Role of diabaticity in reactions forming heavy elements

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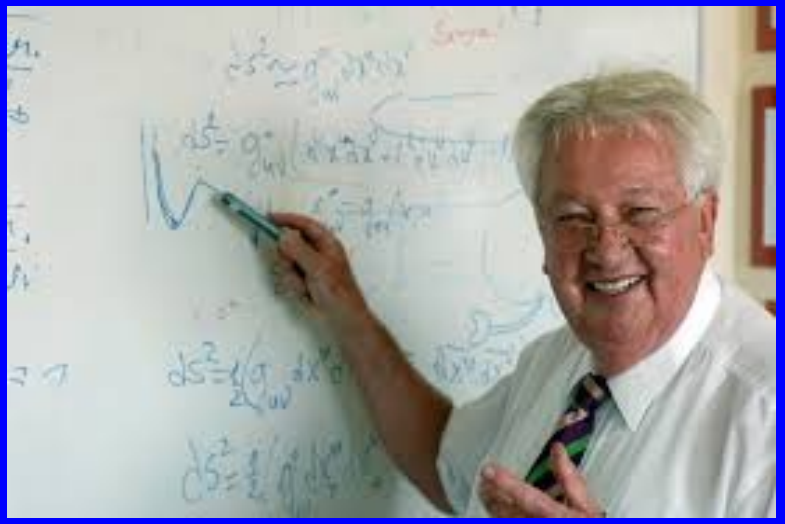
Outline

- Two-Centre Shell Model: adiabatic & diabatic states
- Effects of **diabaticity** on fusion of heavy nuclei
- Summary & Outlook

The Two-Centre Shell Model is a basic microscopic approach to the single-particle motion in low-energy heavy-ion collisions

A legacy of the Frankfurt school of theoretical nuclear physics



Walter Greiner

Joachim Maruhn

Some developments of the TCSM over 50 years

Holzer, Mosel & Greiner, Nucl. Phys. A 138 (1969) 241

Maruhn & Greiner, Z. Phys. 251 (1972) 431

Gareev, Gizzatkulov & Revai, Nucl. Phys. A 286 (1977) 512

Pruess & Lichtner, Nucl. Phys. A 291 (1977) 475

Nuhn, Scheid & Park, Phys. Rev. C 35 (1987) 2146

Mirea, Phys. Rev. C 54 (1996) 302

Gherghescu, Phys. Rev. C 67 (2003) 014309

AD-T & Scheid, Nucl. Phys. A 757 (2005) 373

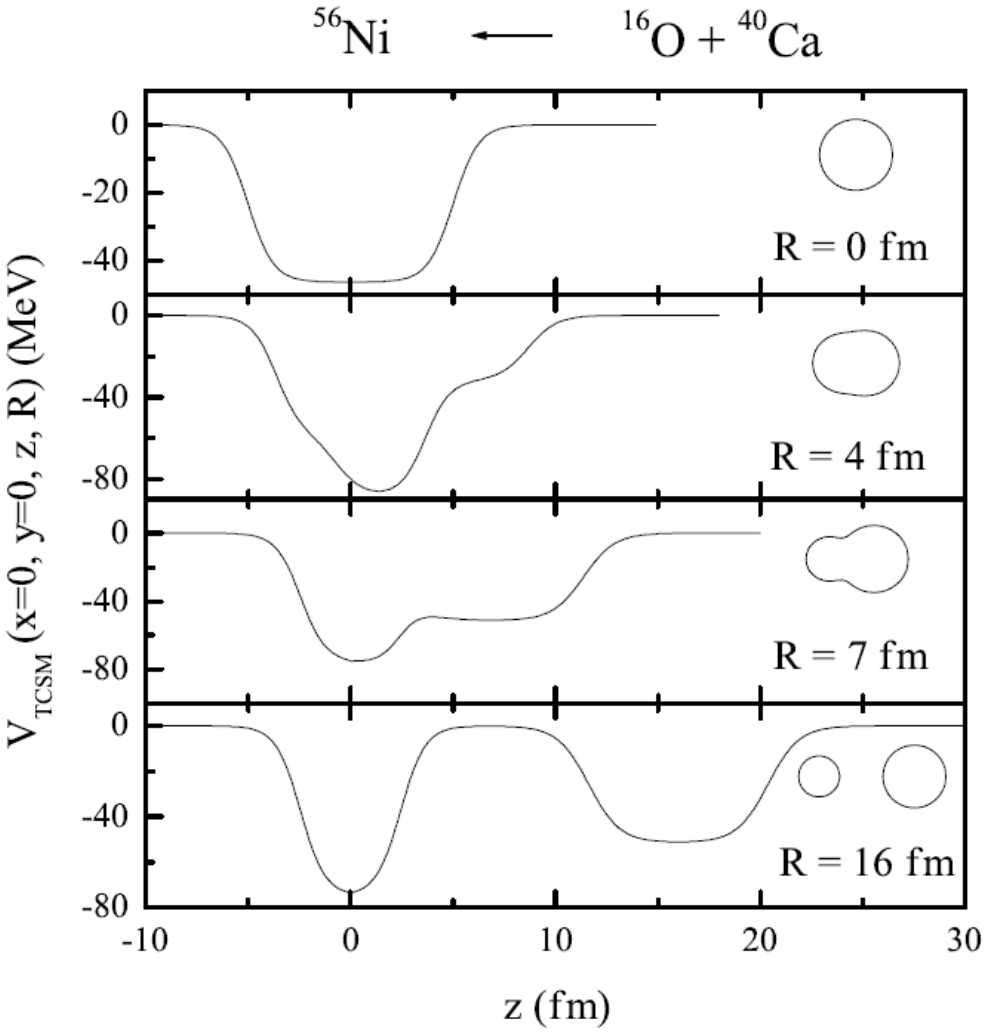
AD-T, Phys. Rev. Lett. 101 (2008) 122501

