Detector Array on Gas-filled Separator, SHANS

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The gas-filled recoil separator has been a useful tool for separation of heavy evaporation residues (EVRs) produced in complete fusion reactions. To study the properties of heavy and superheavy nuclei, the Lanzhou gas-filled separator[1], SHANS (Spectrometer for Heavy Atom and Nuclear Structure), has been commissioned at IMP. In this work, we describe the new detector array installed at the focal plane position. And the primary performances of the system in the $^{40}Ca+^{175}Lu$ reaction are discussed.

The schematic view of the detector array is shown in Fig. 1. It consists of a Multi-Wire Proportional Counter (MWPC) and a silicon detector box (Si-box). When arriving the detector chamber, the EVRs pass though the MWPC and are finally implanted into the Si-box. The event chains consisting of implanted recoils and their subsequent α decays and/or spontaneous fission are identified by the position-and-time correlation method[2].

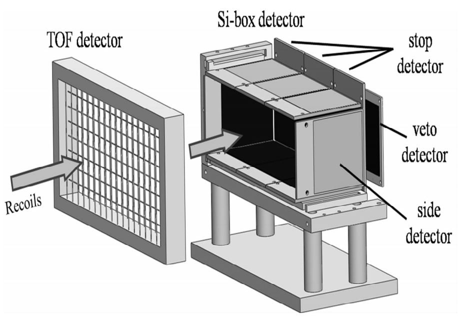

Fig. 1 The new detector array installed at the focal plane position of SHANS.

For the time-of-flight (TOF) detector, an active area of the MWPC is about 180×80 mm^2. The isobutane gas is filled at the pressure of about 200 Pa. An ultra-thin 0.5 μm mylar window separates the TOF system from the gas media (usually 70～100 Pa Helium gas) of the separator. Combining with the signals from the MWPC and Si-box, the timing resolution is determined to be about 10 ns. The TOF information is used to distinguish the α-particle signals from the implantation events.

Three 300-μm thick Position Sensitive silicon Detectors (PSD) are mounted at the back of Si-box as the implantation detectors (stop detectors). They have total active area of 150×50 mm^2 and are divided into 48 independent vertical strips providing 3-mm horizontal position accuracy. Signals are provided from both the top and bottom of each strip. Resistive charge division provides 1.5-mm vertical position resolution with each strip. The typical energy resolution of PSD is 50 keV FWHM for 6～8 MeV α particles. Signals from the preamplifiers are processed through two amplification branches, one for detecting α particles and the other for implantation and fission fragments. Eight non-position-sensitive silicon side detectors are mounted in an open box arrangement around the strip detectors to detect the escaping radioactive decay events. Three punch-though detectors (veto detectors), which have the same size and thickness as the implantation detectors, are mounted behind the PSD to provide veto signals for light particles passing through the strip detectors.

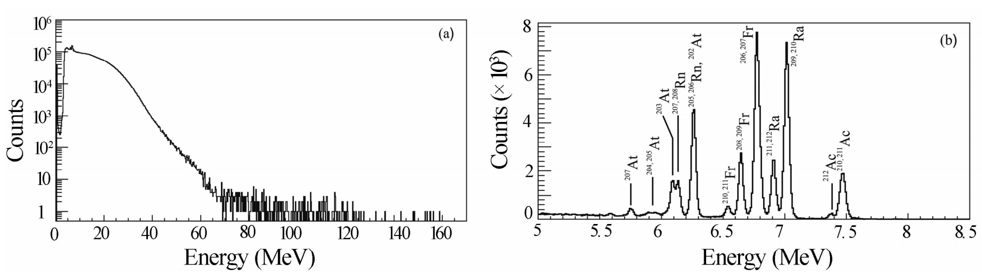

Fig. 2 The energy spectrum measured in the silicon strip detector during the entire $^{40}Ca+^{175}Lu$ experiment. (a) The ungated total energy spectrum. (b) The α-decay spectrum after applying the MWPC veto.

