ANGULAR MOMENTUM TRANSFER IN THE INCOMPLETE FUSION REACTIONS OF 180 MeV AND 310 MeV ^{16}O

R. K. Choudhury, M. N. Namboodiri, L. Adler, M. Berlanger, J. D. Bronson, U. Garg, P. Gonthier, D. Haenni, K. Hagel, Y.-W. Lui, G. Mouchaty, T. Murakami, J. B. Natowitz, R. P. Schmitt, S. Simon, J. P. Sullivan and D. H. Youngblood

Cyclotron Institute, Texas A&M University, College Station, TX 77840

Using a sixteen-segment NaI(TI) total gamma energy detector the angular momentum transfer in the reactions of ^{16}O with ^{154}Sm and ^{90}Zr has been determined at energies of 180 and 310 MeV. The ℓ-transfer for ejectiles with Z=2-8 is found to be substantially less than expected for binary peripheral collisions.

The experiment was performed using ^{16}O beams of 180 and 310 MeV energy from the Variable Energy Cyclotron at Texas A&M University. Self-supporting targets of ^{90}Zr and ^{154}Sm of thickness of 1mg were employed. The target location was at the center of a sixteen-segment NaI(TI) total gamma energy counter (TEC) array. Fragments with Z from 2 to 10 were detected at 12 deg. with respect to the beam direction using two telescopes consisting of 50, 100 and 1000 micron Si detectors. Isotope resolution was obtained for all products of $Z < 8$ that penetrated to the third detector in the telescopes.

The spectrum of gamma rays emitted in coincidence with each ejectile isotope was determined for every 10 MeV interval in the ejectile energy.

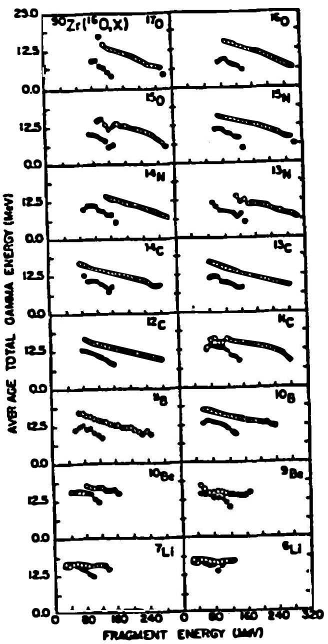


Fig. 1 $\overline{T}_{\gamma}$ for $^{16}O + ^{90}Zr$

310 MeV o

180 MeV •

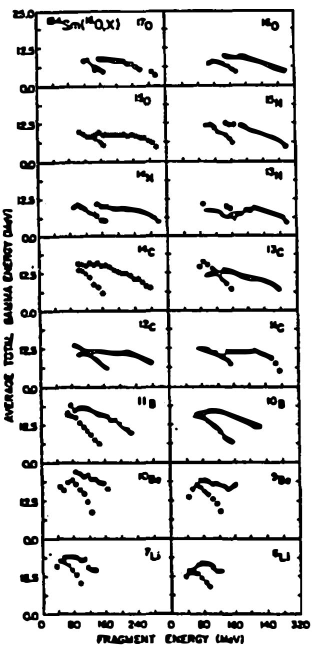
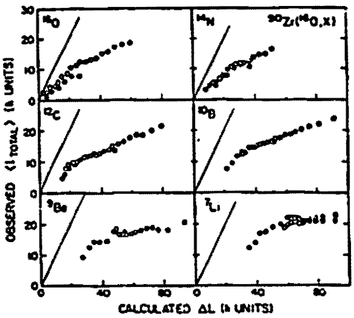


Fig. 2 $\overline{T}_{\gamma}$ for $^{16}O + ^{154}Sm$

The average total gamma energies corresponding to 10 MeV bins in the ejectile energy are plotted in Figs. 1 and 2 as a function of the laboratory energy of the ejectile for selected isotopes. Assuming that the gamma emission is entirely from the undetected target-like fragment, we derived values for the average angular momentum transfer from the average gamma energies. For this transformation from average total gamma energies to angular momenta, we used the systematics of the average multiplicities and the average energies of gamma rays from fusion reactions. The values of the angular momentum transfer determined in this manner are displayed in Figs. 3 and 4 for the most abundant isotope of each element observed with the ^{154}Sm and ^{90}Zr targets, respectively.



310 MeV O

180 MeV ●

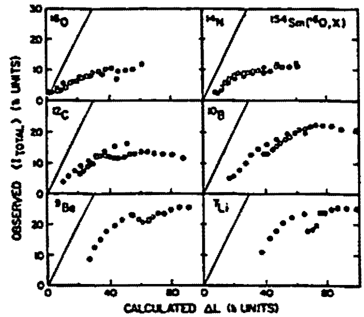


Fig. 3 ΔL for $^{16}O + ^{90}Zr$

Fig. 4 ΔL for $^{16}O + ^{154}Sm$

The transferred angular momenta are seen to increase with decreasing ejectile mass as would be expected, in general, for increasing mass transfer to the target. For individual ejectiles the transferred angular momentum is seen to increase and then apparently to saturate, with decreasing ejectile energy.

It is instructive to attempt an interpretation of these results on the basis of a simple binary collision model. For this purpose, it is assumed that the fragments arise from two-body peripheral collisions in which a narrow range of impact parameters are involved. The interaction radius is assumed to be $R_1 + R_2 + C$ where R_1 and R_2 are the sharp surface radii and C is an overlap parameter taken to be 1.0 fm. The total center-of-mass kinetic energies in the entrance and the exit channels can then be written as sums of the respective coulomb and rotational energy terms.

The transfer of angular momentum to intrinsic spin ($\Delta L - L_i - L_f$) can thus be calculated as a function of th observed ejectile energy.

The straight lines in Figs. 3 and 4 are drawn with a slope of unity. It is seen that the observed angular momentum transfer is considerably less than the calculated value in every case and a factor of three or four less than the calculated ones at high energy losses for most isotopes. This observation is analogous to that of Hsu, et al[1] who made a similar comparison for the system $^{20}Ne + ^{181}Ta$ at bombarding energies ranging from 7.5 to 42 MeV/u.

The reasons for this discrepancy are, most probably, to be found in the failure of the assumption of two binary processes made in the collision model. Particle emission from the projectile or the composite system will contribute to momentum loss that is not accounted for in the two-body collision model.

1. C. C. Hsu, et al, LBL 12519 (1981) unpublished.