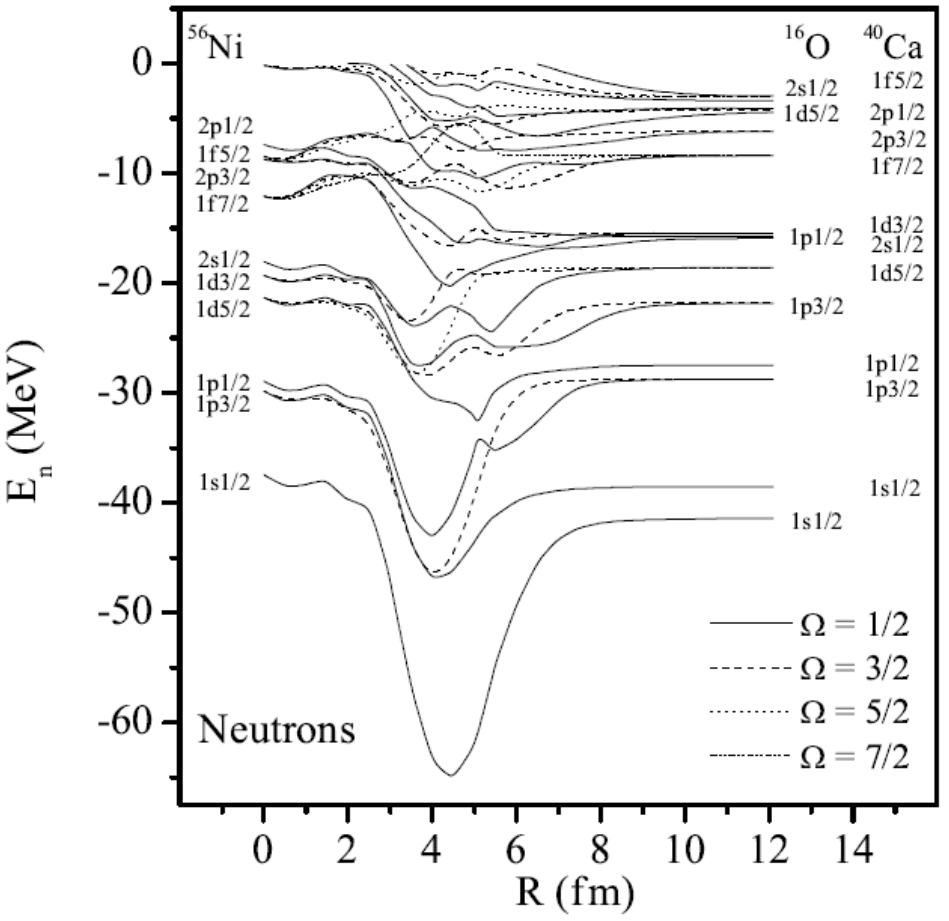
AD-T, Comp. Phys. Comm. 224 (2018) 381

TCSM with Woods-Saxon Potentials

AD-T & Scheid, Nucl. Phys. A **757** (2005) 373

AD-T, Phys. Rev. Lett. **101** (2008) 122501





Contents lists available at ScienceDirect

Computer Physics Communications

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OWL: A code for the two-center shell model with spherical Woods–Saxon potentials☆

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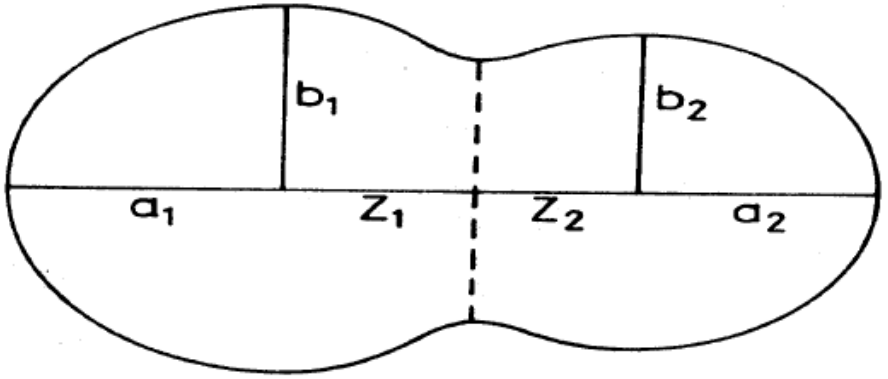
Department of Physics, University of Surrey, Guildford, GU2 7XH, UK

AD-T, Computer Physics Communications **224** (2018) 381-386.

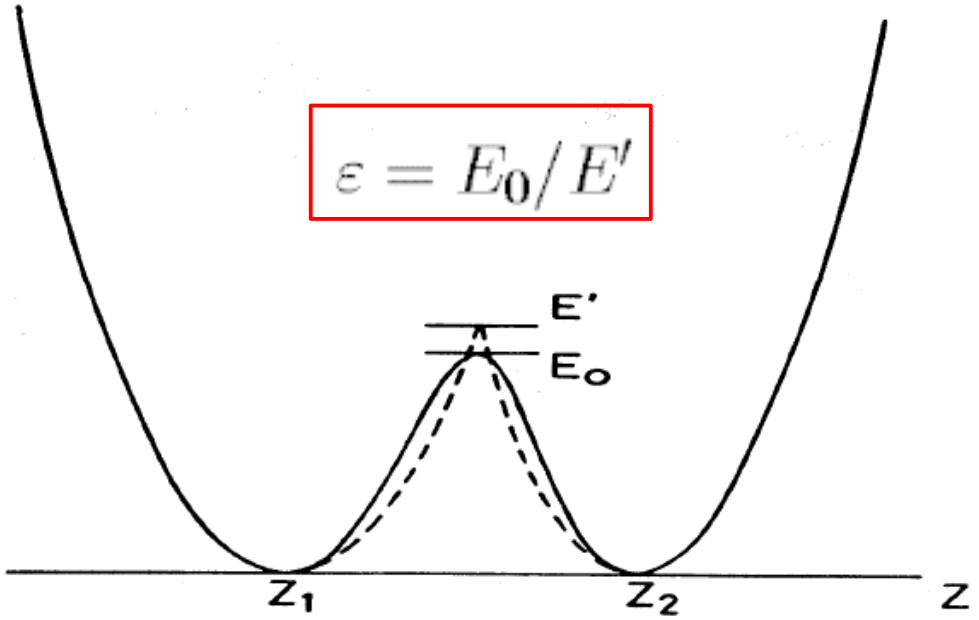
TCSM with Harmonic Oscillator Potentials

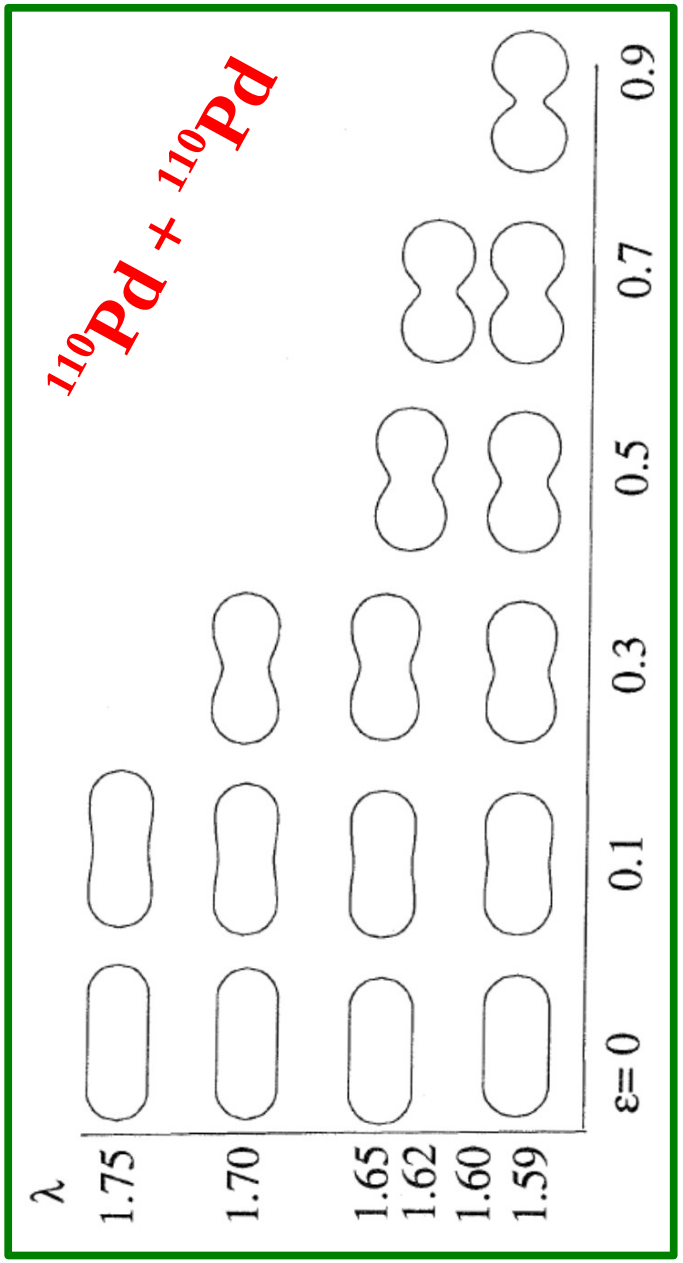
Maruhn & Greiner, Z. Phys. **251** (1972) 431

