Reaction processes at near barrier energies: the case of $^{9}Be+^{197}Au$

MALIKA KAUSHIK[1], G. Gupta[2], S.K. Pandit[3], V.V. Parkar[3,4], Swati Thakur[1], Pushpendra P. Singh[1], V. Nanal[2,*], A. Shrivastava[3,4], R. G. Pillay[1], H. Krishnamoorthy[4,5], K. Mahata[3,4], S. Pal[6], C.S. Palshetkar[2], K. Ramachandran[3]

[1]Department of Physics, Indian Institute of Technology Ropar, Punjab-140 001, India; [2]DNAP, Tata Institute of Fundamental Research, Mumbai - 400005, India ; [3] NPD, Bhabha Atomic Research Centre, Mumbai - 400085, India; [4]Homi Bhabha National Institute, Anushaktinagar, Mumbai - 400094, India ; [5] INO, Tata Institute of Fundamental Research, Mumbai - 400005, India; [6]PLF, Tata Institute of Fundamental Research, Mumbai - 400085, India.

Email: malika.kaushik@iitrpr.ac.in

Motivation

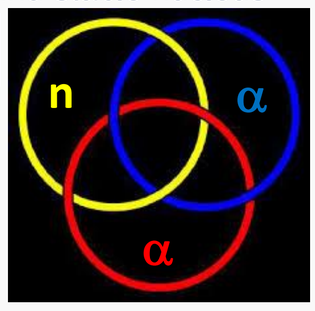
Distinctive features of weakly bound stable nuclei (^{6,7}Li, ^{9}Be) [1,2]

- Low breakup threshold
- Small binding energy
- Cluster structure
- Mimic radioactive ion beams

Borromean weakly bound stable nucleus

$$^{9}Be \rightarrow \alpha + \alpha + n$$

$$\alpha + n, E_B > 0$$
$$n + n, E_B > 0$$
$$\alpha + \alpha + n, E_B < 0$$



➢ Study of complete fusion (CF), incomplete fusion (ICF), and *n*-transfer processes in ^{9}Be+^{197}Au system.

Experimental Details

- Projectile-Target Combination: ^{9}Be+^{197}Au
- BARC-TIFR Pelletron Linac Facility (PLF), at TIFR, Mumbai.
- Stack-foil technique.
- E = 30 – 47MeV.
- V_B = 38.4 MeV.
- Beam Current (^{9}Be) ~ 8 -15 pnA. [3]

HPGe Detector set up for offline analysis and target mounting set up

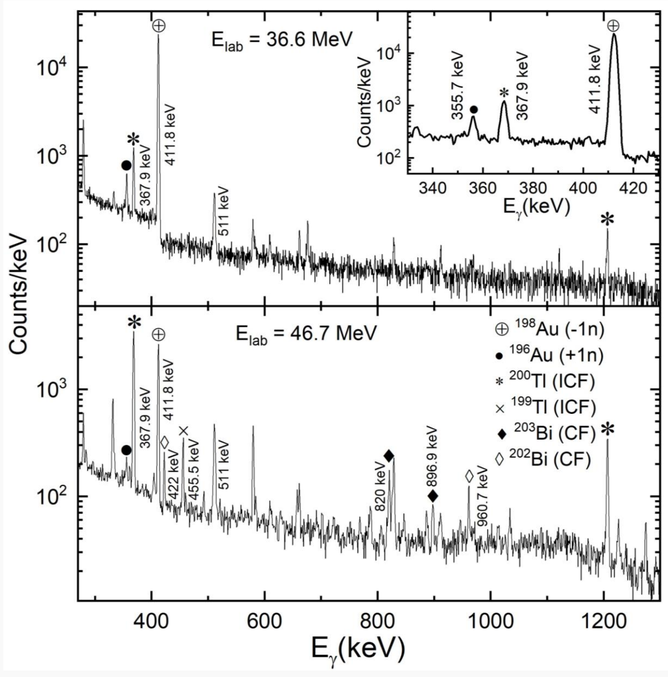


Fig. 1. Offline gamma spectra in the ^{9}Be + ^{197}Au system at E_{lab} = 36.6 and 46.7 MeV. The characteristic gamma-lines of complete fusion (CF), incomplete fusion (ICF), and transfer (tr) reaction products are marked.

