MICROSCOPIC DESCRIPTION OF FOUR PARTICLE TRANSFER REACTIONS BETWEEN HEAVY IONS.

F.CATARA[a], L.FERREIRA[b], A.INSOLIA[c], A.VITTURI[d]
a)Istituto di Fisica and INFN,Catania(Italy); b)Departamento de Fisica,Coimbra(Portugal); c)Istituto di Fisica,Lecce and INFN, Catania(Italy); d)Istituto di Fisica and INFN,Padova(Italy)

Let us consider an "α-particle" transfer reaction ($\alpha \rightarrow \beta$); the transition amplitude in DWBA is then

$$T_{\beta\alpha} = \int d^3\vec{R}_{aA} \int d^3\vec{R}_{bB}\, \chi_\beta^{(-)*}(\vec{k}_\beta, \vec{R}_{bB}) \langle bB|V|aA\rangle\, \chi_\alpha^{(+)}(\vec{k}_\alpha, \vec{R}_{aA}) \qquad (1)$$

where $\chi^\pm$ are distorted waves and $\langle bB|V|aA\rangle$ is the form factor for the considered reaction. In our microscopic approach we have evaluated the form factor by introducing a description of both the projectile and the residual nucleus as a core plus a superposition of 2 protons and 2 neutrons configurations. We allow the internal quantum numbers of the transferred group of nucleons to assume any value coming from the microscopic wave function we use. This is the main difference with respect to the usual calculations which assume only 0s relative motions and no configuration mixing. We will refer to these as "cluster calculations". We have used our microscopic form factors in a few cases:

i) $^{12}C(^6Li, d)^{16}O$

We have assumed ZR-DWBA and an ($\alpha + d$) cluster description of to be valid, while the $0^+_{g.s.}$, 2^+, 1^- and 4^+ considered levels of ^{16}O have been described by means of the Zuker, Buck, McGrory (ZBM) w.f. The results[1] show a fairly good agreement with the shape of the experimental angular distributions; on the other hand the ratios $R/R_{g.s.}$, with $R = (d\sigma/d\Omega)_{exp}/(d\sigma/d\Omega)_{th}$, run from ~ 1 to ~ 10. Anyway the calculations are very sensitive to different component of the w.f., since some orbitals give larger cross sections. In this respect we feel that α-transfer reactions can be a profiteable spectroscopic tool. To test its sensitivity we have included in the 2^+ w.f. a 10% of $[(0p_{1/2})^2]_0 [(0d_{3/2})^2]_0$ component getting $R_{2^+}/R_{g.s.} \simeq 2$ instead of the previous value of ~ 10.

ii) $^{A+4}Mo(d, {}^6Li)^{A}Zr$

(ZR-DWBA + ($\alpha + d$) cluster description of ^6Li). We have studied the transition to the ground and first excited 0^+ states of ^AZr assuming for the proton part of the w.f. of Zr isotopes

$$|gs(^AZr)\rangle_\pi = \alpha(A)|0\rangle_\pi + \beta(A)\Gamma_a^+(\pi)\Gamma_r^+(\pi)|0\rangle_\pi \qquad (2)$$

and the orthogonal one for the 0^+ excited states, with

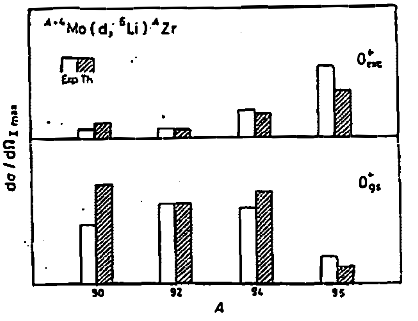
$$\Gamma_a^+(\pi) = 1/\sqrt{2}\left[a^+_{g9/2}(\pi)\, a^+_{g9/2}(\pi)\right]_0 \quad \text{and}$$

$$\Gamma_r^+(\pi) = 1/\sqrt{2}\left\{c_1\left[a_{p1/2}^{(\pi)}\, a_{p1/2}^{(\pi)}\right]_0 + c_2\left[a_{p3/2}^{(\pi)}\, a_{p3/2}^{(\pi)}\right]_0 + c_3\left[a_{f5/2}^{(\pi)}\, a_{f5/2}^{(\pi)}\right]_0\right\} \qquad (3)$$

where π means protons and the amplitudes have been fixed from the values of the emptiness parameters measured in $^{A}Zr(^{3}He,d)$ reactions. Analogously we have used

$$|gs(^{A}Mo)\rangle_{\pi} = \gamma(A)\,\Gamma_{a}^{\dagger}(\pi)|0\rangle_{\pi} + \delta(A)\left[\Gamma_{a}^{\dagger}(\pi)\right]^{2}\Gamma_{r}'(\pi)|0\rangle_{\pi} \qquad (4)$$

with $\Gamma_r' \neq \Gamma_r$. For the neutron part of the w.f. we have assumed pure shell model configurations. With these w.f. we have been able to reproduce a great body of experimental data on $2p$, $2n$ and $2p$-$2n$ transfer reactions. As an example we report in fig.1 the theoretical transition strengths to the g.s. and the first 0^+ excited states of Zr isotopes populated in the reaction $^{A+4}Mo(d,^{6}Li)^{A}Zr$ in comparison with experimental data.



iii) Heavy Projectiles.
When considering an heavy projectile we have introduced a microscopic description also for its w.f. In particular we have studied the reaction $^{40}Ca(^{16}O,^{12}C)^{44}Ti_{g.s.}$ by using the ZBM model for ^{16}O and the McCullen, Bayman, Zamick one for ^{44}Ti .
Our results can be summarized as follows:

a) the absolute cross section is underestimated by a factor of ~ 5 .
b) values of the intrinsic spin of the "α-particle" different from zero give important contributions to the cross section.
c) contributions coming from different configurations sum up coherently.

We can then conclude that "cluster calculations" give hardly reliable results and that adding more configurations in the w.f. (especially for $^{44}Ti_{g.s.}$) we could, hopefully, reproduce better the absolute cross section.

References

1) A.Insolia, M.Baldo, F.Catara, A.Vitturi
NBI preprint 80-55; to be published in Z.Physik A(1981)

2) F.Catara, L.Ferreira, A.Insolia, A.Vitturi
Proc.XIX Int.Winter Meeting on Nucl.Physics,(1981)Bormio

3) F.Catara, L.Ferreira, A.Insolia, A.Vitturi
Proc.XIX Int.Winter Meeting on Nucl.Physics,(1981)Bormio