TDHF + Langevin approach to hot fusion reactions for superheavy elements

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1. Hot fusion reactions for superheavy elements
2. Towards Z = 119 and 120
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4. Summary

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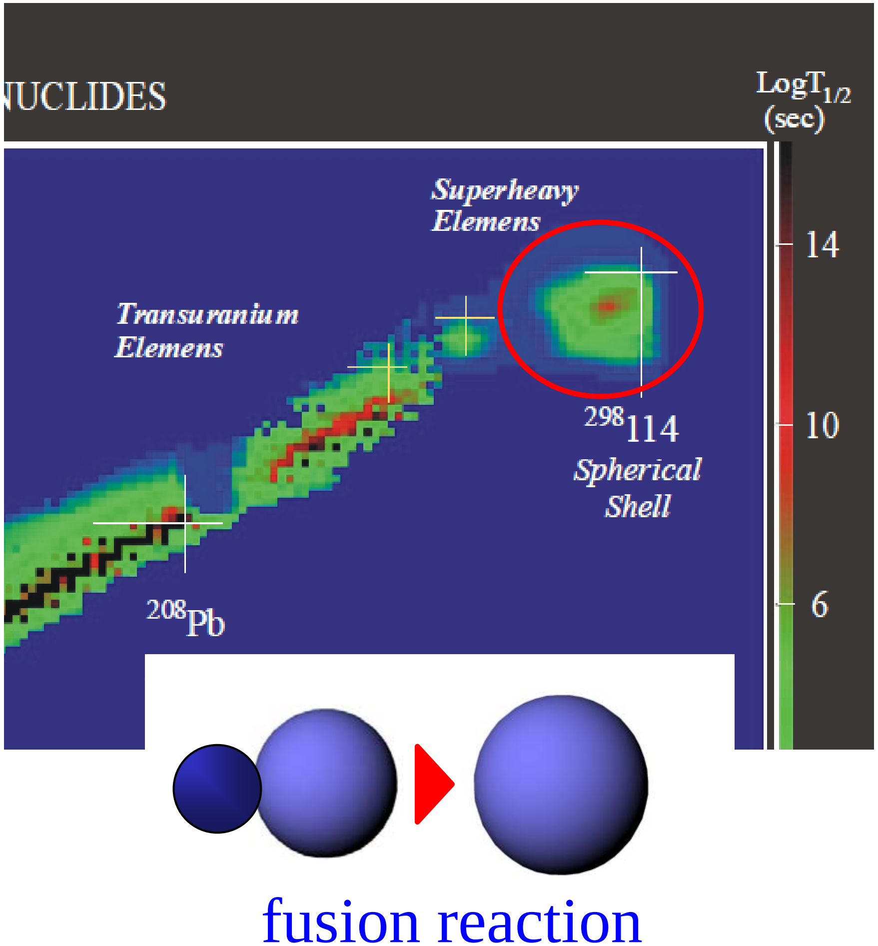
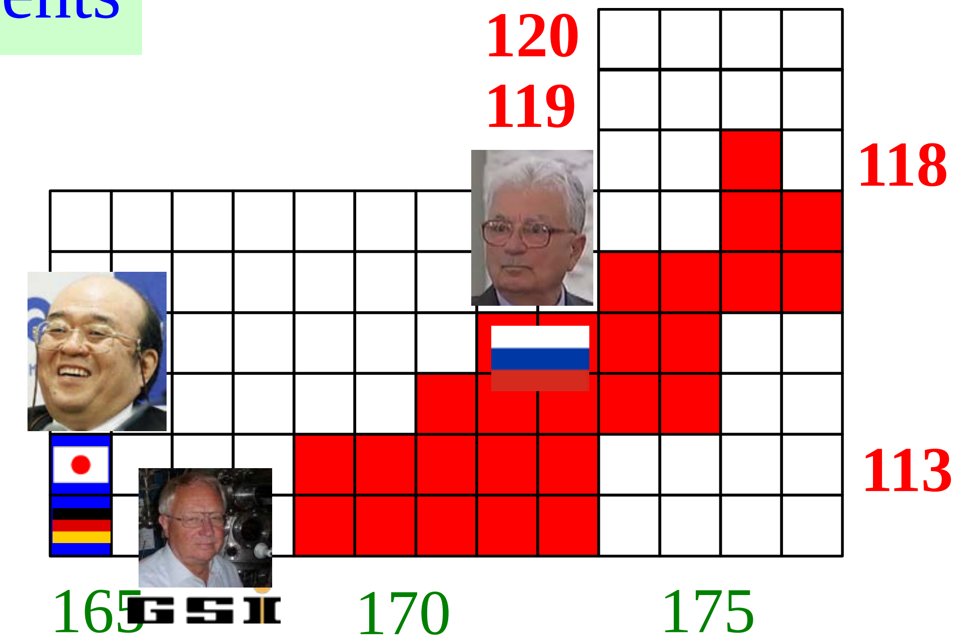
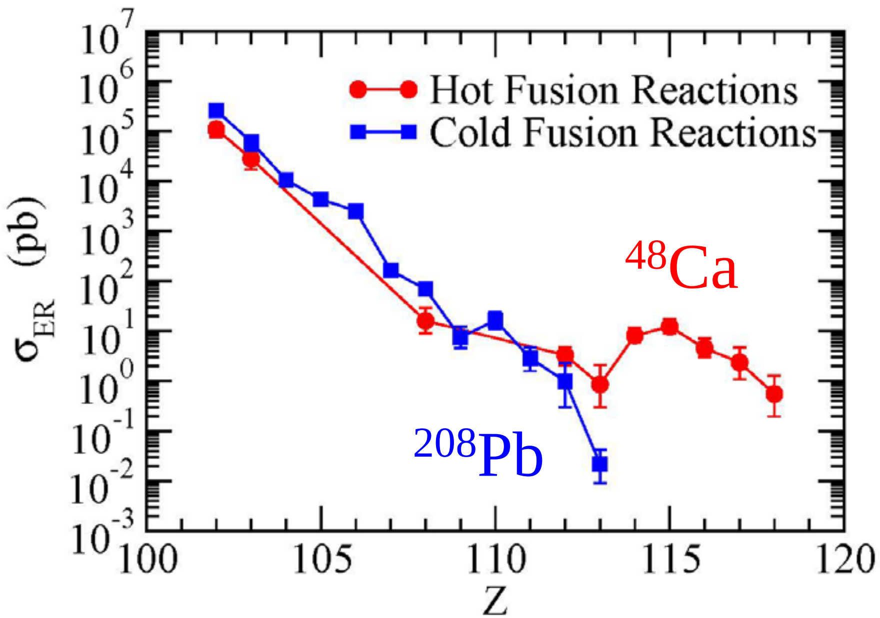
Dec. 10-12, 2018, Tsukuba, Japan

