Multi-nucleon Transfer Reactions in $^{18}O+^{206}Pb$ at $E(^{18}O)$ = 140 MeV

B. J. Roy[*1], V. Jha[1], U. K. Pal[1], K. Mahata[1], S. K. Pandit[1], V. V. Parkar[1], A.Parmar[2]

1: *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai-400085*
2: *Department of physics, Sardar Patel university, Vallabh Vidyanagar - 388120*
* *Corresponding author:* bjroy@barc.gov.in

Nuclear reactions involving a large number of nucleons transferred have been often observed [1, 2] to occur with a probability comparable to that of single nucleon and account for a large fraction of the total reaction cross section at and above barrier energies. Depending on the reaction mechanism and projectile – target combination, the origin of multi-nucleon transfer could be direct transfer of cluster (two particle pairing, alpha clustering etc.) or multistep sequential transfer of nucleons. For reactions between two complex nuclei, which is not so well understood because of the complicacy involved in the reaction processes, it is usually very difficult to discriminate the population of individual states in experiments involving particle detection only. Nevertheless, measurements of the individual projectile like fragments (PLF) yields could provide a detailed insight into the underlying reaction mechanisms and its effect on the other reaction processes.

The reaction $^{16}O+^{208}Pb$ is well studied and is a benchmark in nuclear reaction studies as both the projectile and target are doubly magic nuclei. However, the reaction $^{18}O+^{206}Pb$ has advantageous over the $^{16}O+^{206}Pb$ for probing transfer effects on other reaction channels as the former reaction has positive Q-value for the 2n transfer channel while no transfer channel with Q>0 found in the 2[nd] system. With this motivation in mind, we have studied the reaction $^{18}O+^{206}Pb$ at $E(^{18}O)$= 140.4 MeV. To our knowledge this is the first measurement in this system at this energy.

The experiment was carried out with ^{18}O beam obtained from the BARC-TIFR Pelletron-LINAC facility at Mumbai. The target was an enriched ^{206}Pb target (t~250μg/cm^2) on carbon backing with a backing thickness of ~ 30 μgm/cm^2. Data have also been collected using a separate ^{12}C target in order to subtract contribution from the backing, if any. PLFs were detected and identified by four ΔE-E counter telescopes of suitable thickness and a clean separation of transfer products up to ΔN=11 nucleon transfer is obtained (Fig.1.).

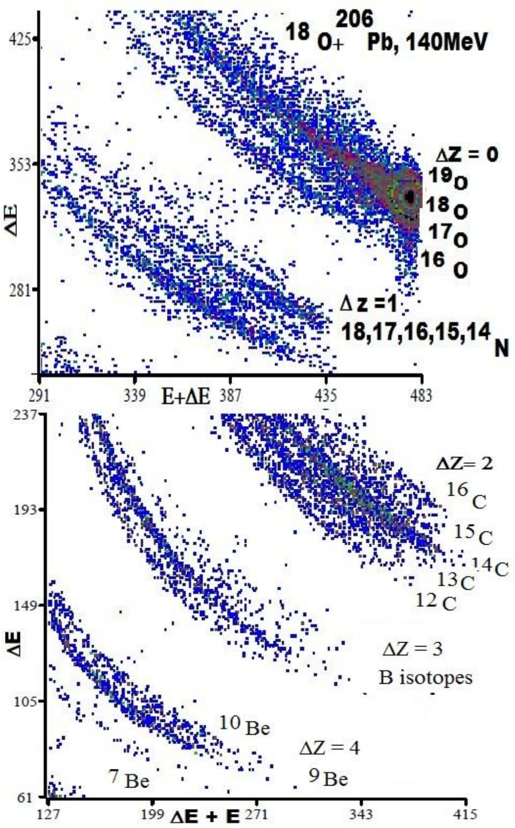

Fig.1: Two dimensional plot for the projectile like fragments in the reaction $^{18}O+^{206}Pb$ at the indicated energy. ΔZ corresponds to the number of protons transferred.

The elastic scattering angular distribution has been measured and is shown in Fig.2.

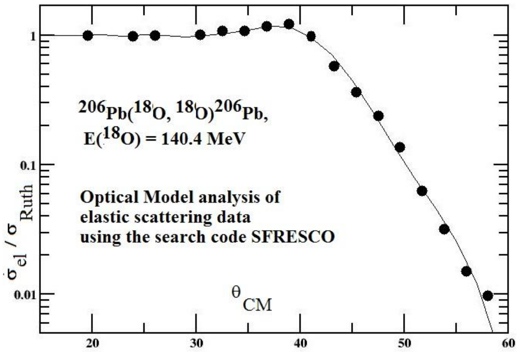

Fig.2. Angular distribution for elastic scattering cross section for the indicated system along with results from the SFresco calculations.