$$\lambda = l/(2R_0)$$

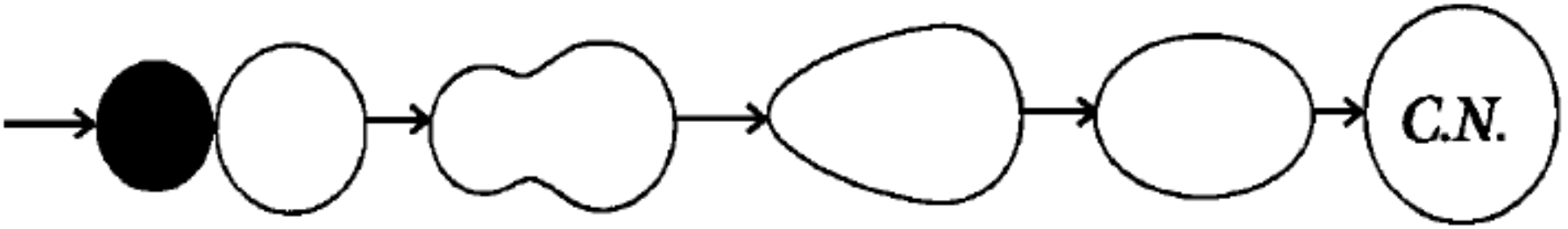


$$\varepsilon = E_0/E'$$

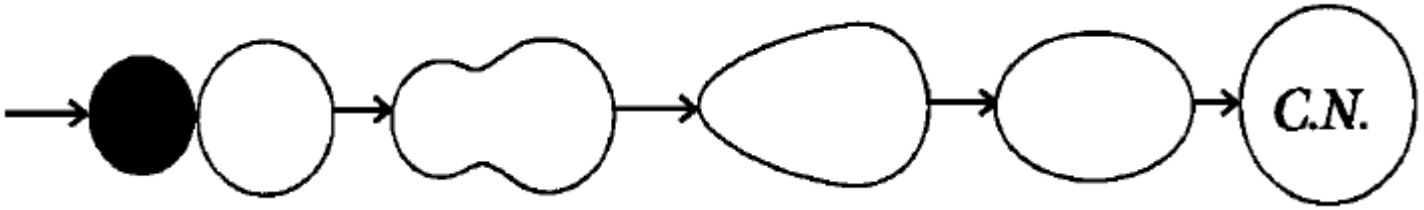




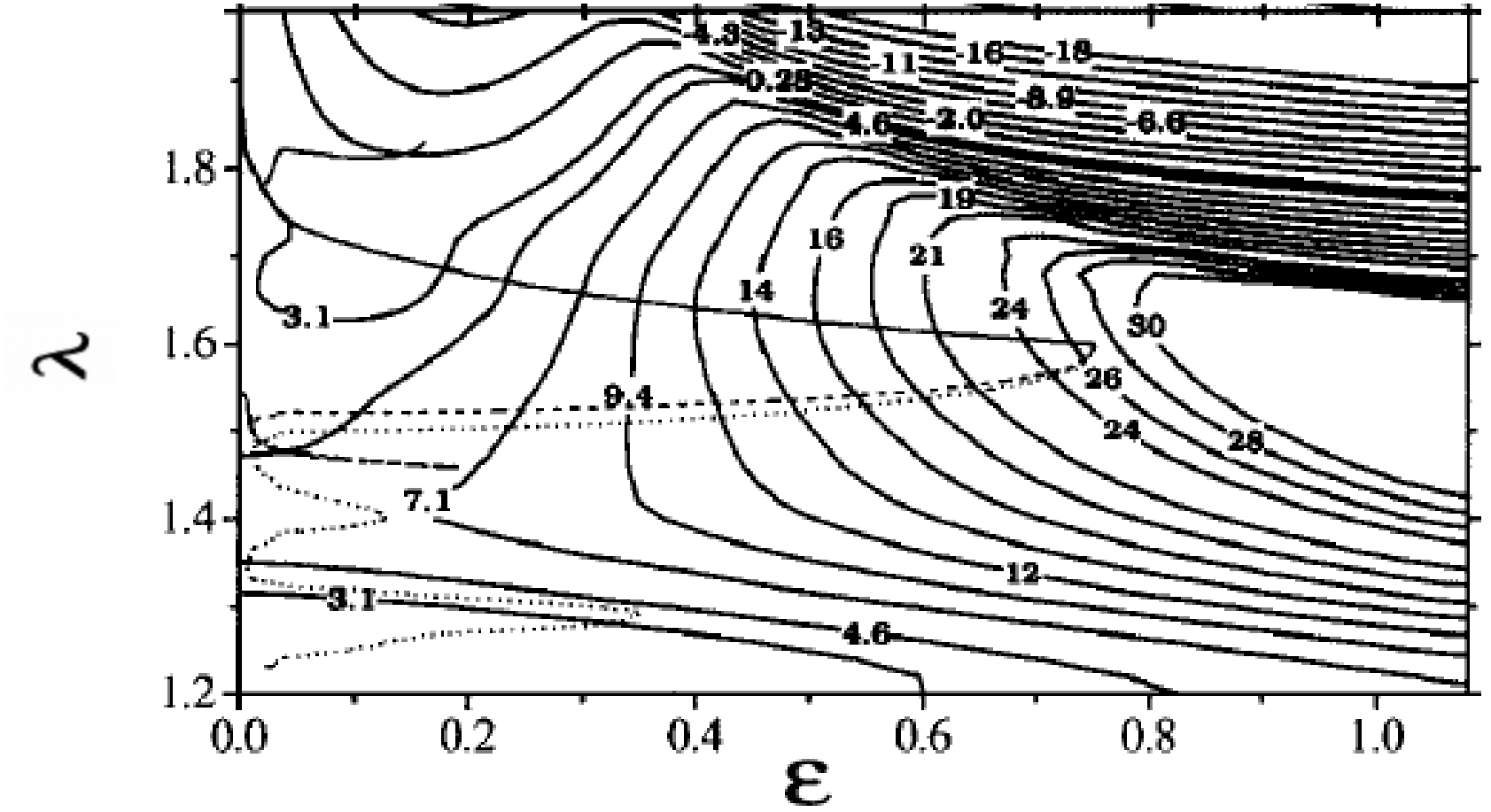
The Adiabatic **Picture of Fusion**



The Adiabatic **Picture of Fusion**