Introduction: superheavy elements

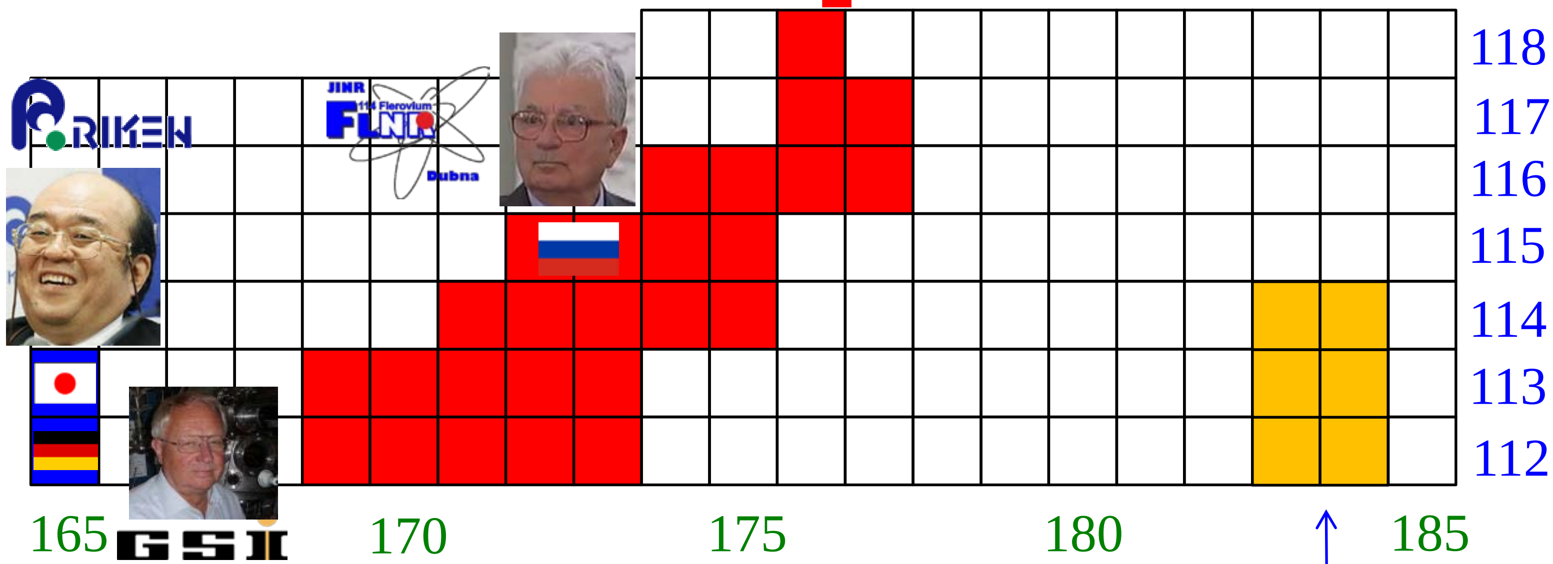




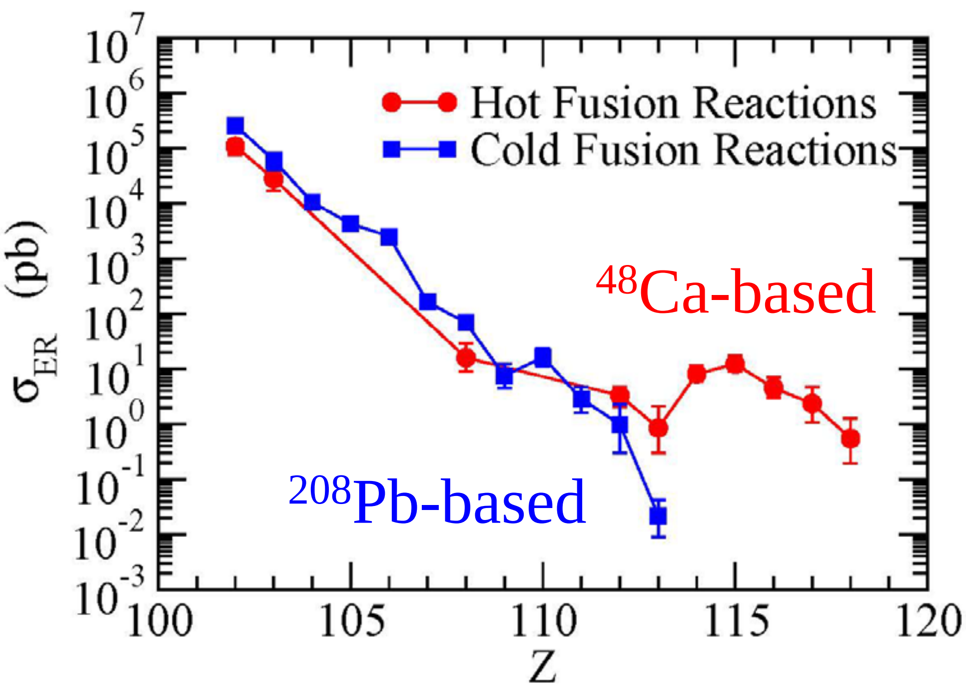


Hot fusion reactions: ^{48}Ca+actinides

Z = 119 and 120



the island
of stability?