^{9}Be+^{197}Au: Measurements

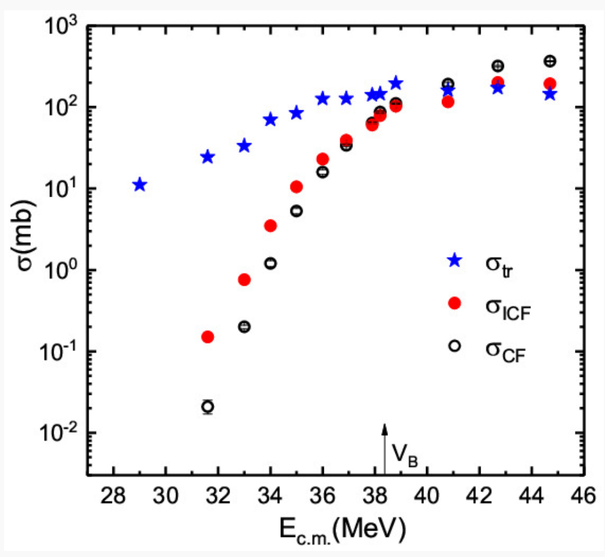


Fig. 2. Comparison of measured transfer (tr), ICF, and CF cross sections as a function of $E_{c.m.}$ in the ^{9}Be + ^{197}Au system. [4].

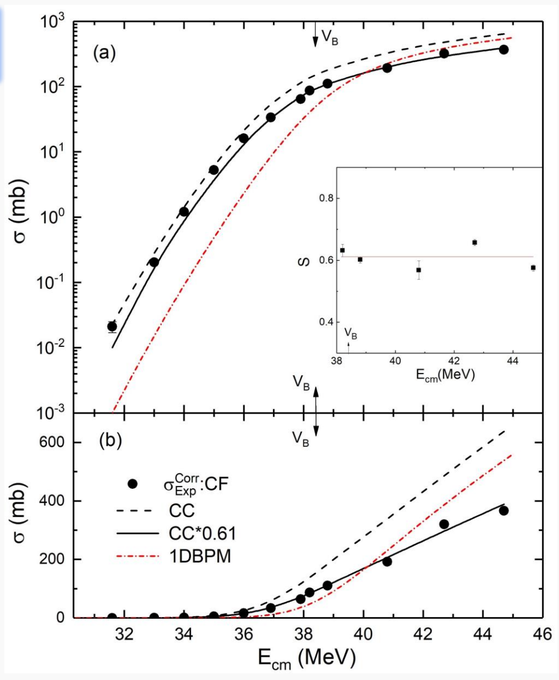


Fig. 3. CF excitation function (EF) of ^{9}Be + ^{197}Au system is compared with calculations obtained using coupled-channels code CCFULL on linear and logarithmic scales [3].

Comparison of reduced fusion EFs: x + ^{197}Au systems

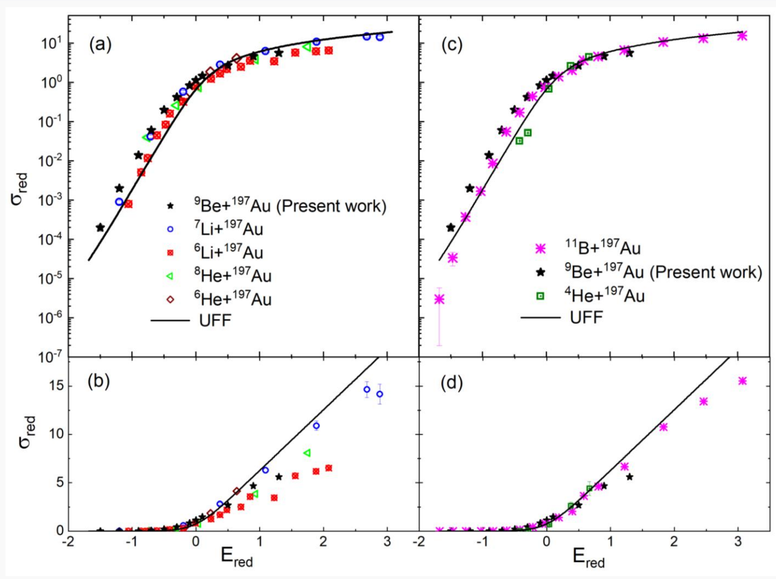


Fig. 4 Comparison of reduced fusion excitation functions (EFs) of x +^{197}Au: (a) weakly bound projectiles ^{6}He,^{8}He,^{6,7}Li, and (c) projectiles with higher break-up threshold ^{4}He,^{11}B. Panels (b) and (d) show data of (a) and (c), respectively, on a linear scale for better visibility of the above-barrier region. Universal fusion function (UFF) is also plotted (black solid line) [3].