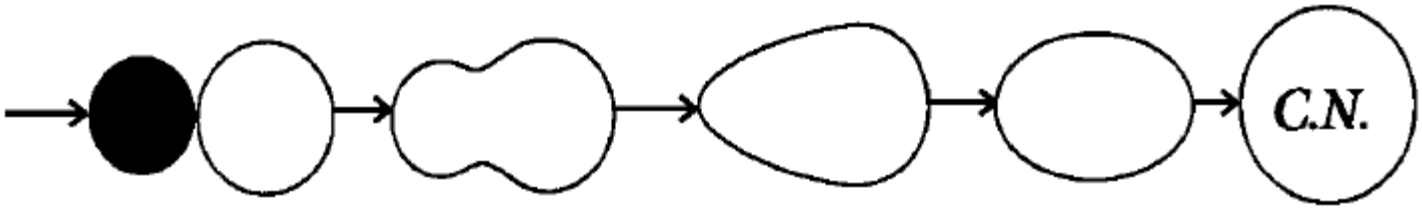


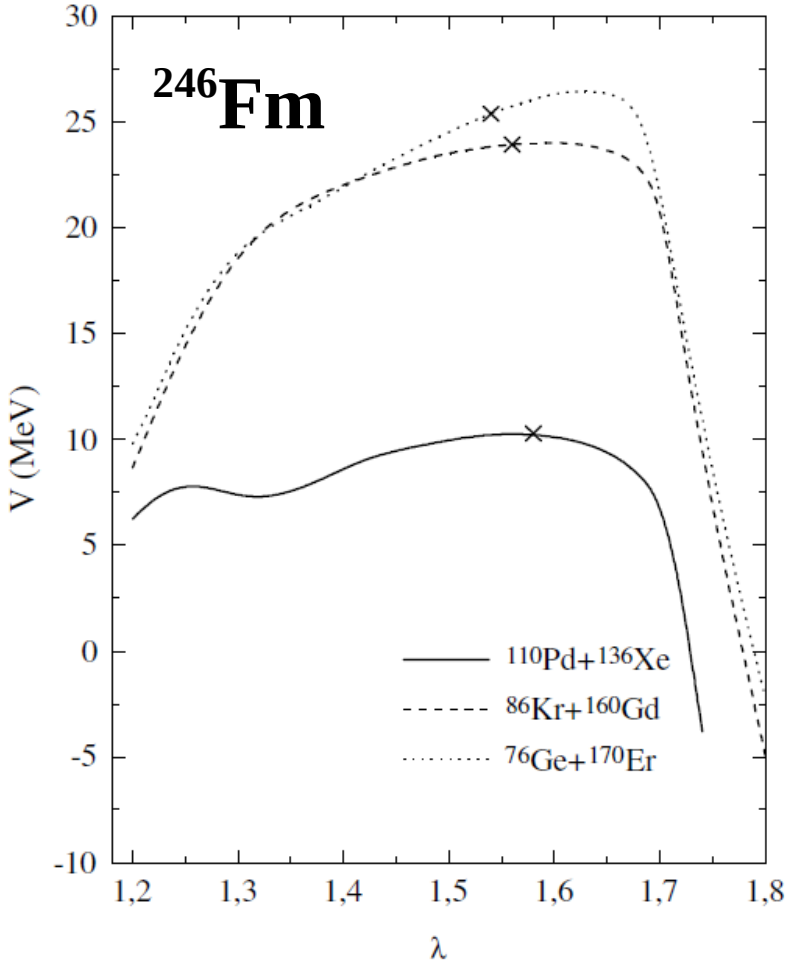
^{110}Pd + ^{110}Pd

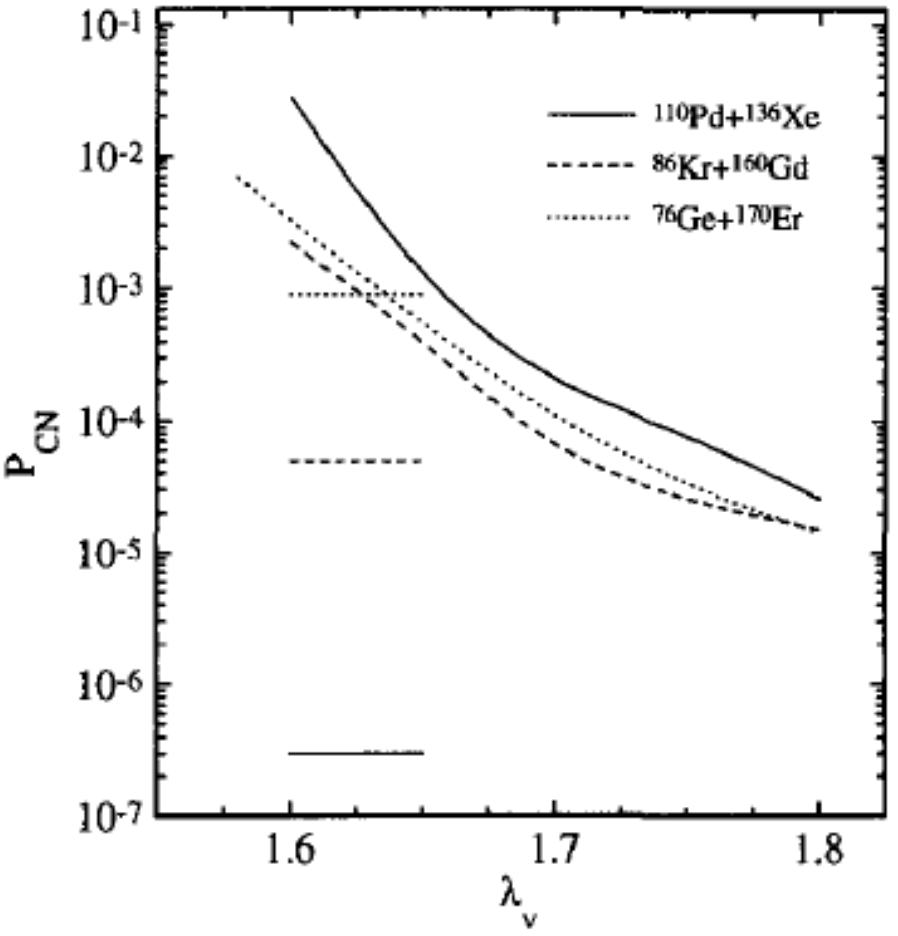


Adamian, Antonenko, Ivanova & Scheid, Nucl. Phys. A **646** (1999) 29

