PHYSICAL REVIEW C **102**, 061602(R) (2020)

Calculation of the $^{12}C + ^{12}C$ sub-barrier fusion cross section in an imaginary-time-dependent mean field theory

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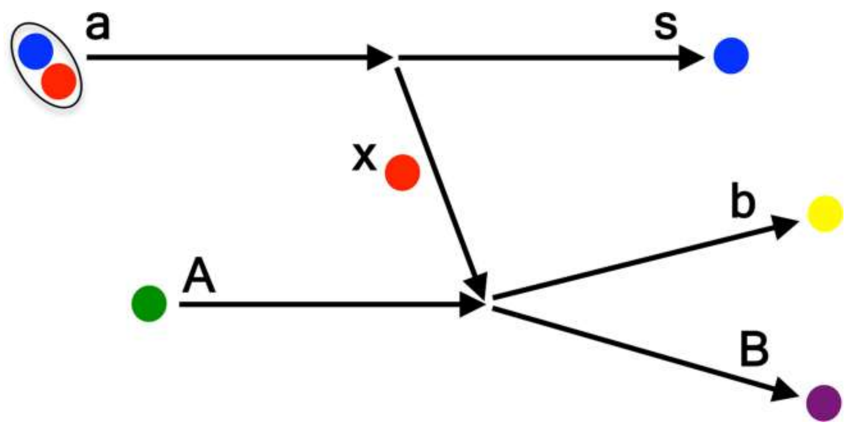
INTRODUCTION&MOTIVATION

Letter 688| Nature | VOL557 | 31MAY2018

An increase in the $^{12}C + ^{12}C$ fusion rate from resonances at astrophysical energies

A. Tumino[1,2*], C. Spitaleri[2,3], M. La Cognata[2], S. Cherubini[2,3], G. L. Guardo[2,4], M. Gulino[1,2], S. Hayakawa[2,5], I. Indelicato[2], L. Lamia[2,3], H. Petrascu[4], r. G. Pizzone[2], S. M. r. Puglia[2], G. G. rapisarda[2], S. romano[2,3], M. L. Sergi[2], r. Spartá[2] & L. Trache[4]



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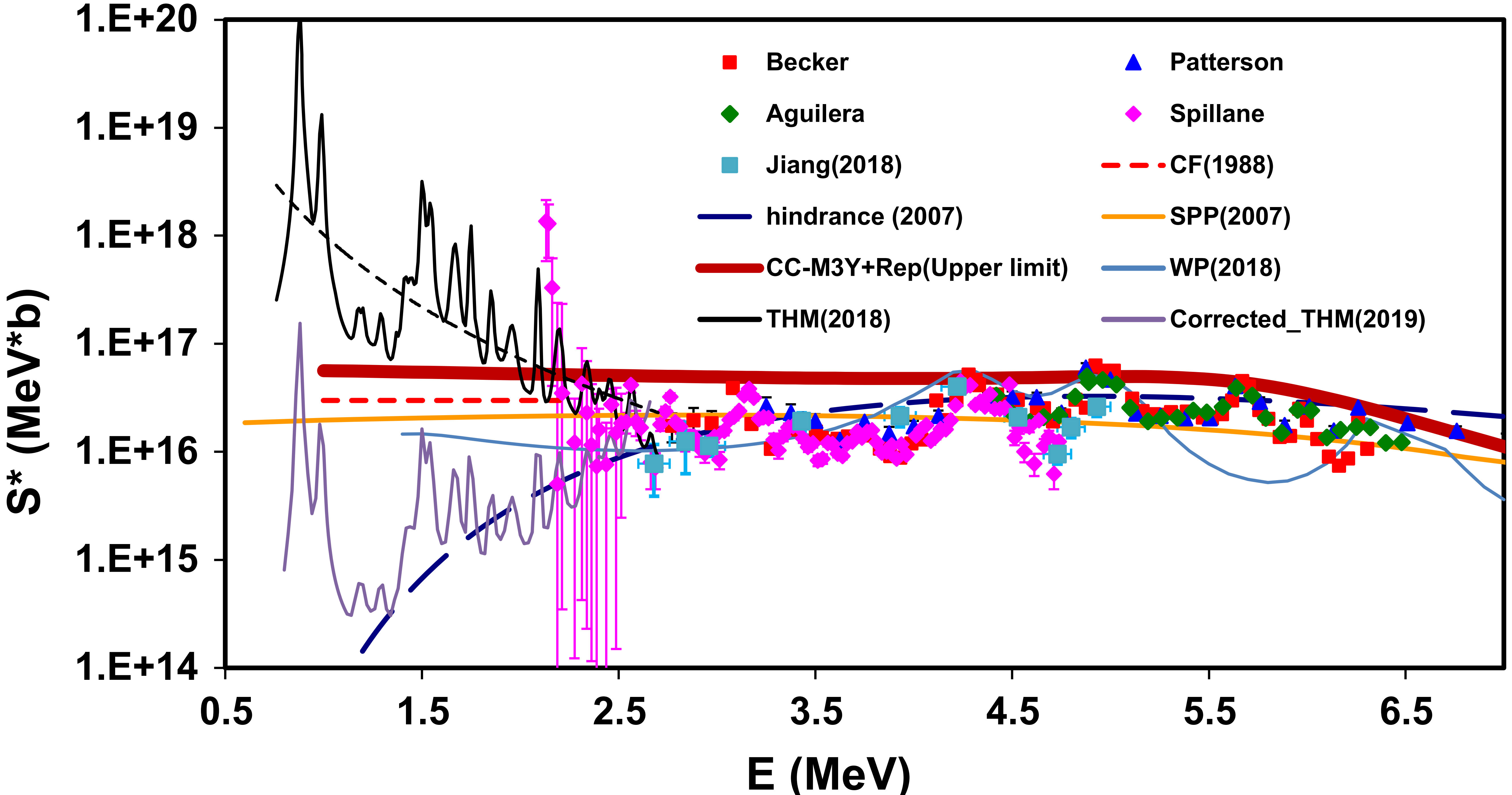