Recently, with the newly installed detector array (MWPC+Si-box), a measurement was made using a ^{40}Ca beam at 204 MeV incident on a stationary 500-μg/cm^2 thick ^{175}Lu target. In Fig. 2(a), the ungated total energy spectrum recorded in the strip detectors during the entire experiment is displayed. The MWPC-vetoed α-particle energy spectrum is shown in Fig. 2(b). Several isotopes from xpyn evaporation channels and their subsequent α-decay nuclei were identified. The suppression of the full energy primary beam was estimated to be a factor of 10^{15}. Analysis of the experimental data is still in progress.

References

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2 - 3 Dynamics Aspect of Subbarrier Fusion Reaction in Light Heavy Ion Systems

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Nuclear fusion reactions near the Coulomb barrier are strongly affected by thestructure of the interacting nuclei, especially with weakly bound neutrons[1]. Some theoretical calculations predict that the fusion cross section is enhanced over well-bound nuclei because of the larger spatial extent of halo nucleons[2]. On the other hand halo nuclei can easily break up in the field of the other nucleus, due to their low binding energies. Experimentally this is still a hot debate because of experimental difficulties.

Another interest we propose here is the influence of the cluster structure in the fusion mechanism. Recent calculations, using an antisymmetrized molecular dynamics model(AMD), indicate that light nuclei exhibit variety of distinct cluster structures[3-6]. The cluster structures are predicted even for nuclei with $Z\sim N$ of Li and Be[4](where Z and N are the charge and neutron number in a nucleus, respectively). When nuclei with a well-developed cluster structure are involved in fusion reactions near the barrier, it will be reflected on the fusion cross section. In this report we present the calculated results in the study of the fusion reactions of the ^{7}Li + ^{12}C system near the Coulomb barrier using AMD simulations.

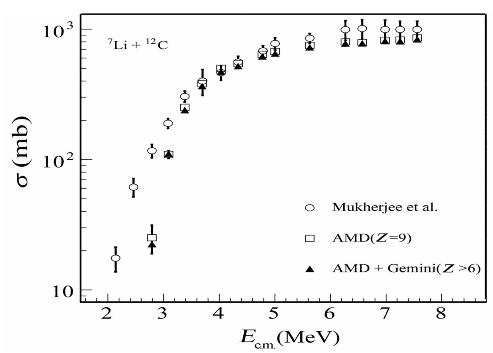

Fig. 1 Fusion cross section for the ^{7}Li + ^{12}C. Circles represent experimental results and taken from Ref. [8].

The AMD calculations were performed up to times ranging from 3000 fm/c at lower energies to 1000 fm/c at higher energy side and clusterized at the end of the calculation, using a coalescence technique in phase space. Even after such a relatively long time, most clusters were in an excited state. In order to compare the simulated results to those of the experiments, the excited fragments were cooled down using the statistical decay code, GEMINI[7]. These events are referred to as the AMD + GEMINI events hereafter, whereas the events without the GEMINI calculation are called the primary events and referred to as the AMD events. The occurrence of the fusion reactions in the AMD + GEMINI events is defined here by the emission of the fragments with $Z>6$ in a given event.

In Fig. 1 the calculated fusion cross sections, indicated by closed triangles, are compared to those of the experiments (open circles). The experimental data are taken from Ref. [8]. The experimental data are reproduced well within the experimental errors above $E_{cm}>3$ MeV in the absolute scale. The absolute cross sections predicted by the AMD simulations were calculated using the number of events generated in the given impact parameter range. At $E_{cm}\leqslant 3$ MeV the AMD simulation underestimated the fusion cross sections. In this energy range, the tunneling effect through the Coulomb barrier becomes important and in the present AMD formulation, this process is not incorporated. In the figure the formation cross sections of ^{19}F in the primary AMD events are also plotted by open square symbols.

In summary, the fusion cross section of the ^{7}Li + ^{12}C reaction was studied using the AMD and GEMINI codes. The AMD+GEMINI simulation reproduced the experimental total fusion cross sections reasonably well at $E_{cm}>3$ MeV but under estimated it below that energy.