Some Problems with the Adiabatic Picture of Fusion



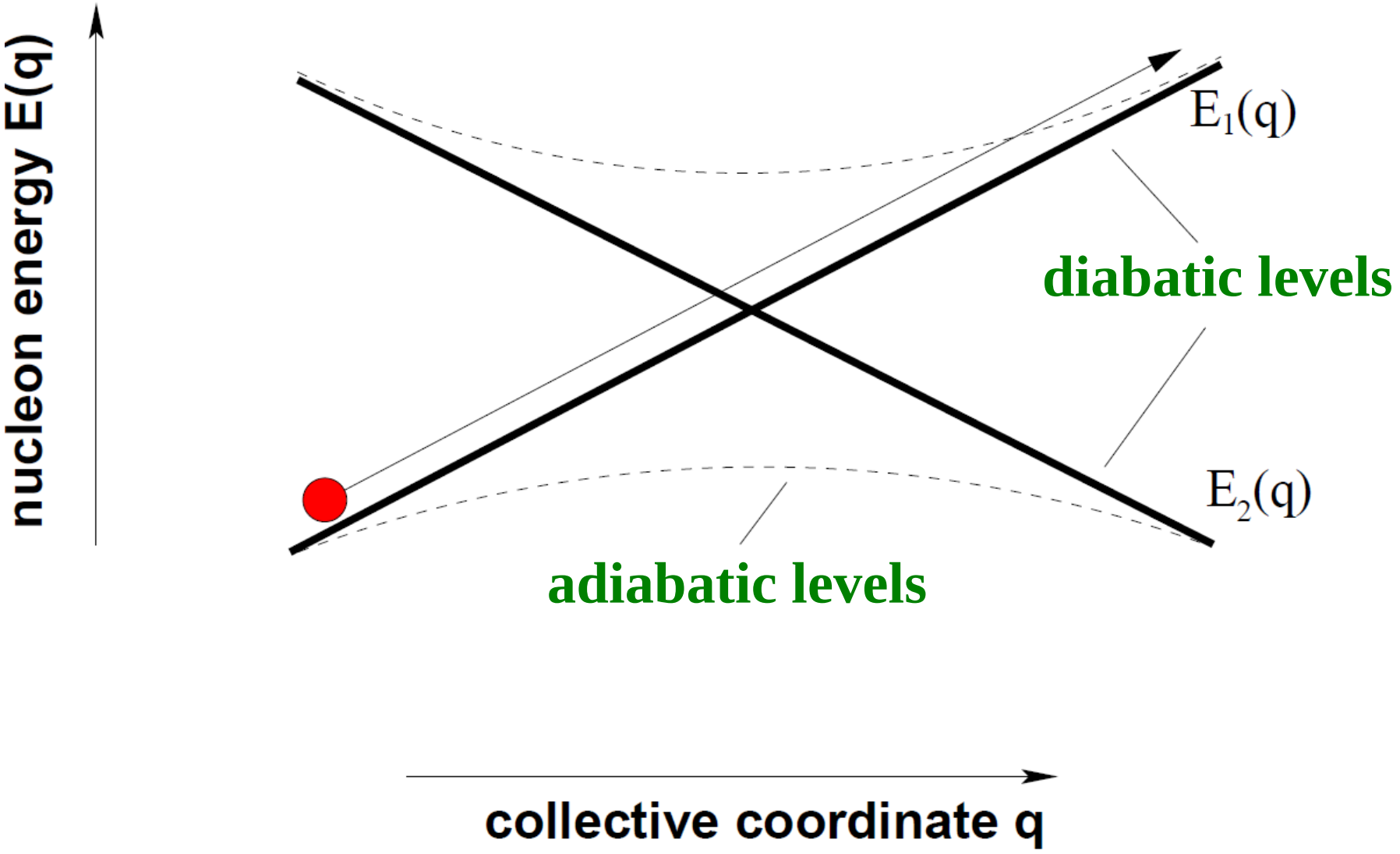




Adamian, Antonenko, Ivanova & Scheid, Nucl. Phys. A **646** (1999) 29

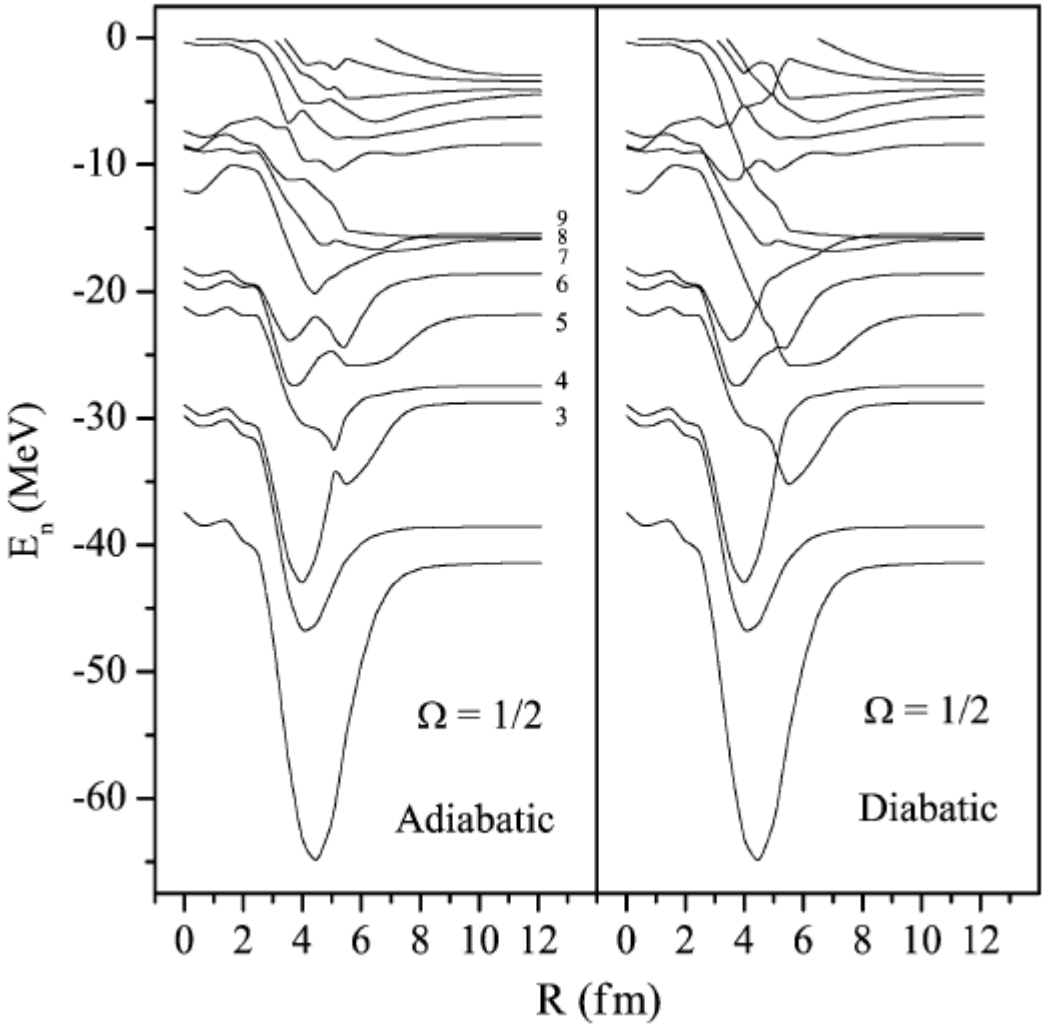
Adiabatic and Diabatic Single-Particle Motion