Status on $^{12}C + ^{12}C$ fusion at deep subbarrier energies: impact of resonances on astrophysical S^* factors

C. Beck[1,a], A. M. Mukhamedzhanov[2,b], X. Tang[3,4,c]

Eur. Phys. J. A (2020) 56:87

$$S^*(E_{c.m.}) = E_{c.m.}\sigma(E_{c.m.})\exp\left(87.12E_{c.m.}^{-1/2} + 0.46E_{c.m.}\right) = S(E_{c.m.})\exp(0.46E_{c.m.}) \quad (1)$$

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DOE grant: DE-FG03-93ER40773

Feynman path integration in phase space

Physics Letters B 339 (1994) 207–210

Phys.Rev.Lett.78(1997)187

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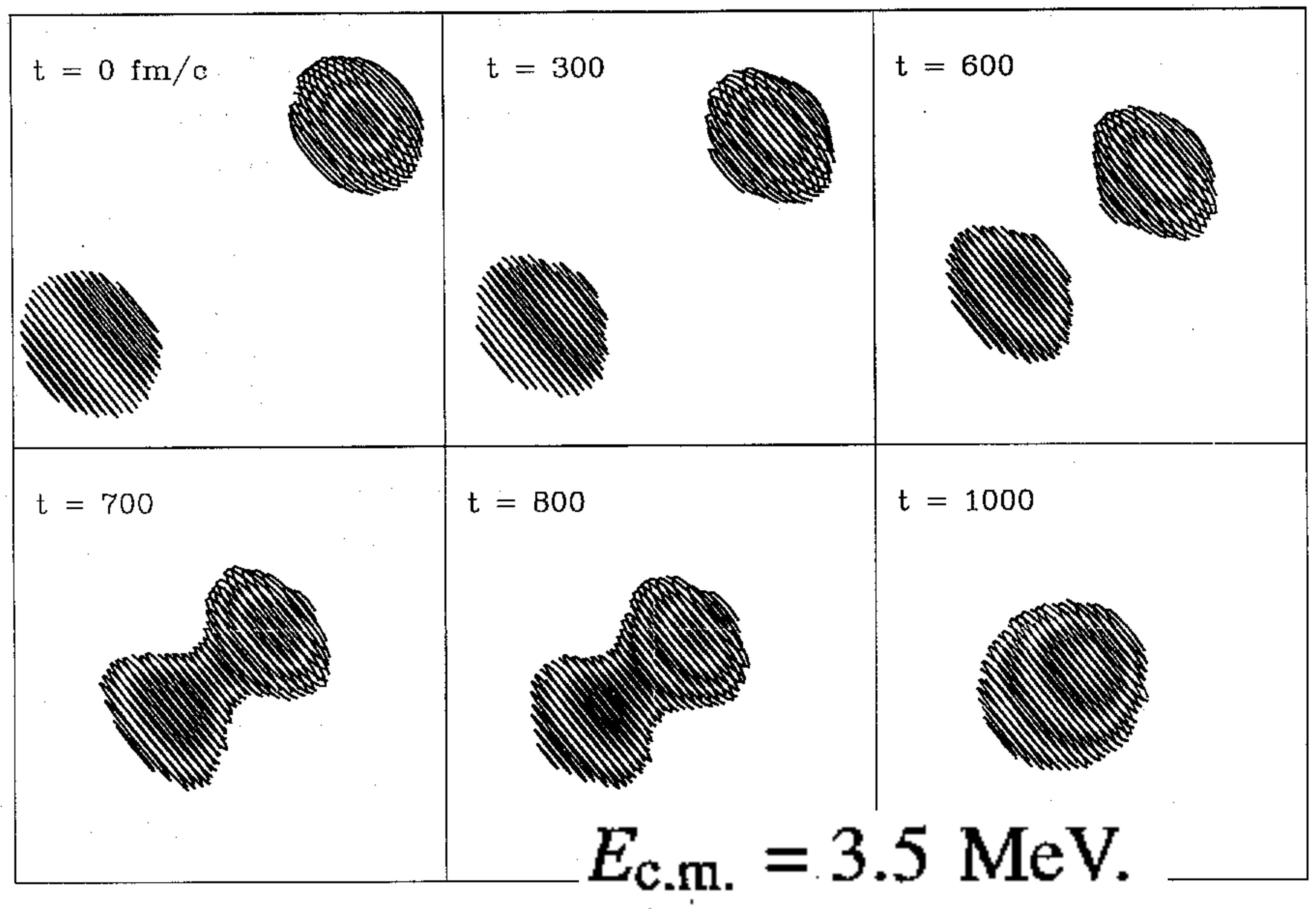
Solve the Vlasov equation in imaginary time. Define collective variables R&P