Transfer reaction cross sections for the Q-integrated data have been extracted and are shown in Table 1. ΔN with '+' sign indicates pickup reaction while a '-' sign is used for stripping reactions. Most dominant transfer processes are highlighted in bold. The present energy integrated data includes contribution from ^{12}C backing.

Table 1. Reaction cross section for different transfer process measured at θ_{CM} = 32.5 deg.

Reaction	Q_{gs} MeV	ΔZ	ΔN	dσ/dΩ mb/sr
$^{206}Pb(^{18}O,^{19}O)$	-4.13	0	**+1n**	**17.98**
$^{206}Pb(^{18}O,^{17}O)$	-1.31	0	**-1n**	**23.4**
$^{206}Pb(^{18}O,^{16}O)$	+1.92	0	**-2n**	**18.58**
$^{206}Pb(^{18}O,^{18}N)$	-17.65	1	-1p+1n	3.61
$^{206}Pb(^{18}O,^{17}N)$	-12.38	1	-1p	19.4
$^{206}Pb(^{18}O,^{16}N)$	-11.38	1	-1p-1n	10.93
$^{206}Pb(^{18}O,^{15}N)$	-6.4	1	**-1p-2n**	**35.29**
$^{206}Pb(^{18}O,^{14}N)$	-12.64	1	-1p-3n	3.64
$^{206}Pb(^{18}O,^{16}C)$	-20.8	2	-2p	5.55
$^{206}Pb(^{18}O,^{15}C)$	-18.08	2	-2p-1n	7.84
$^{206}Pb(^{18}O,^{14}C)$	-11.64	2	**-2p-2n**	**52.22**
$^{206}Pb(^{18}O,^{13}C)$	-15.26	2	**-2p-3n**	**34.02**
$^{206}Pb(^{18}O,^{12}C)$	-14.2	2	**-2p-4n**	**27.55**
$^{206}Pb(^{18}O, B)$	-	3	-	37.66
$^{206}Pb(^{18}O,^{10}Be$	-32.86	4	-4p-4n	8.54
$^{206}Pb(^{18}O,^{9}Be)$	-34.75	4	-4p-5n	13.72
$^{206}Pb(^{18}O,^{7}Be)$	-43.99	4	-4p-7n	1.87
$^{206}Pb(^{18}O, Li)$	-	5	-	38.28

For establishing the reaction mechanism aspects, it is a great challenge to achieve a clear distinction between multistep sequential and one step cluster transfer. The pair/cluster transfer is a clear signature of and is a probe to study correlations amongst nucleons. In order to study these aspects, the measured cross section data has been used to extract (Fig.3) the transfer probability $P_{tr}(\theta)$ as defined in [1]

$$(d\sigma/d\Omega)_{tr} = (d\sigma/d\Omega)_{el} \;.\; P_{tr}(\theta).$$

The experimentally measured transfer probabilities for multi-nucleon transfer can then be compared with the corresponding probabilities for multi-step sequential transfer, also measured simultaneously, to study the importance of direct cluster transfer of nucleons vis-à-vis multi-step single particle transfer. Analysis is in progress.

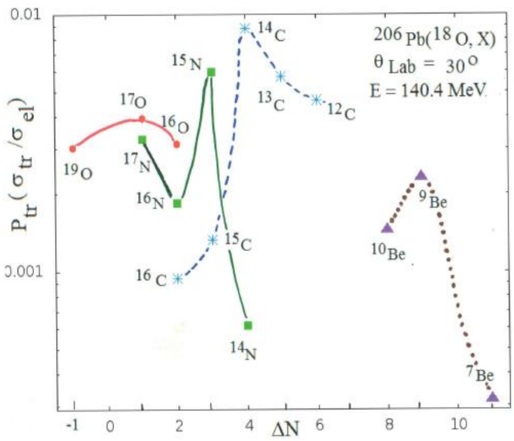

Fig. 3. Transfer probability for Q-integrated data plotted as a function of number of nucleons transferred (ΔN). The negative values of ΔN correspond to pick up channels. Smooth lines are drawn through the data points to guide the eye.

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References

[1] B.J.Roy et al; Nucl. Phys. **A597**, 151 (1996)
[2] V.Jha, B.J.Roy et al; EPJ **A19**, 347 (2004)