Hot fusion for
Z = 119 and 120

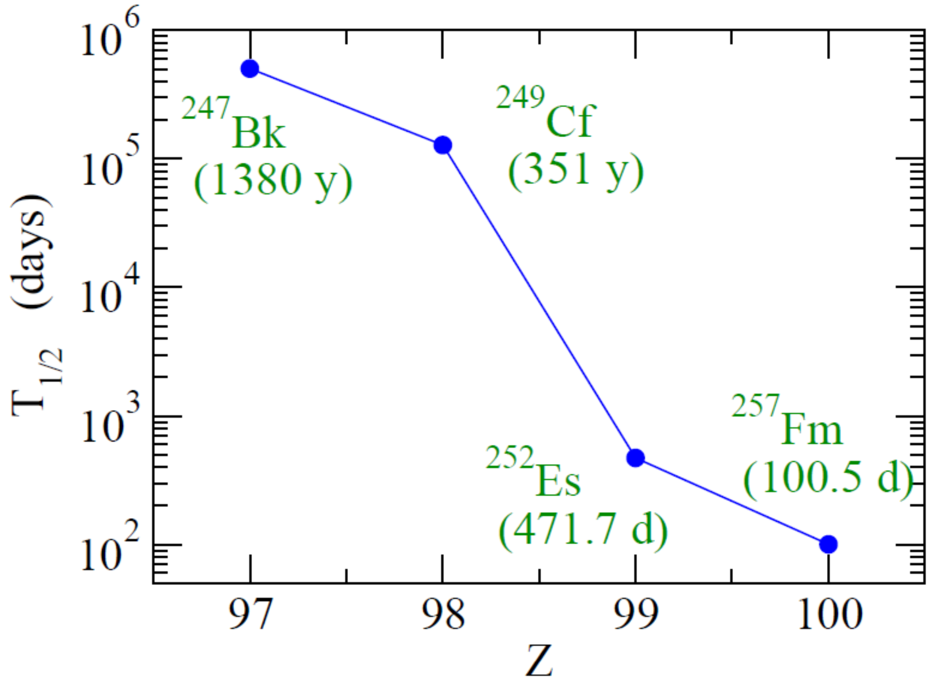
Towards Z=119 and 120 nuclei

hot fusion reactions with ^{48}Ca:

$^{48}_{20}Ca + {}_{99}Es \rightarrow 119$

$^{48}_{20}Ca + {}_{100}Fm \rightarrow 120$

short lived → not available with sufficient amounts

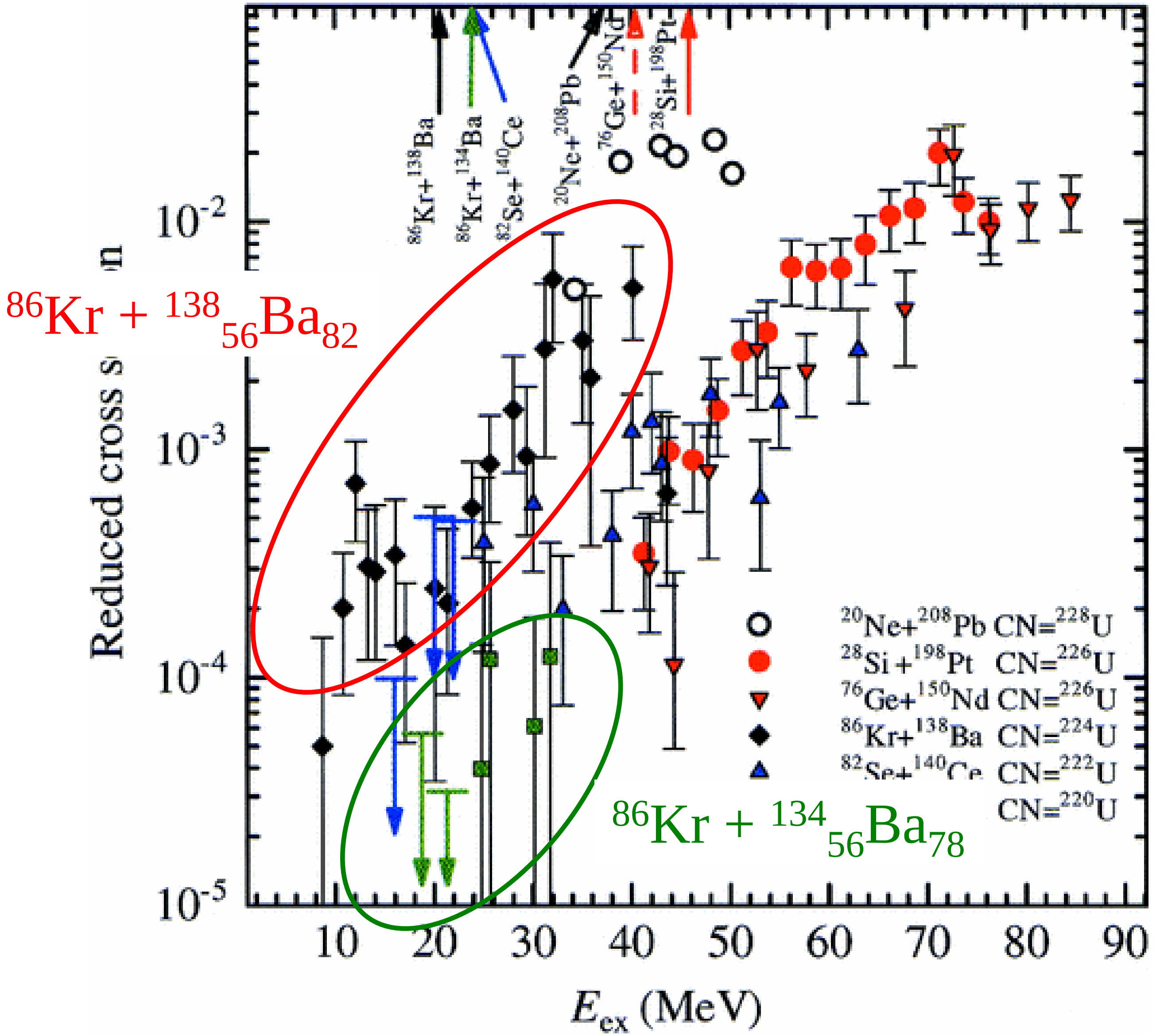


$^{48}Ca \rightarrow {}^{50}_{22}Ti,\ {}^{51}_{23}V,\ {}^{54}_{24}Cr$ projectiles

closed shell → open shells

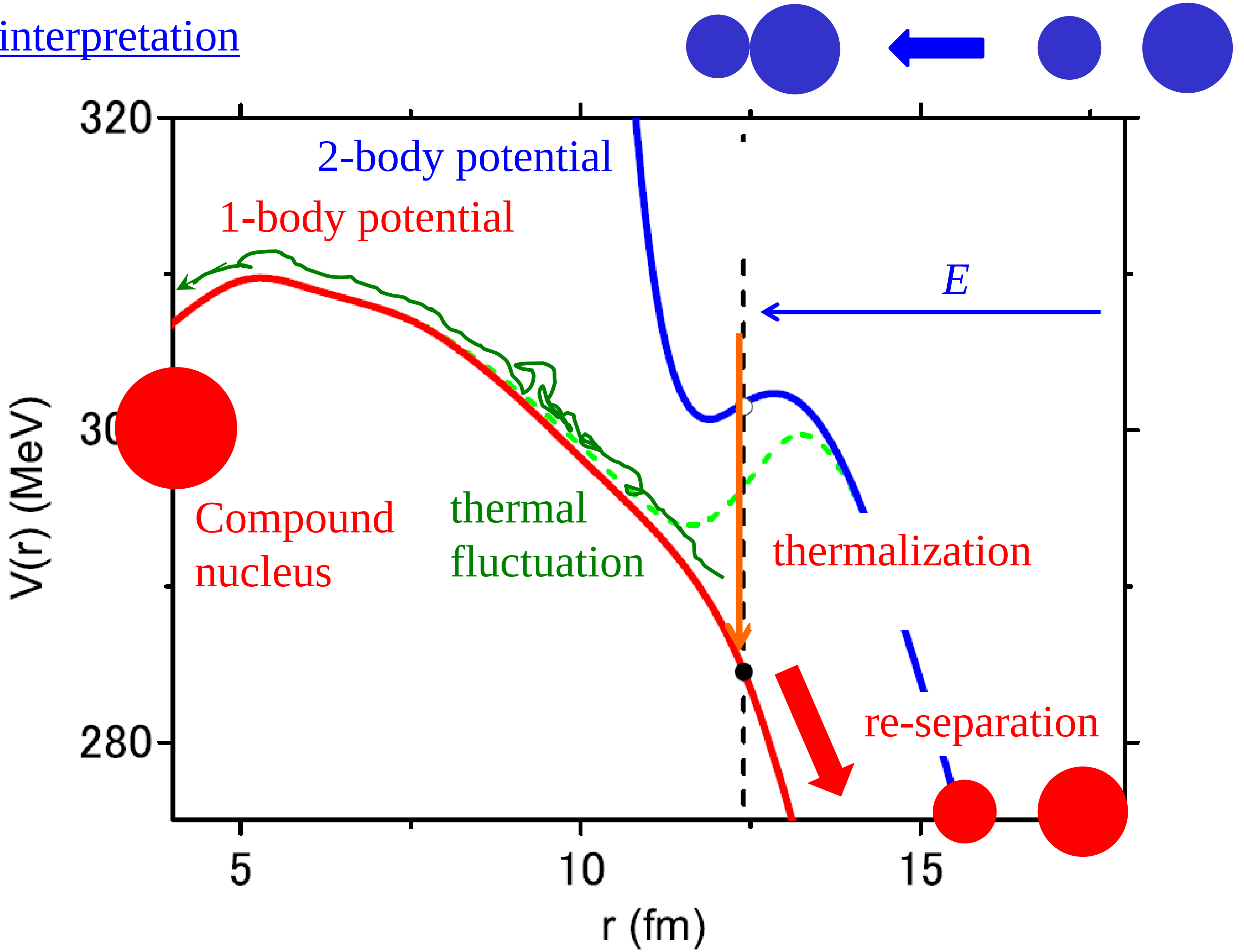
how much will cross sections be affected?