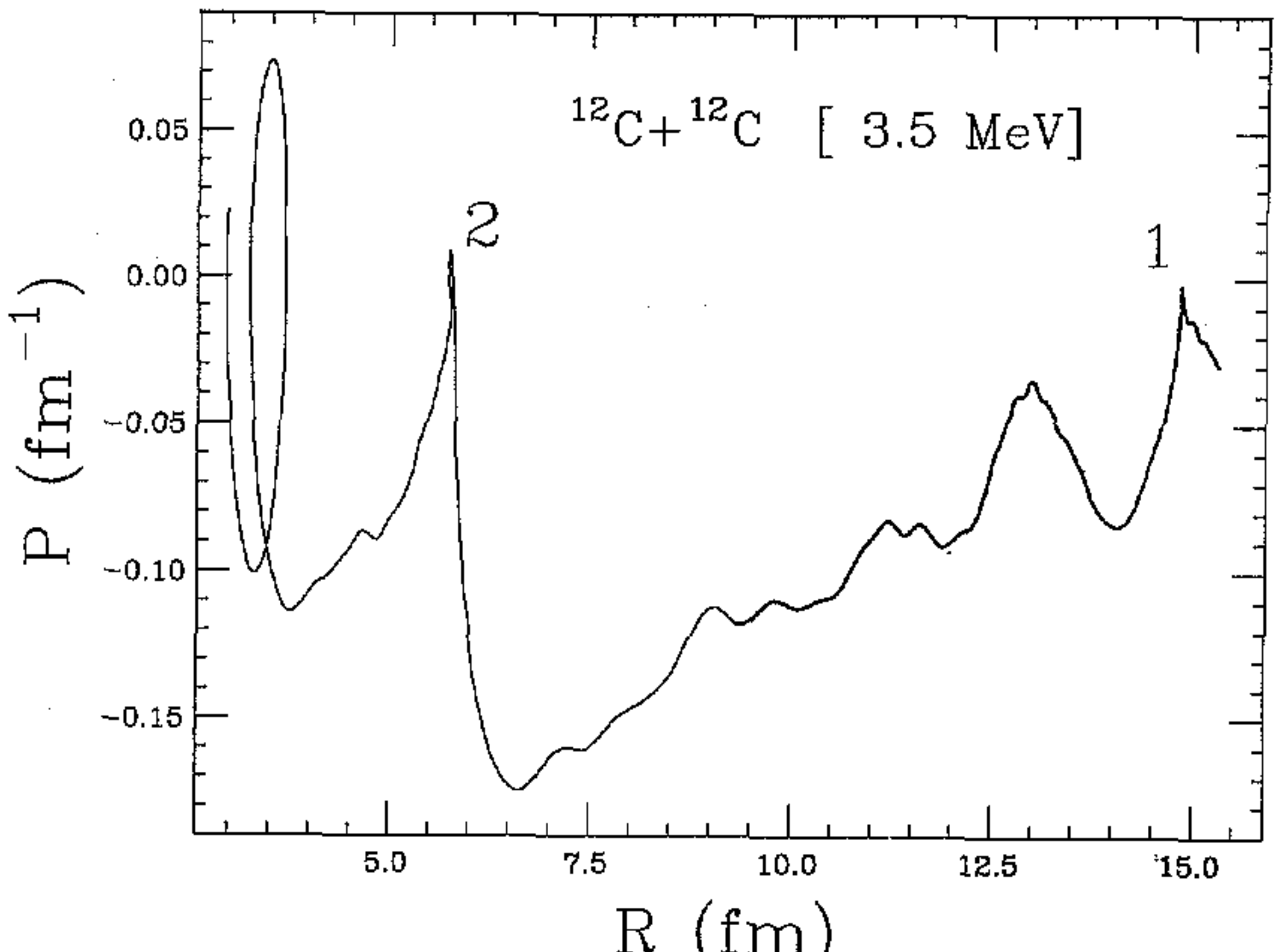
$$\begin{Bmatrix} \boldsymbol{R} \\ \boldsymbol{P} \end{Bmatrix} = \int_A d\boldsymbol{r} d\boldsymbol{p} \begin{Bmatrix} \boldsymbol{r} \\ \boldsymbol{p} \end{Bmatrix} f(\boldsymbol{r},\boldsymbol{p};\, t) - \int_B d\boldsymbol{r} d\boldsymbol{p} \begin{Bmatrix} \boldsymbol{r} \\ \boldsymbol{p} \end{Bmatrix} f(\boldsymbol{r},\boldsymbol{p};\, t)$$