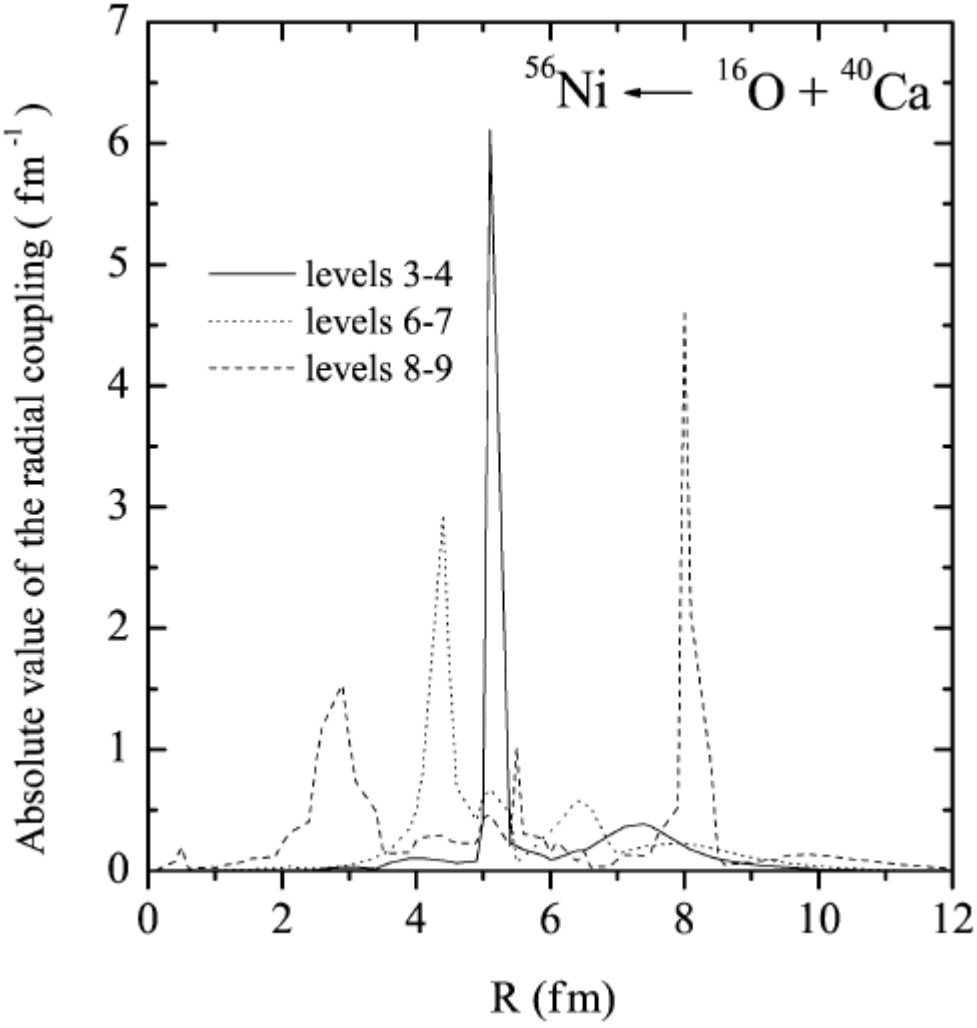
Lukasiak, Cassing & Noerenberg, Nucl. Phys. A **426** (1984) 181



Adiabatic and Diabatic Single-Particle Motion

AD-T & Scheid, Nucl. Phys. A **757** (2005) 373





$$\langle \alpha | \frac{\partial}{\partial R} | \beta \rangle$$ **Radial non-adiabatic coupling**

Effects of diabaticity on low-energy fusion of heavy nuclei

- A study using the Frankfurt TCSM -

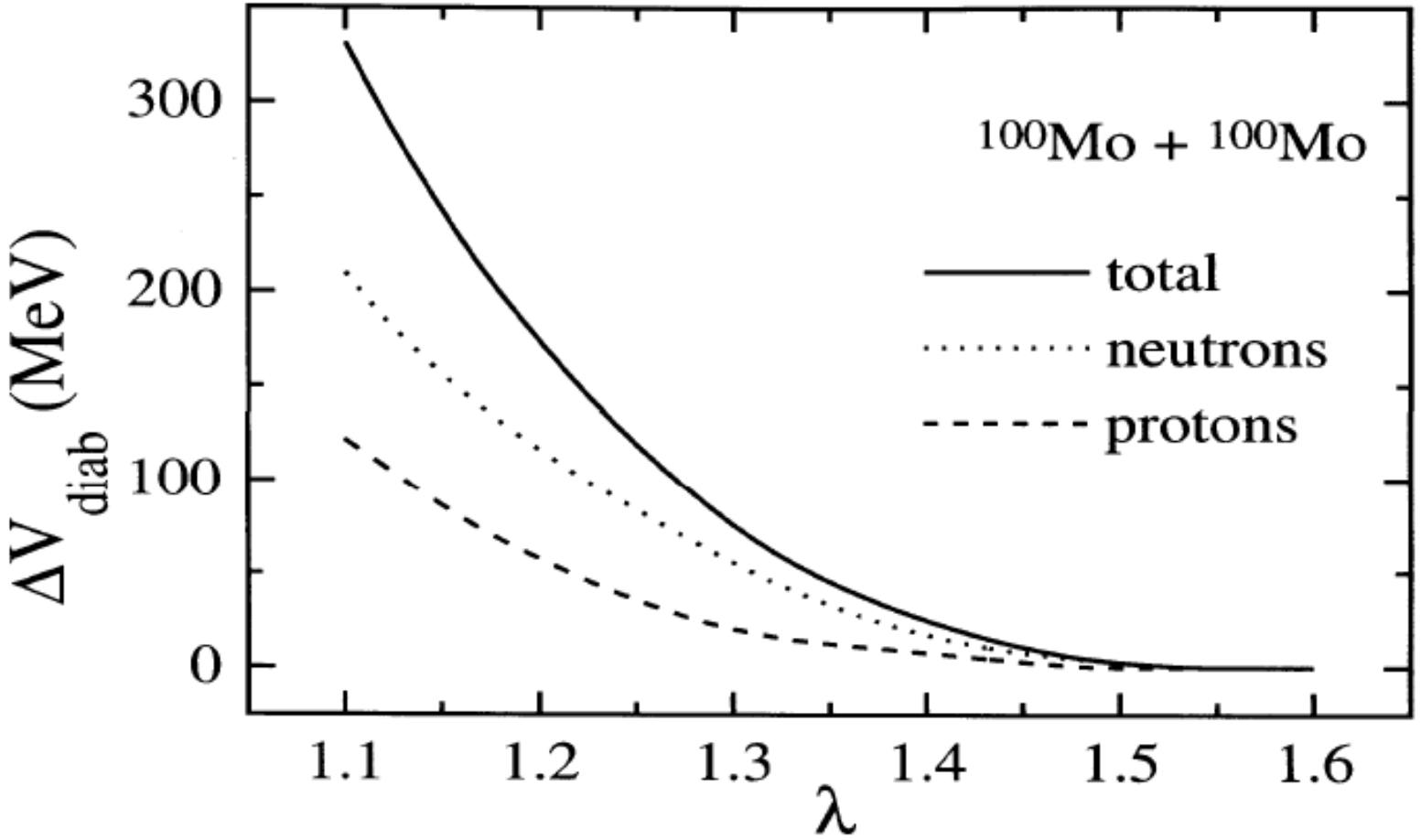
- To hinder both the motion to small relative distances and the growth of the neck in the dinuclear system.
- The diabatic effects support the dinuclear system model of fusion in low-energy collisions of heavy nuclei.

