A SCALING LAW FOR THE COMPLEX PROXIMITY INTERACTION POTENTIAL

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For peripheral collision between two nuclei, the surface properties of the nucleonic density distribution are relevant. The proximity form of potentials, depending on a universal function and geometrical parameters of the nuclear density is expected to be a valid form of representation.

We have calculated both the real and the imaginary part of the interaction potential self consistently using the two-body effective interaction of Bertsch et al[1]. The real part is computed by double folding the two density distributions whereas the imaginary part is calculated in a second-order perturbation formalism. The imaginary potential, which is the cumulative signature of all inelastic channels can be constructed essentially by incorporating either by simultaneous particle-hole excitations in both the nuclei, triggered by the two-body interaction or particle-hole excitation, triggered by the single particle field of either the target or the projectile. The real part is given by[2]

$$U(R) = \int \rho_1(r_1)\, \rho_2(r_2)\, v(|r_1 - r_2 + R|)\, d^3r_1\, d^3r_2 \quad -(1)$$

and the imaginary part by

$$U_2 = \sum_{\substack{m\neq 0\\ n\neq 0}} \left[\langle \phi_0 \psi_0 | \sum_{ij} v_{ij} | \phi_m \psi_n \rangle\, G_{mn}\, \langle \phi_m \psi_n | \sum_{i'j'} v_{i'j'} | \phi_0 \psi_0 \rangle \right] \quad (2)$$

where the propagator G_{mn} is given by

$$G_{mn} = \frac{1}{(2\pi)^3}\int d^3k \, \frac{\exp(i\vec{k}\cdot\vec{s})}{(\hbar^2/2\mu)(K_{mn}^2 - k^2) + i\epsilon} \qquad (3)$$

implicit in this rep...entation is the assumption of plane wave relative motion ; $\hbar^2 K_{mn}^2/2\mu = E - E_{mn}$, E being the centre of mass energy for relative motion and E_{mn} is the sum of the excited state energies. For collisions between two nuclei $E \gg E_{mn}$; we further assume that the energy of excitation can be approximated by an average energy of excitation $\langle \Delta E \rangle$; the assumption we feel, is justified on the grounds that the imaginary potential for two nuclei is not sensitive to the details of dynamics of excitation but rather on the geometrical properties of the surface, as shown below.

With the assumption mentioned one can perform the integration over the kinetic energy of the two nuclei in the intermediate states and apply "closure" yielding[2] the imaginary potential for one-body and two-body excitation respectively

$$W_{21}(R,S) = I_m \bar{G}_{21}(s)\Big[\int U_{12}(|\vec{R}-\vec{r}+\tfrac{1}{2}\vec{s}|)\, U_{12}(|\vec{R}-\vec{r}-\tfrac{1}{2}\vec{s}|)\, \rho_t(r)\, d^3r$$

$$- \frac{1}{4}\int U_{12}(|\vec{R}_0-\vec{R}-\tfrac{1}{2}\vec{s}_0+\tfrac{1}{2}\vec{s}|)\, U_{12}(|\vec{R}-\vec{R}_0+\tfrac{1}{2}\vec{s}_0-\tfrac{1}{2}\vec{s}|)\, \rho_t^2(R_0,s_0)\, d^3R_0\, d^3s_0 \qquad (4)$$

and

$$W_{22}(R,S) = I_m \bar{G}_{22}(s)\Big[\int \rho_1(r_1)\rho_2(r_2)\, v(|\vec{r}_1-\vec{r}_2+\vec{R}+\tfrac{1}{2}\vec{s}|)\, v(|\vec{r}_1-\vec{r}_2-\vec{R}-\tfrac{1}{2}\vec{s}|)\, d^3r_1\, d^3r_2 \qquad (5)$$

where G_{21} and G_{22} are appropriate propagators for one and two-body excitation U_{12}, the single particle field obtained by folding in the two-body effective interaction with the projectile/target de..sity distribution and $\rho_t(R_0,S_0)$ is the density matrix. For eq.( ), the tensor term[1,2] is also included. What is remarkable is that, for both eqns. ( ) and ( ) We find the proximity form

$$\frac{W^{ij}K}{\mu} = \frac{R_1 R_2}{R_1+R_2}\, f_I^{ij}(s) \qquad (6)$$

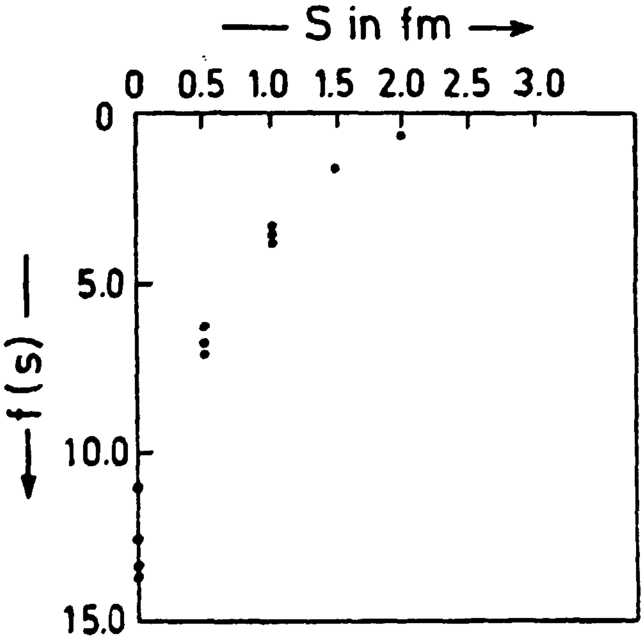
$i = 2$; $j = 1$ or 2 for one-body and two-body excitation mechanism respectively. $f_I^{ij}(s)$ is universal function. For the real

central part eq.(1) a proximity form can be derived for
$s > R - R_1 - R_2$ such that

$$U = \frac{R_1 R_2}{R_1 + R_2} f_R(s) \qquad (7)$$

It is evident therefore that $WK/\mu U$ should depend on the ratio of the universal functions f_I^{ij}/f_R and therefore should be a constant at a particular intra-nuclear radius. This is what we find, $\tau(WK/\mu U)$ scales to a constant value throughout the periodic table - the theoretical prediction of the ratio ($WK/\mu U$) agrees rather well with the empirical findings.

1. G. Bertsch. et al Nucl. Phys. A284 (1977) 399
2. A.B. Santra and B. Sinha Phys. Letts. to be published.



The universal function for one and two-body excitation as a function of $S = R - R_1 - R_2$ being the intranuclear distance.