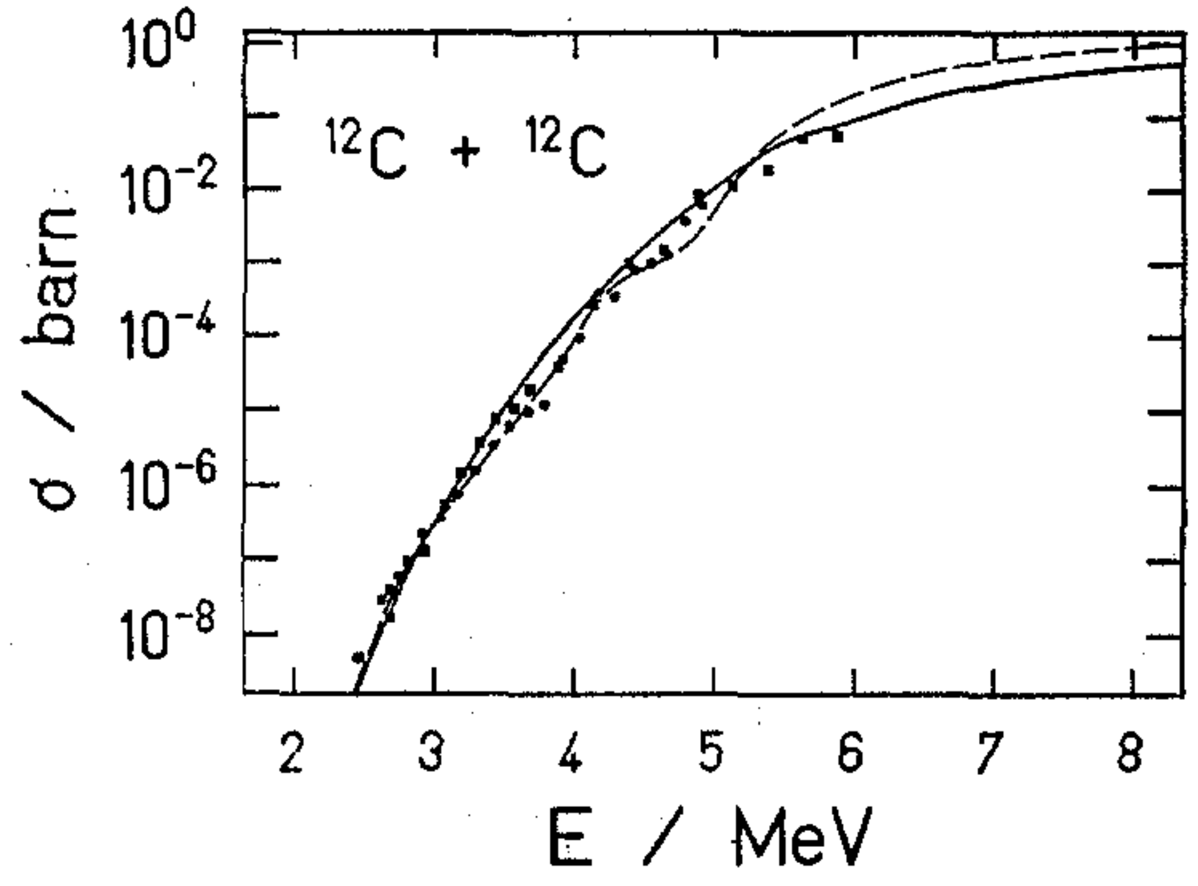
$$\frac{d\boldsymbol{R}_{A(B)}}{dt} = \frac{\boldsymbol{P}_{A(B)}}{m}; \quad \frac{d\boldsymbol{P}_{A(B)}}{dt} = \boldsymbol{F}_{A(B)}$$

in imaginary time t—>it

$$\frac{d\boldsymbol{R}^i_{A(B)}}{dt} = \frac{\boldsymbol{P}^i_{A(B)}}{m}; \quad \frac{d\boldsymbol{P}^i_{A(B)}}{dt} = -\boldsymbol{F}_{A(B)}$$