Role of magicity

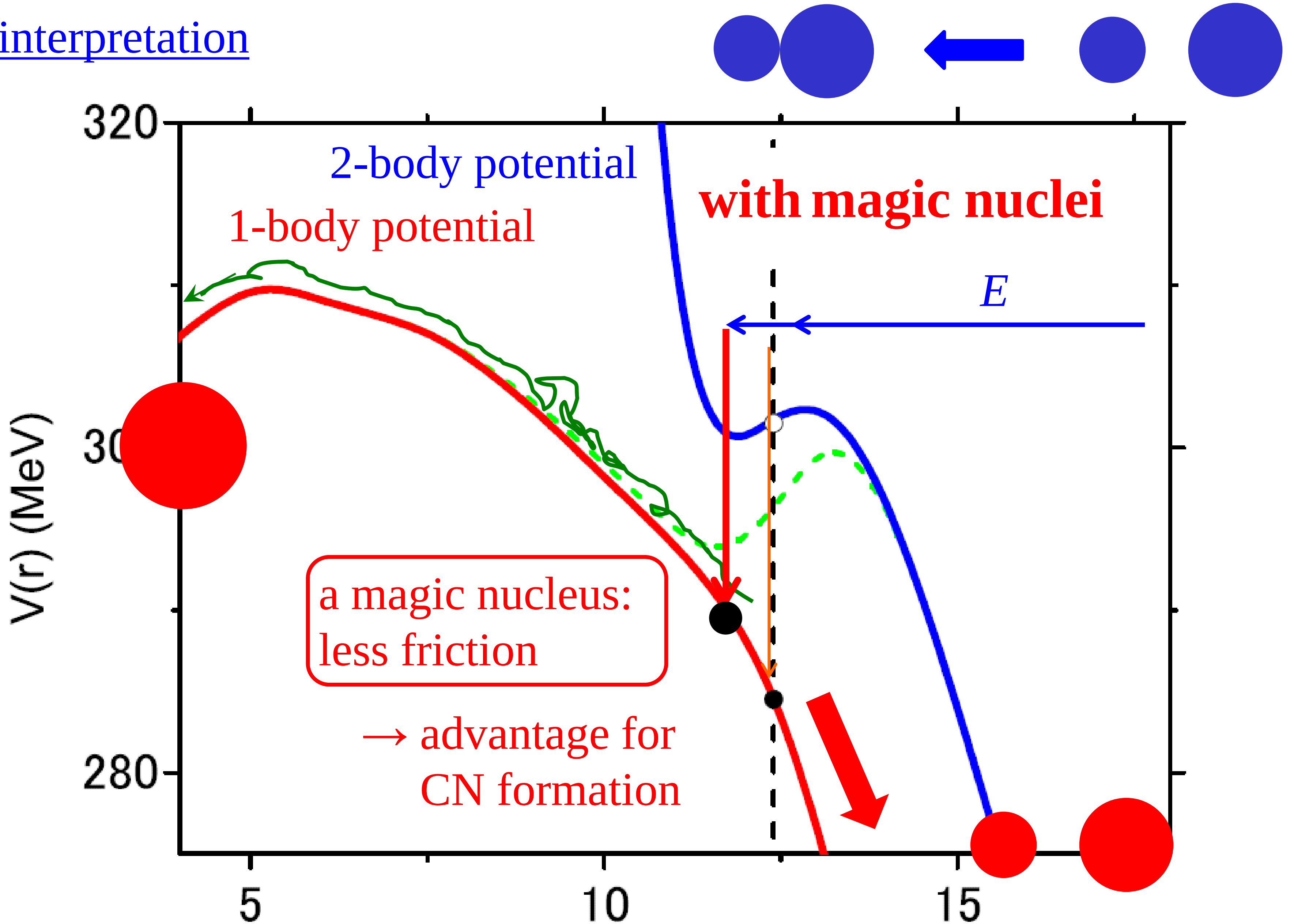


K. Satou, H. Ikezoe et al., PRC73 (‘06) 034609

An interpretation



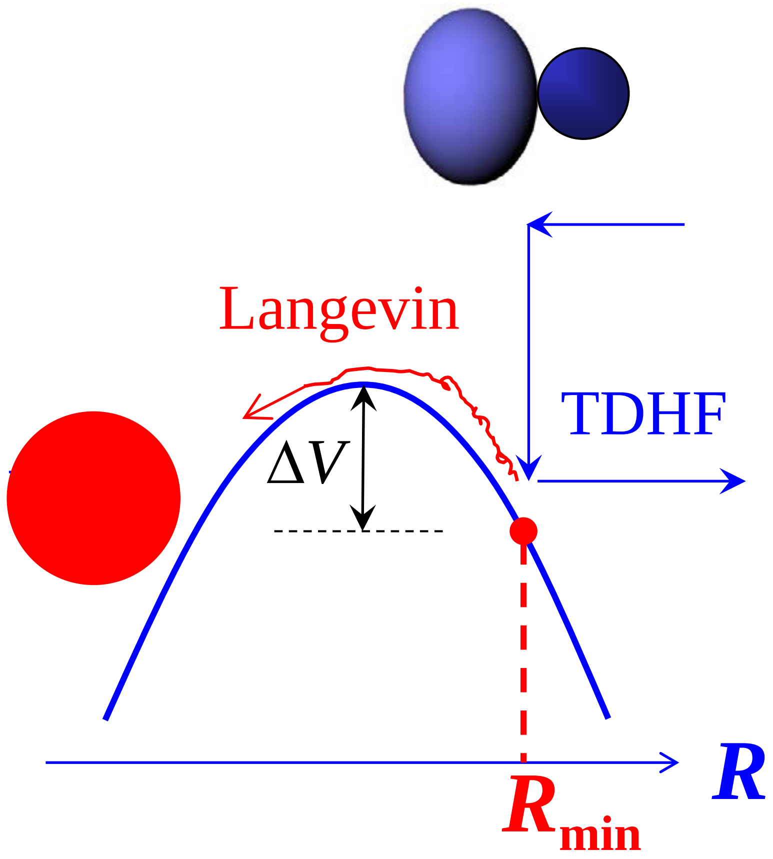
An interpretation



Can one expect a similar mechanism for ^{48}Ca?