http://geb.uni-giessen.de/geb/volltexte/2000/218

Diabatic Contribution to the Collective PES

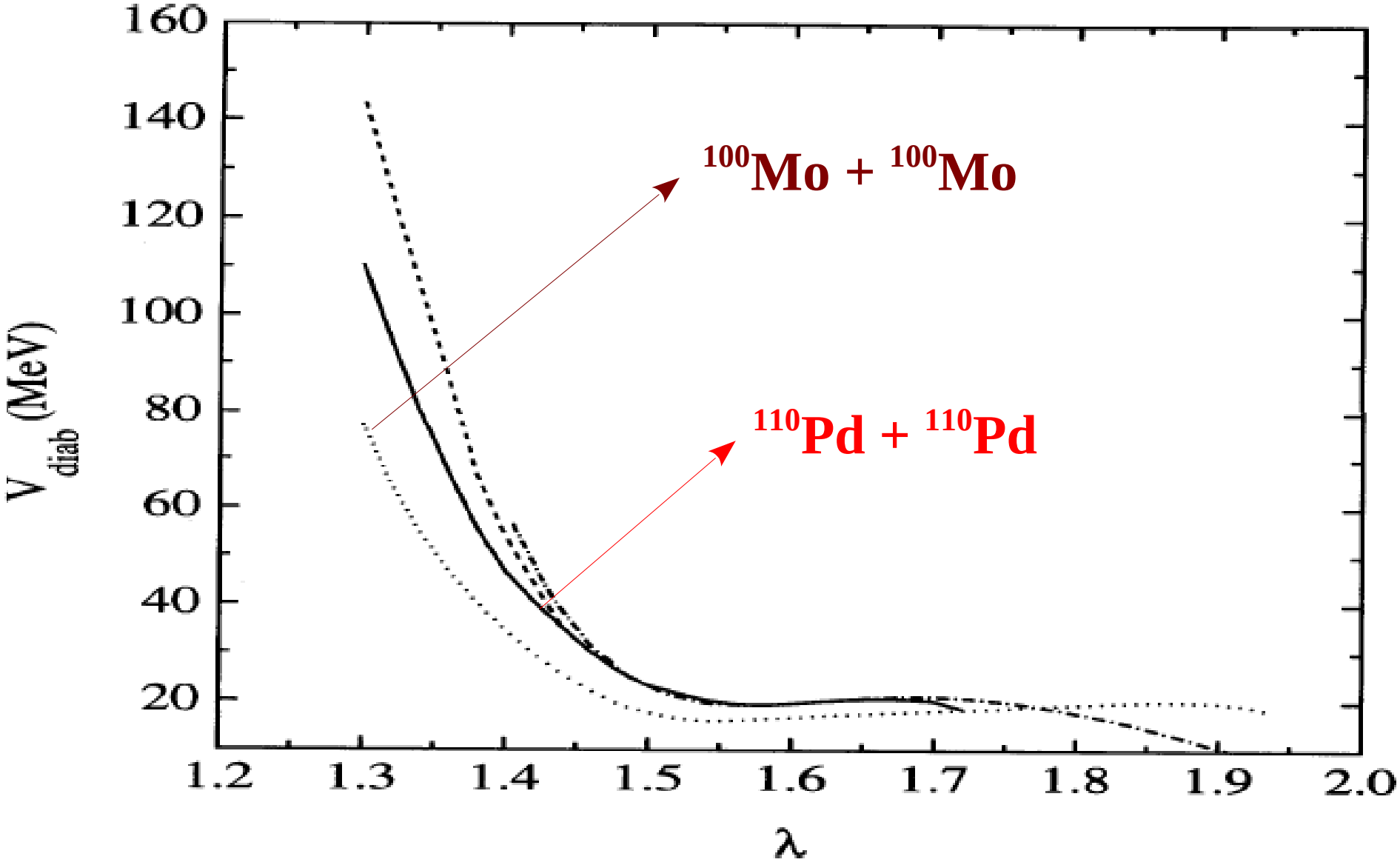
AD-T, Antonenko & Scheid, Nucl. Phys. A **652** (1999) 61

$$\Delta V_{diab}(q) \approx \sum_{\alpha} E_{\alpha}^{diab}(q)\,(n_{\alpha}^{diab} - n_{\alpha}^{adiab})$$