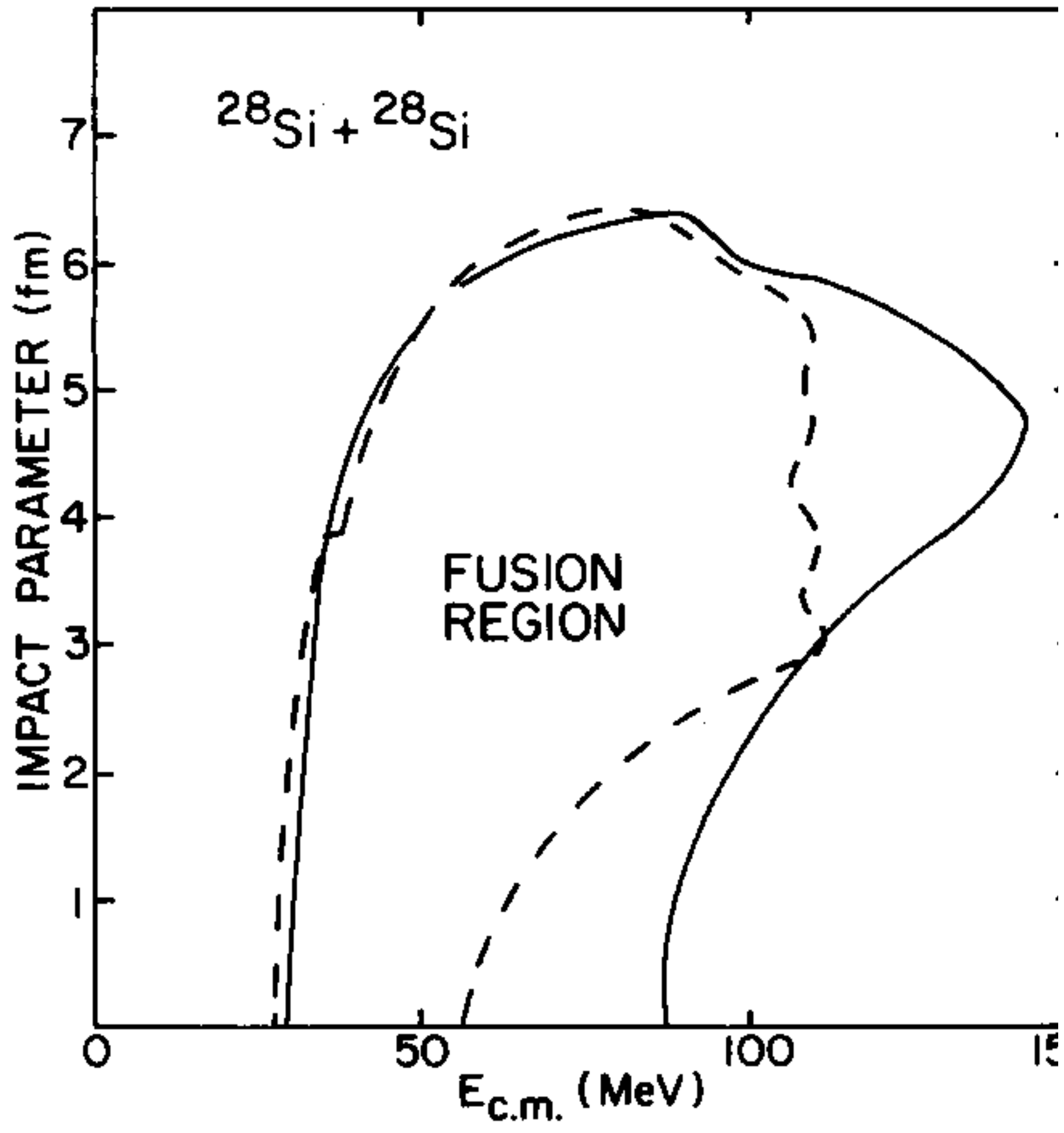


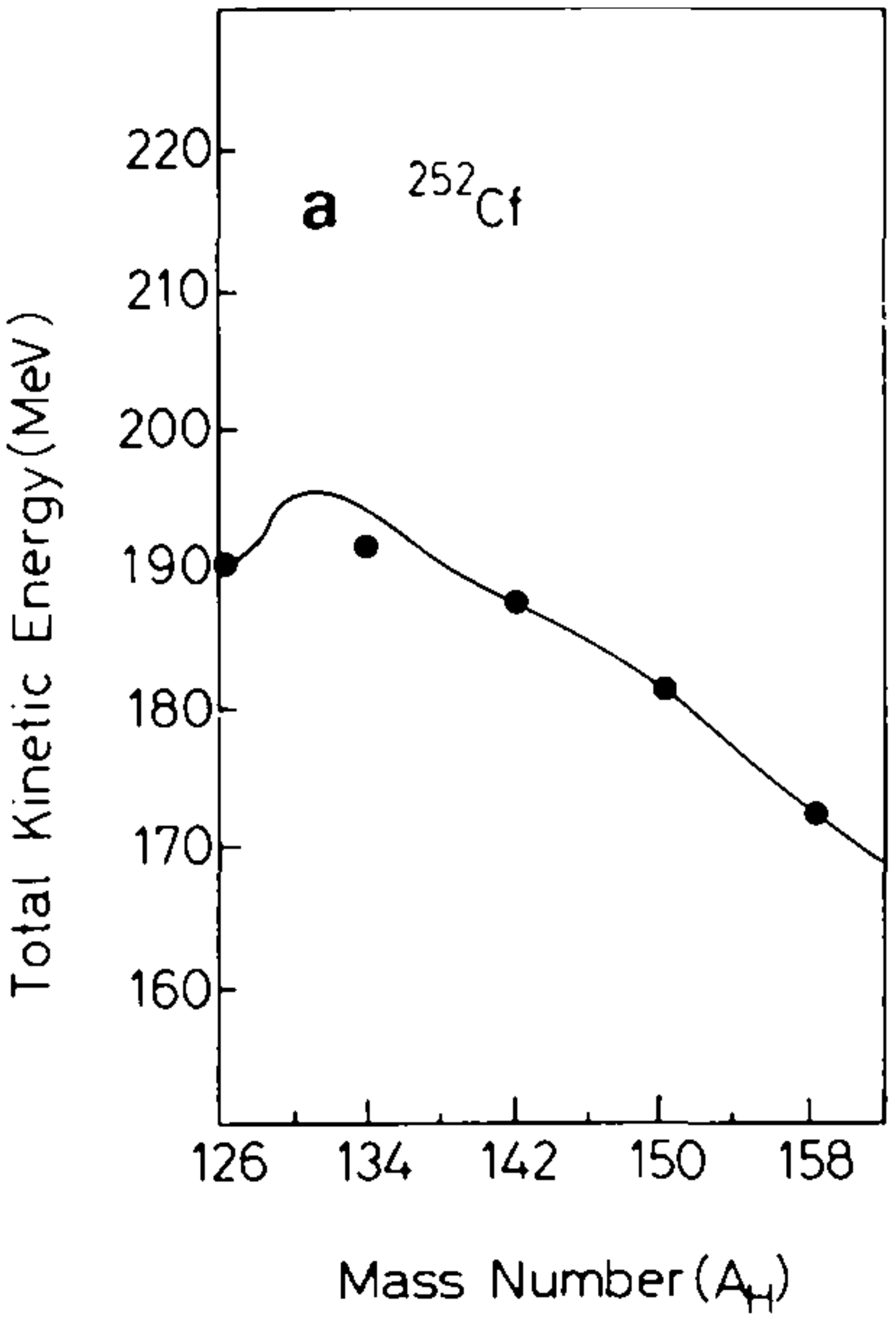
NEWTONIAN DYNAMICS OF TIME-DEPENDENT MEAN FIELD THEORY

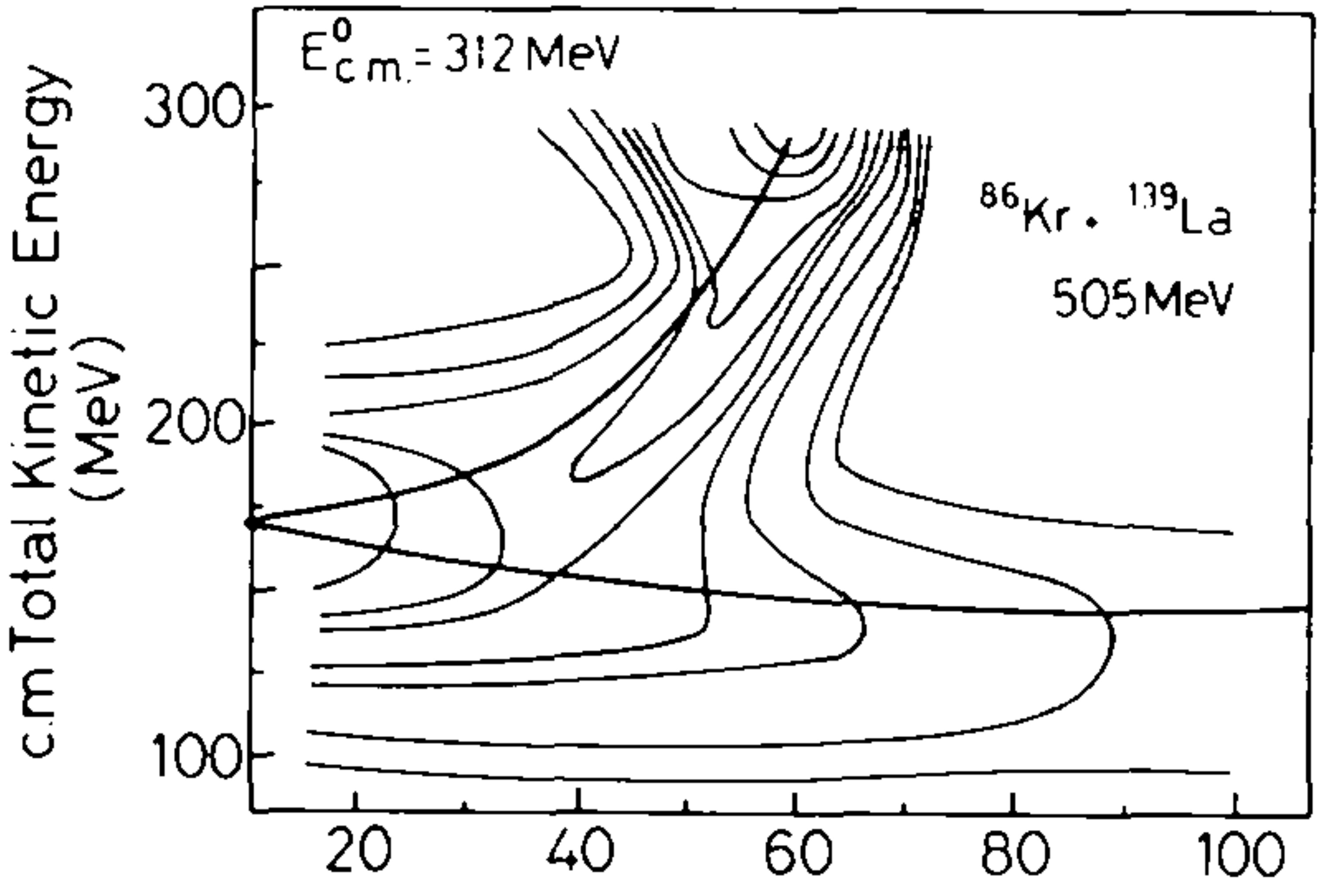