TDHF + Langevin approach

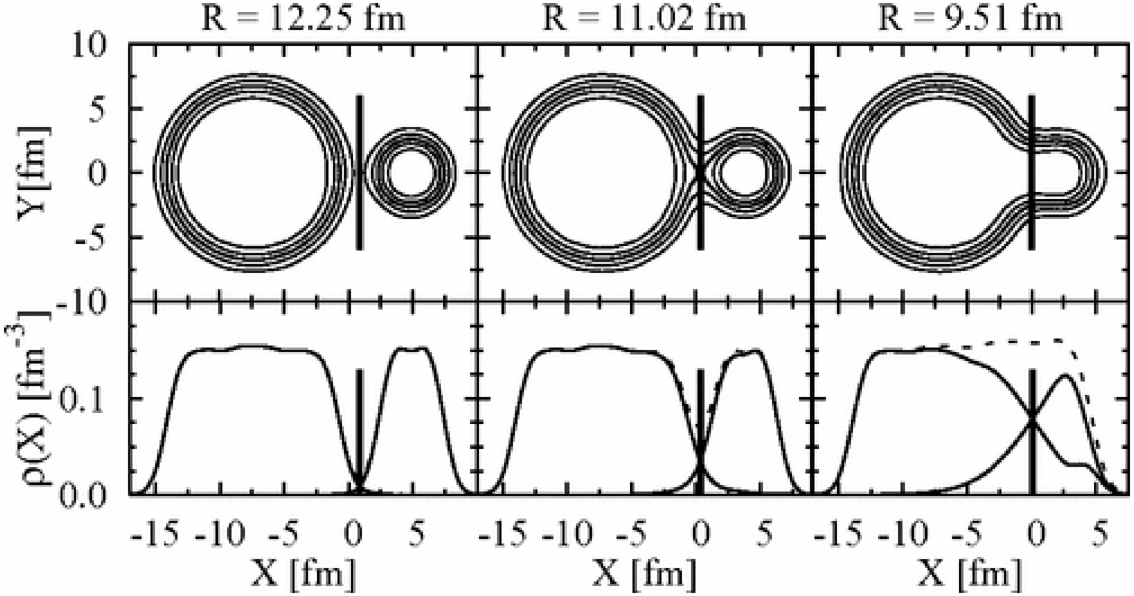
K. Sekizawa and K. Hagino, a work in progress



Mapping TDHF onto a classical equation of motion

K. Washiyama and D. Lacroix, PRC78 ('08) 024610

TDHF simulations



→ $R(t)$, $P(t)$

$$\dot{P} = -\frac{dV}{dR} - \frac{d}{dR}\left(\frac{P^2}{2\mu}\right) - \gamma\dot{R}$$

→ $V(R)$, $\gamma(R)$

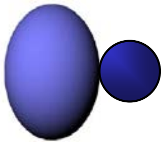
→

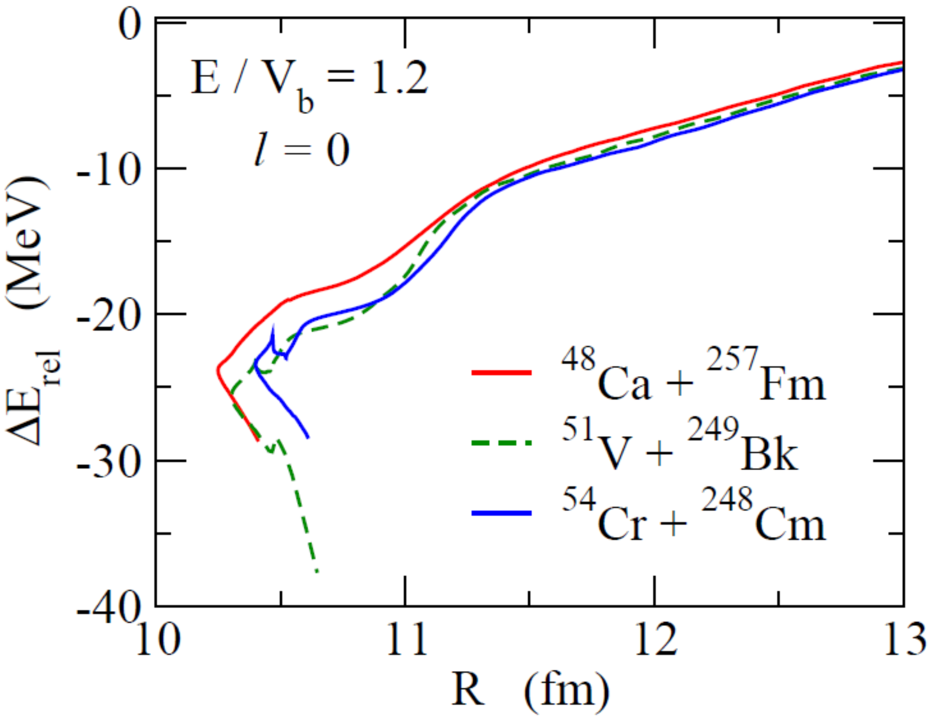
$$\Delta E(t) = -E_{\rm diss}(t) = \frac{P(t)^2}{2\mu(R(t))} + V(R(t)) - E_{\rm ini}$$

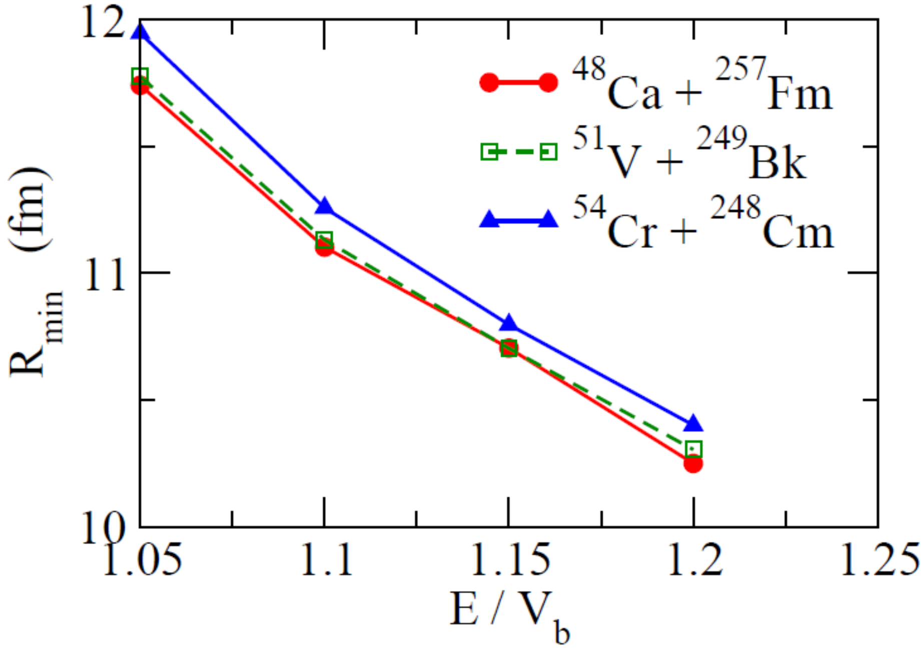
TDHF + Langevin approach

K. Sekizawa and K. Hagino, a work in progress

TDHF ← the distance of the closest approach (side collision)