Reduced variables:

$$E_{red} = \frac{E_{c.m.} - V_B}{\hbar\omega}$$

$$\sigma_{red} = \frac{2.E_{c.m.}}{\hbar\omega.R_B^2}\sigma_F$$

Universal fusion function (UFF)

$$F_0(x) = ln\left[1 + exp\left(2\pi x\right)\right]$$

n-transfer in ^{9}Be + ^{197}Au

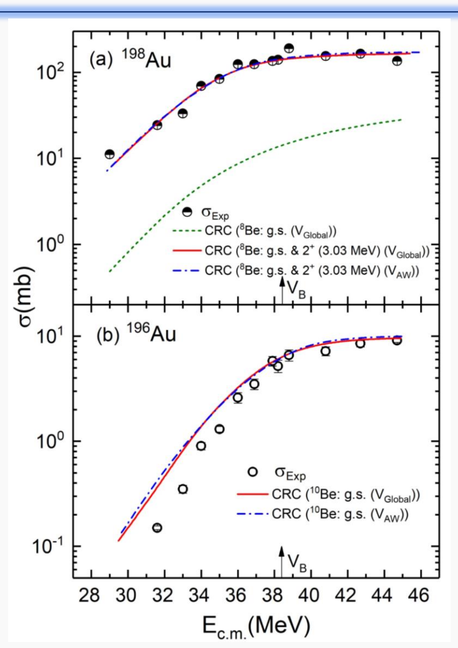


Fig. 5. Comparison of measured EFs with CRC calculations of transfer channels for (a)^{198}Au including the ground state and 2^+ resonance (E = 3.03 MeV) state of ^{8}Be, and only the ground state of ^{8}Be, and (b)^{196}Au with ground state of ^{10}Be using global optical potential (V_{Global}). The dash dotted lines represent the CRC calcuations with Akyuz-Winther (V_{AW}) potential in both of the transfer channels [4].

Potential Parameters

Potential	V_{AW}	V_{Global}
V_0 (MeV)	51.94	257.7
r_0 (fm)	1.17	1.36
a_0 (fm)	0.63	0.73
W_v (MeV)		16.32
r_v (fm)		1.64
a_V (fm)		0.60

^{6,7}Li + ^{197}Au systems

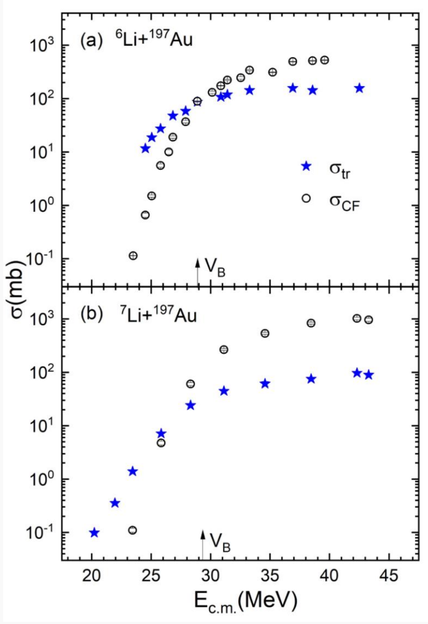


Fig. 6. Comparison of the measured EFs of CF and transfer reaction in (a) ^{6}Li +^{197}Au, and (b)^{7}Li +^{197}Au systems [5], where V_B is the barrier.

Results and conclusions

- CF and transfer cross sections are measured ~ 18% and 24% down the barrier, respectively.
- Suppression factor (>V_B) ≈ 39±1%.
- The prominent role of ^{9}Be ground state deformation in sub-barrier fusion.
- 1*n*-stripping CRC calculations in ^{9}Be+^{197}Au system have highlighted the significant impact of the 2^+ resonance state of ^{8}Be.
- Ratio of transfer to CF cross sections is considerably higher in ^{9}Be+^{197}Au in comparison to ^{6,7}Li+^{197}Au systems which can be attributed to the structural difference in these projectiles.

References: 1. V. Jha *et al.,* Phys. Rep. 845, 1 (2020) and references therein. 2. L. F. Canto *et al.,* Phys. Rep. 596, 1-86 (2015) and references therein. 3. Malika Kaushik *et al.,* Phys. Rev. C 101, 034611 (2020). 4. . Malika Kaushik *et al.,* Phys. Rev. C 104, 024615 (2021). 5. C.S. Palshetkar *et. al.,* Phys. Rev. C 89, 024607 (2014).

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