Phys.Lett.B141(1984)9; 168B(1986)35.

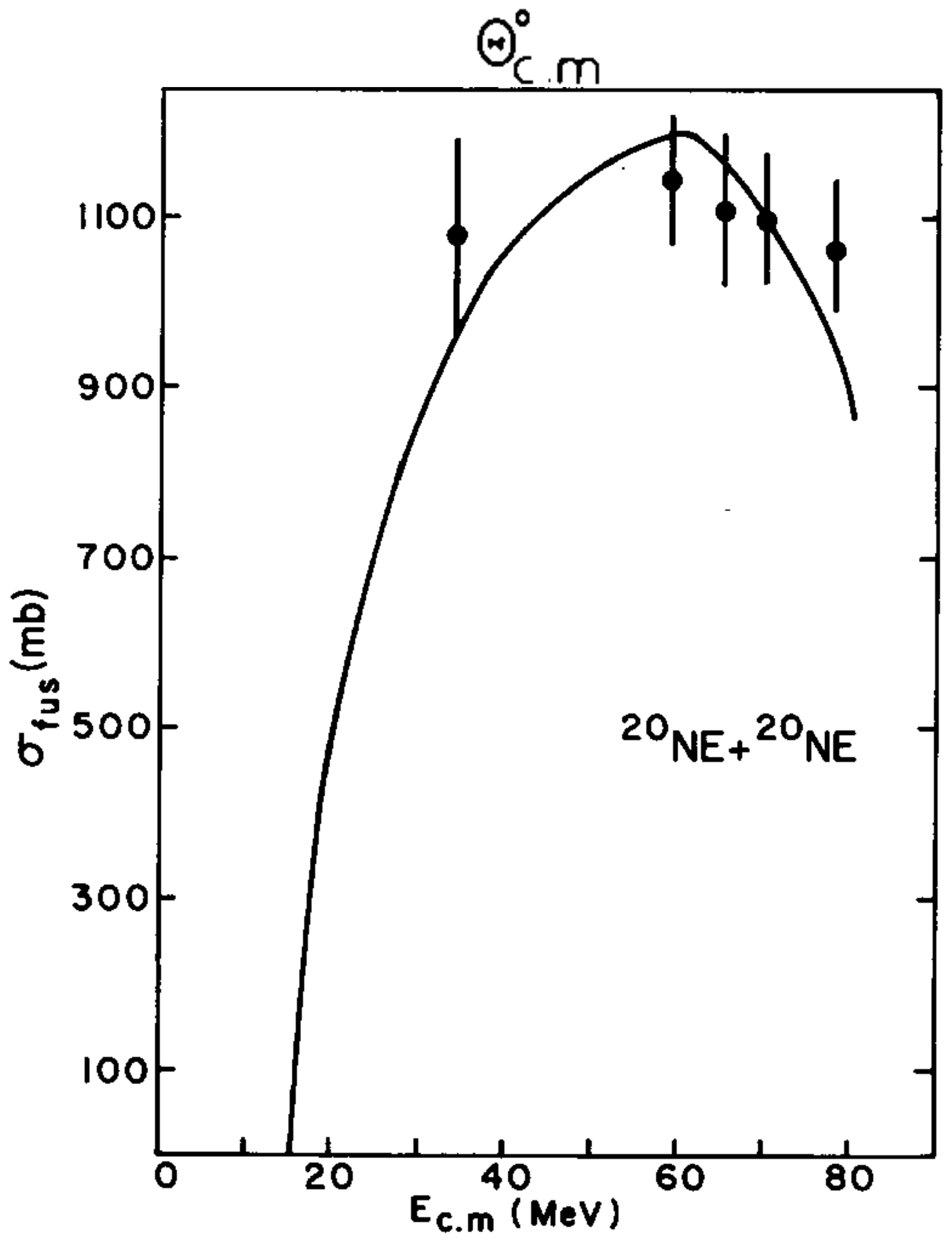
A. BONASERA, G.F. BERTSCH and E.N. EL-SAYED
Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA

Nuclear Physics **A439** (1985) 353–370









Neck model in imaginary times

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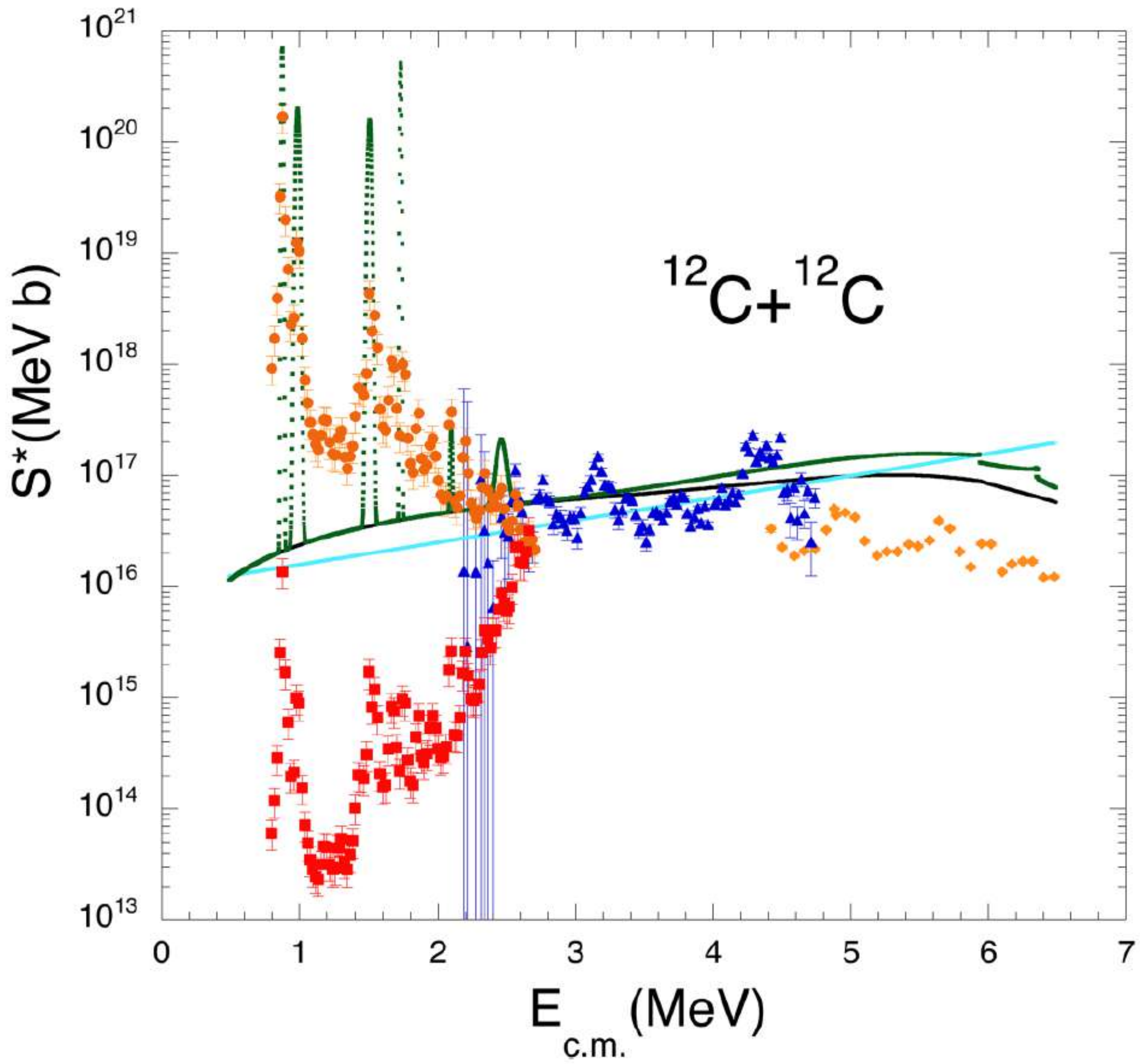
The probability of fusion for the l th-partial wave is given by $T_l = 1/(1 + \exp\{2A\})$, $A = \int_1^2 P\, dR$