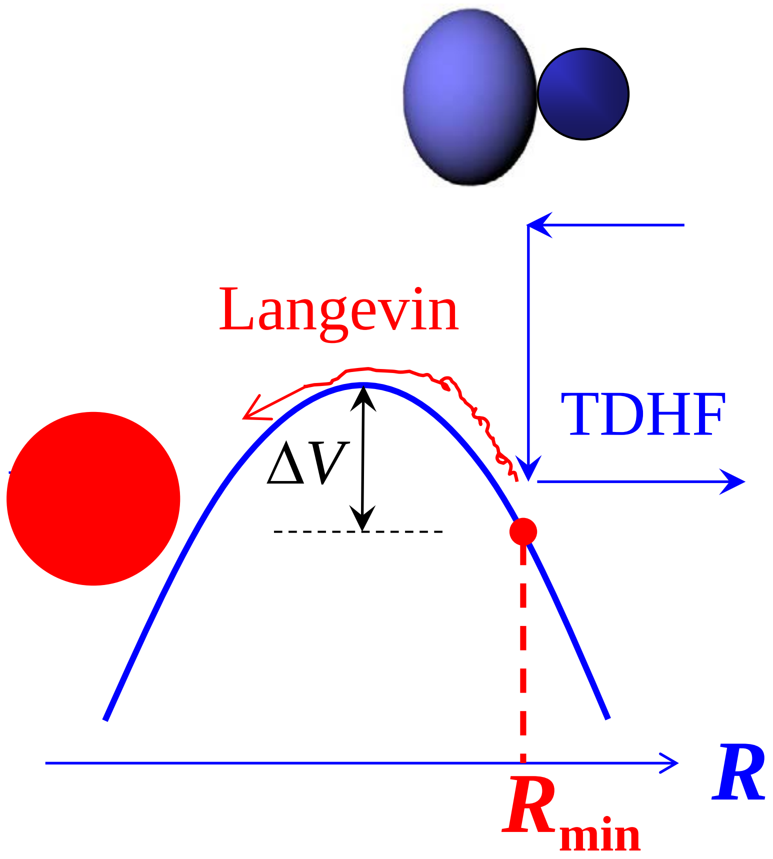


^{48}Ca+^{257}Fm→^{305}120
^{51}V+^{249}Bk→^{300}120
^{54}Cr+^{248}Cm→^{302}120

no special role of magicity in R_{min}?

TDHF + Langevin approach

TDHF ← the distance of the closest approach (side collision)



fusion-by-diffusion model

diffusion over a parabolic barrier in the overdamped limit:

$$P_{\mathrm{CN}}(E) = \frac{1}{2}\left[1 - \mathrm{erf}\left(\sqrt{\frac{\Delta V}{T}}\right)\right]$$

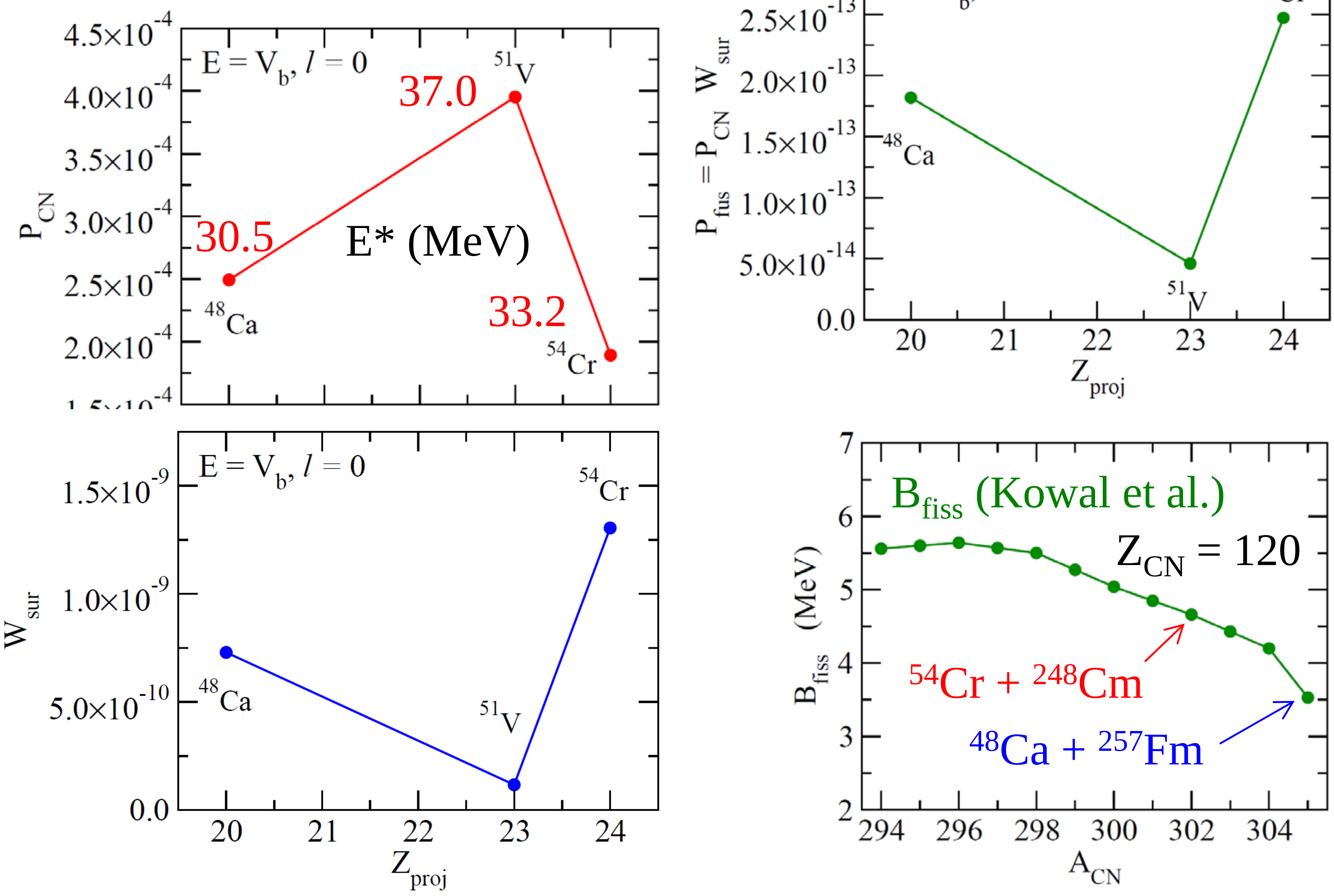
W.J. Swiatecki et al., PRC71 (‘05) 014602

