Study of the reactions 56Fe, 58Ni (12C, αα) and formation of fully stripped ions in multi-nucleon transfer reaction

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We have recently carried out a measurement at the Pelletron accelerator facility, IUAC, Delhi using the general purpose scattering chamber GPSC. The one of the aims of the experiment was to study the reaction (12C, 8Be) through α-α coincidence measurement. Multi-nucleon transfer between heavy ions represents an important reaction mechanism to understand correlation among nucleons. Our earlier study of multi-nucleon transfer reaction (^{18}O, X) [1] indicates a large enhancement of two neutron and two neutron correlated transfer. Such transfer reactions leading to specific states of residual nuclei and a detailed coupled reaction channel analysis in terms of microscopic form factors for two neutrons transfer will allow us to gain information on the two neutron correlations and detailed reaction mechanism. This study may be useful to understand large transfer cross sections measured for reactions involving the radioactive nuclei such as ^{6}He, ^{8}He etc. In addition, the four nucleon transfer reaction (^{12}C, ^{8}Be) is not so well studied due to the complexity involved in detection of the unstable ^{8}Be nucleus which decays into two alphas. On the other hand, cross section for this channel is expected to be large (as compared to the single and/or two nucleon transfer reactions) due to Q-value effect. The reaction mechanism is interesting in order to understand the role of one step alpha transfer vis-à-vis multi step sequential transfer of four nucleons. However, our earlier study [2] on ^{12}C+^{56}Fe system at 60 MeV and a detailed Coupled Reaction Channel calculation indicate a significant contribution from multi-step sequential process for the two and three nucleon stripping reactions.

In the present experiment at IUAC, Delhi we have measured coincidence between the two alphas originating from ^{8}Be decay in ^{12}C(^{58}Ni, ^{8}Be) and ^{12}C(^{56}Fe, ^{8}Be) using two (ΔE-E) and a silicon pad detector. A very good charge and mass separation has been achieved for projectile like products and a typical α-α coincidence

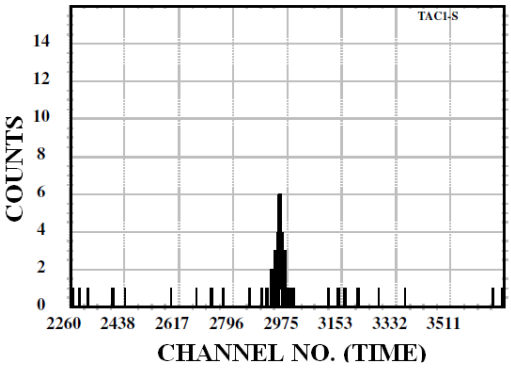

Fig.1. A typical alpha-alpha coincidence spectrum in 12C(58Ni, αα) at E(C)= 60 MeV.

spectrum is shown in Fig.1. The angular distributions of elastic scattering (Fig.2) and transfer reactions have been measured. Analysis is in progress.

The other aim of the experiment was to

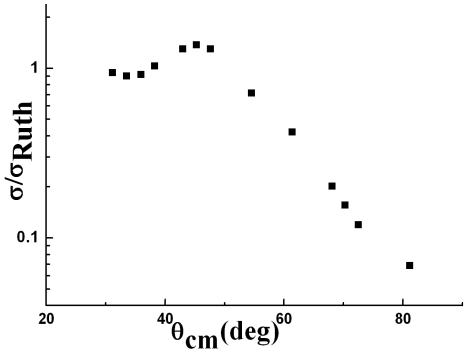

Fig.2. Elastic scattering angular distribution (preliminary results) for ^{12}C + ^{58}Ni at E(^{12}C) = 60 MeV.

investigate the formation of fully strip ions using transfer reaction. In some of our earlier work we have shown that projectile like ions are most likely formed in the fully stripped charged state[3]. Also in an another study we got sufficient hint that ions do capture up to circular Rydberg states while passing through the target[4]. Surprisingly in these studies Rydberg states were observed only with the H-like ions. It can be noted here that no Rydberg states can survive while the ions passing a solid matrix indicating that they can only be formed near exit surface. This requires that the starting ion must be in fully stripped condition. In order to have a further under-standing on this, the present experiment was performed in direct and inverse kinematical conditions. X-ray spectra from the atomic transitions were recorded by a HpGe detector placed at 90° w.r.t beam direction and suitable absorbers were used to attenuate X-ray intensity. Fig.3 & 4(upper panel) show the X-ray spectra for 60 MeV carbon beam on enriched 58Ni & 56Fe target. X-ray lines from target like nuclear products are seen. In order to circumvent impurity problem with 58Ni target, we have used inverse kinematics i.e., 58Ni beams(175 MeV) were bombarded on carbon target to observe x-ray lines from projectile-like ions. Fig.4 shows x-ray spectra observed in the direct and inverse kinematic conditions revealing the electron transfer from target to target-like atoms and projectile to projectile-like ions. Results will be discussed.

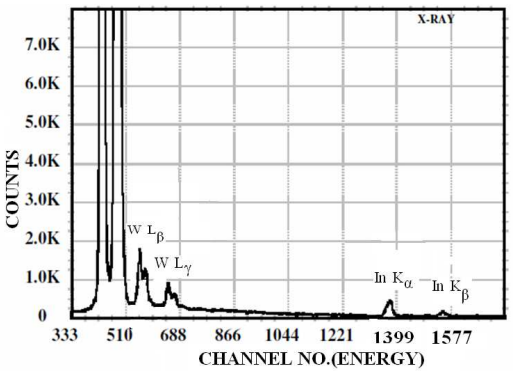

Fig.3 X-ray spectrum as obtained from 60 MeV Carbon bombarding on Ni target

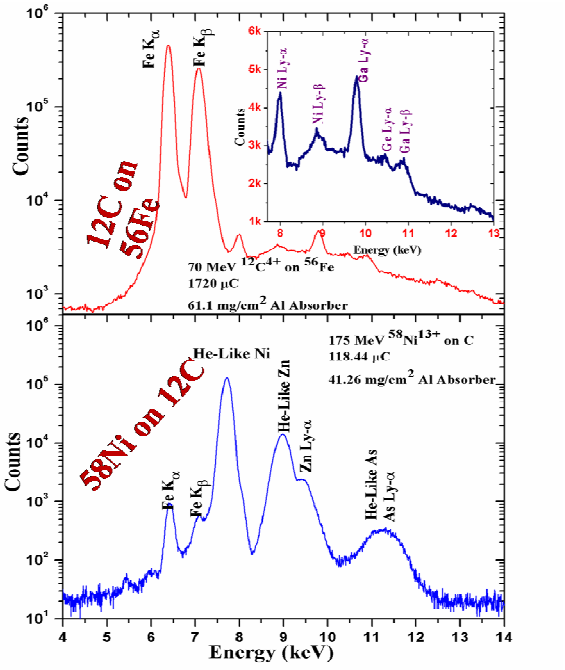

Fig.4 A detailed comparison of the observed X-ray spectra as obtained in direct (upper panel) and inverse (lower panel) kinematics.

References:

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