To take into account resonances modify the Bass potential as:

$$V_B \to V_B[1 + g(x, \gamma, \sigma)],$$

Analytical formula

$$S_0 = S_G e^{\frac{4\sqrt{2\mu Z_1 Z_2 e^2 R_N}}{\hbar}}.$$

$$S_G = \pi \hbar^2/(2\mu)$$

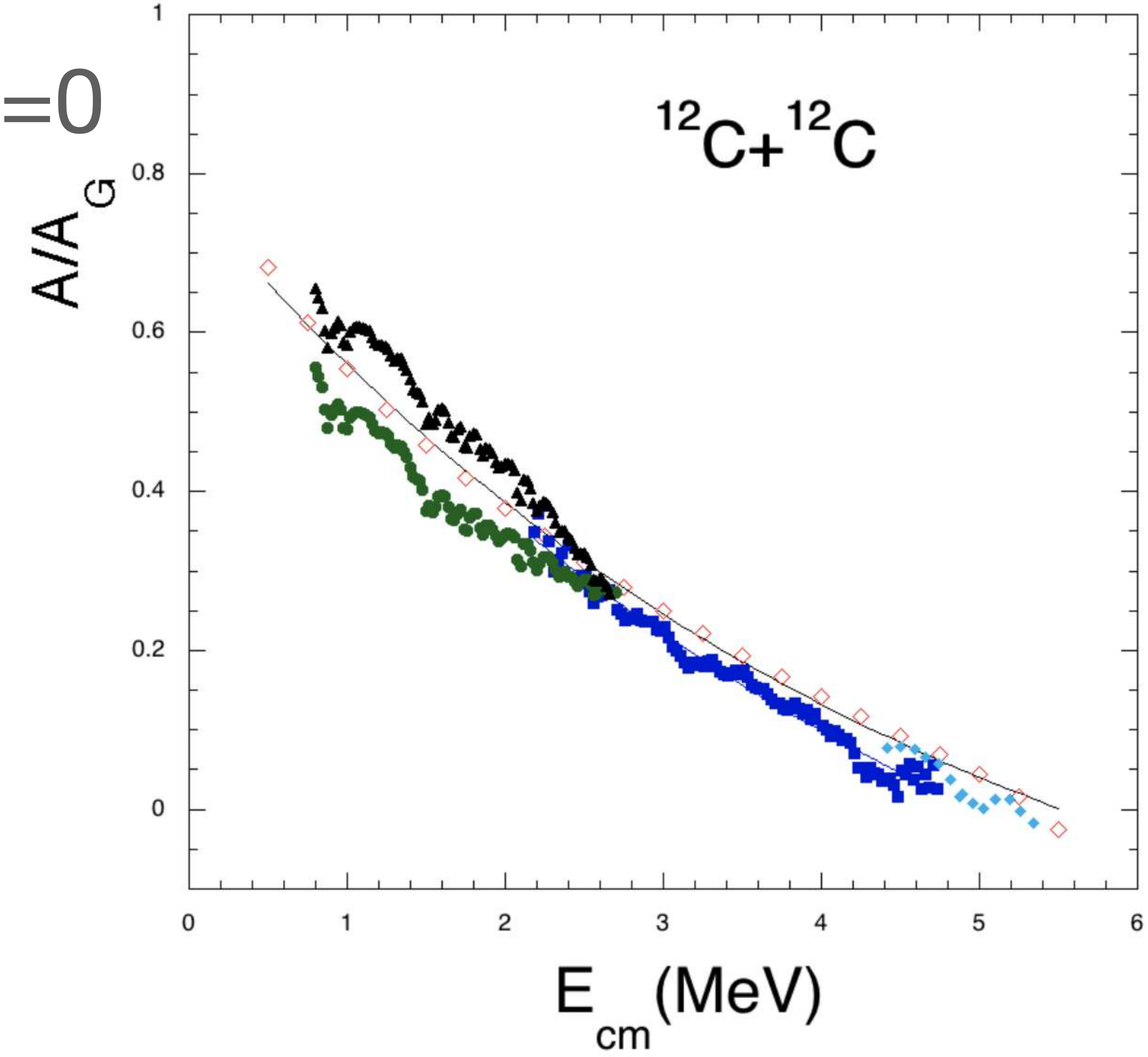
S. Kimura and A. Bonasera, Phys. Rev. C **76**, 031602(R) (2007).

Last but not least, S and S*- what if we use the action A instead?

$$A = \frac{1}{2} ln\left[\frac{\pi\hbar^2}{2E_{cm}\sigma(E_{cm})} - 1\right]$$ l=0

Gamow limit

$$A_G = e^2\pi Z_T Z_P \sqrt{\frac{\mu}{2E_{CM}}}.$$



S. Kimura and A. Bonasera, Phys. Rev. C **76**, 031602(R) (2007).

Conclusions

The Neck model and the Vlasov approach in imaginary time give S*>e16MeVb for Ecm>0.5 MeV (agrees with analytical formula as well)

Adding resonances is in some agreement with the THM

I=0 channel is dominant up to Ecm=3MeV

if the properties of the resonances (spin, width etc..) are confirmed then:

THANKS

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DOE grant: DE-FG03-93ER40773