statistical model

$$W_{xn}(E^*) \sim \left(\frac{\Gamma_n(E^*)}{\Gamma_{\mathrm{fiss}}(E^*)}\right)^x$$

$$P_{\mathrm{ER}}(E) = P_{\mathrm{CN}}(E) \cdot \sum_x W_{xn}(E^*)$$

TDHF + Langevin approach

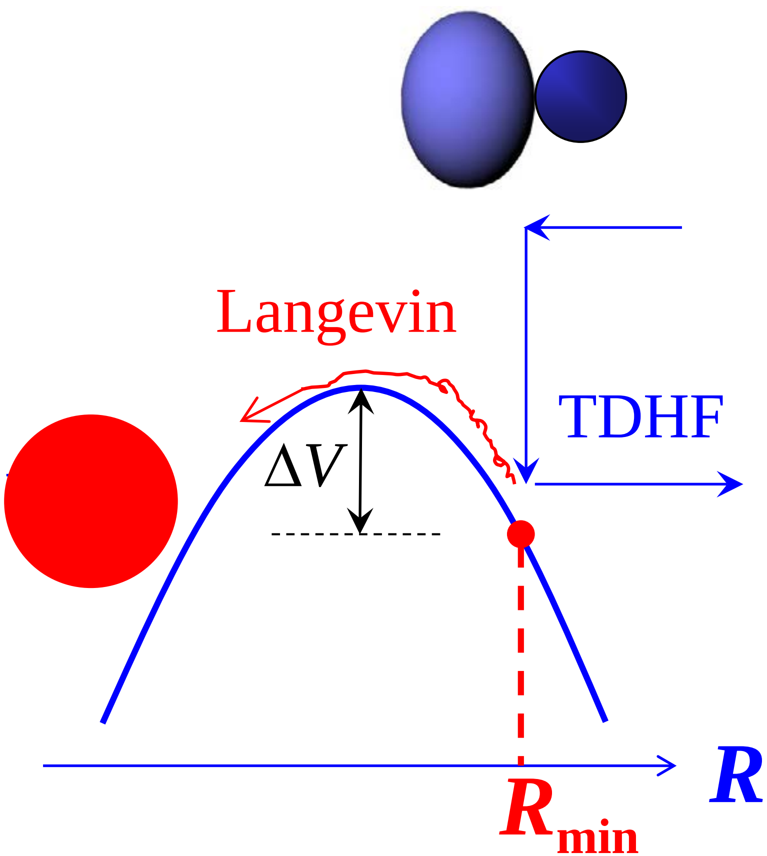


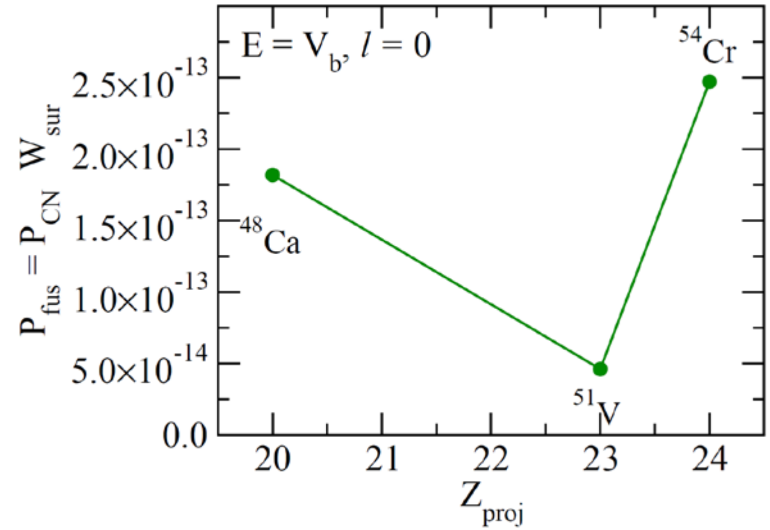
Summary

Hot fusion reactions for Z = 119 and 120 superheavy elements

➢ $^{48}Ca \rightarrow {}^{51}V$ and ^{54}Cr

TDHF + Langevin approach





$$\frac{\sigma_{fus}(^{48}Ca + {}^{257}Fm \rightarrow {}^{305}120)}{\sigma_{fus}(^{54}Cr + {}^{248}Cm \rightarrow {}^{302}120)} < 1$$

To do:

a comparison between

✓ $^{48}Ca + {}^{254}Fm \rightarrow {}^{302}120$

✓ $^{54}Cr + {}^{248}Cm \rightarrow {}^{302}120$