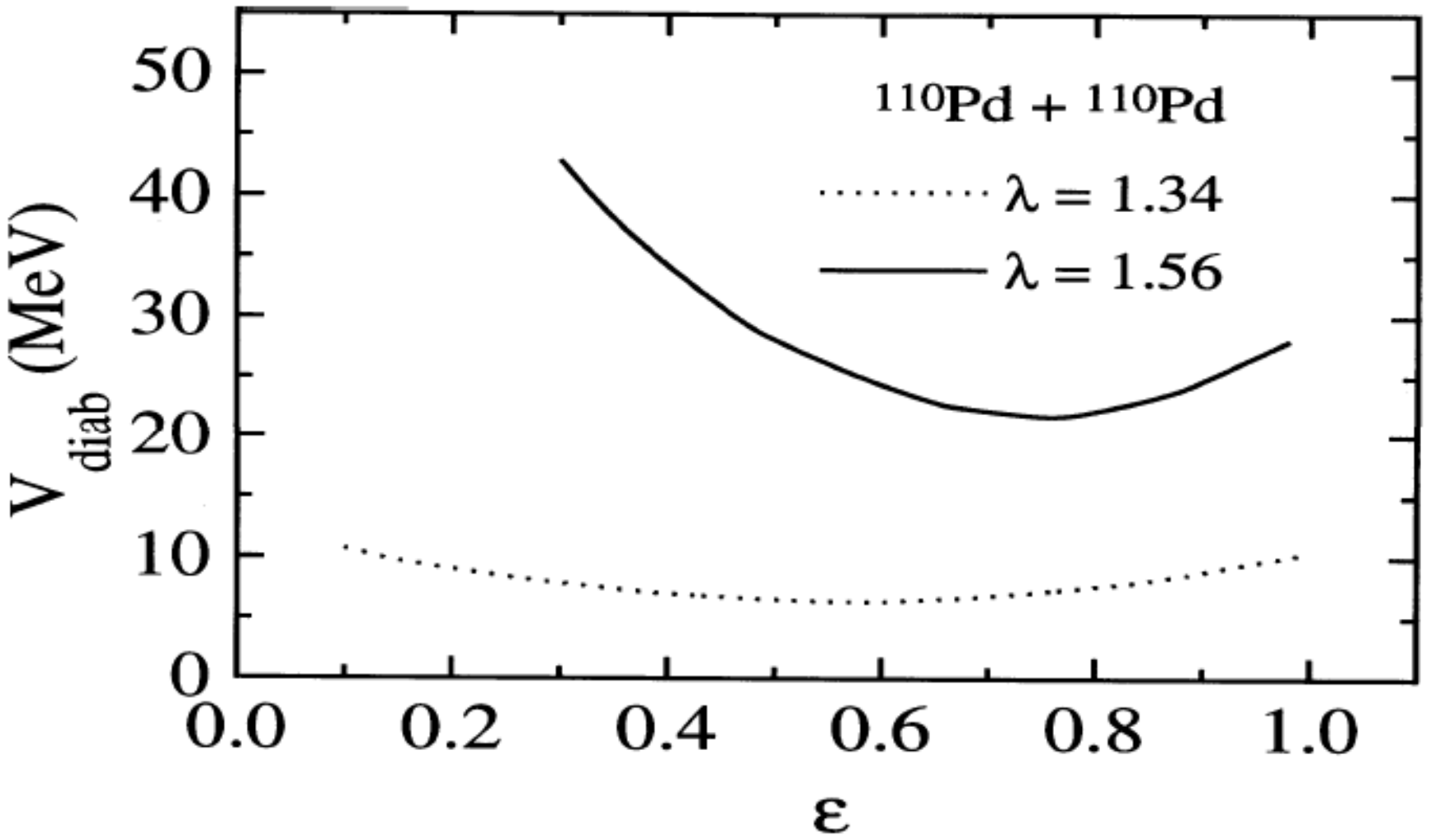
Diabatic Collective PES

AD-T, Antonenko & Scheid, Nucl. Phys. A **652** (1999) 61



The neck of the dinuclear system does not grow much

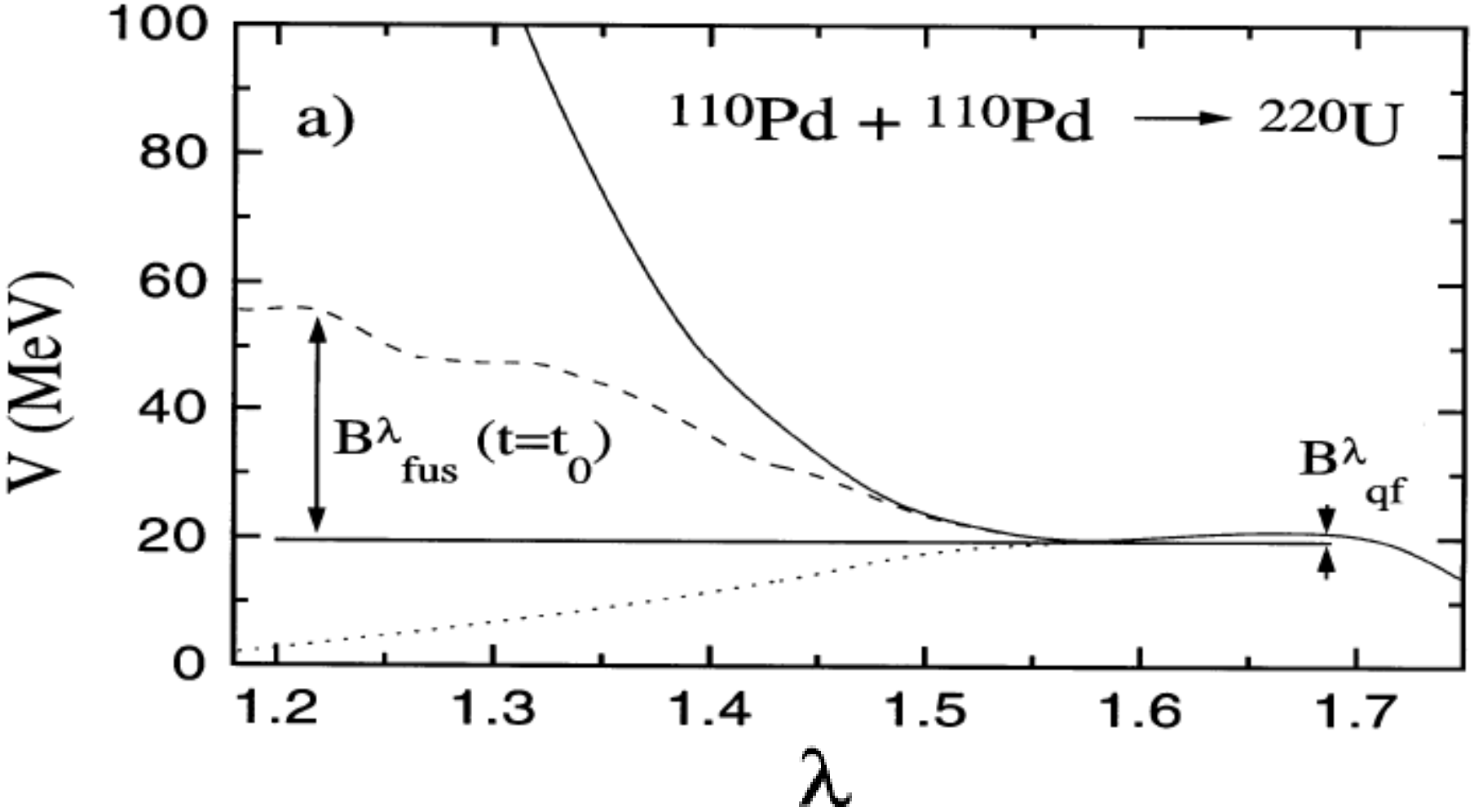
AD-T, Antonenko & Scheid, Nucl. Phys. A **652** (1999) 61



(neck coordinate)

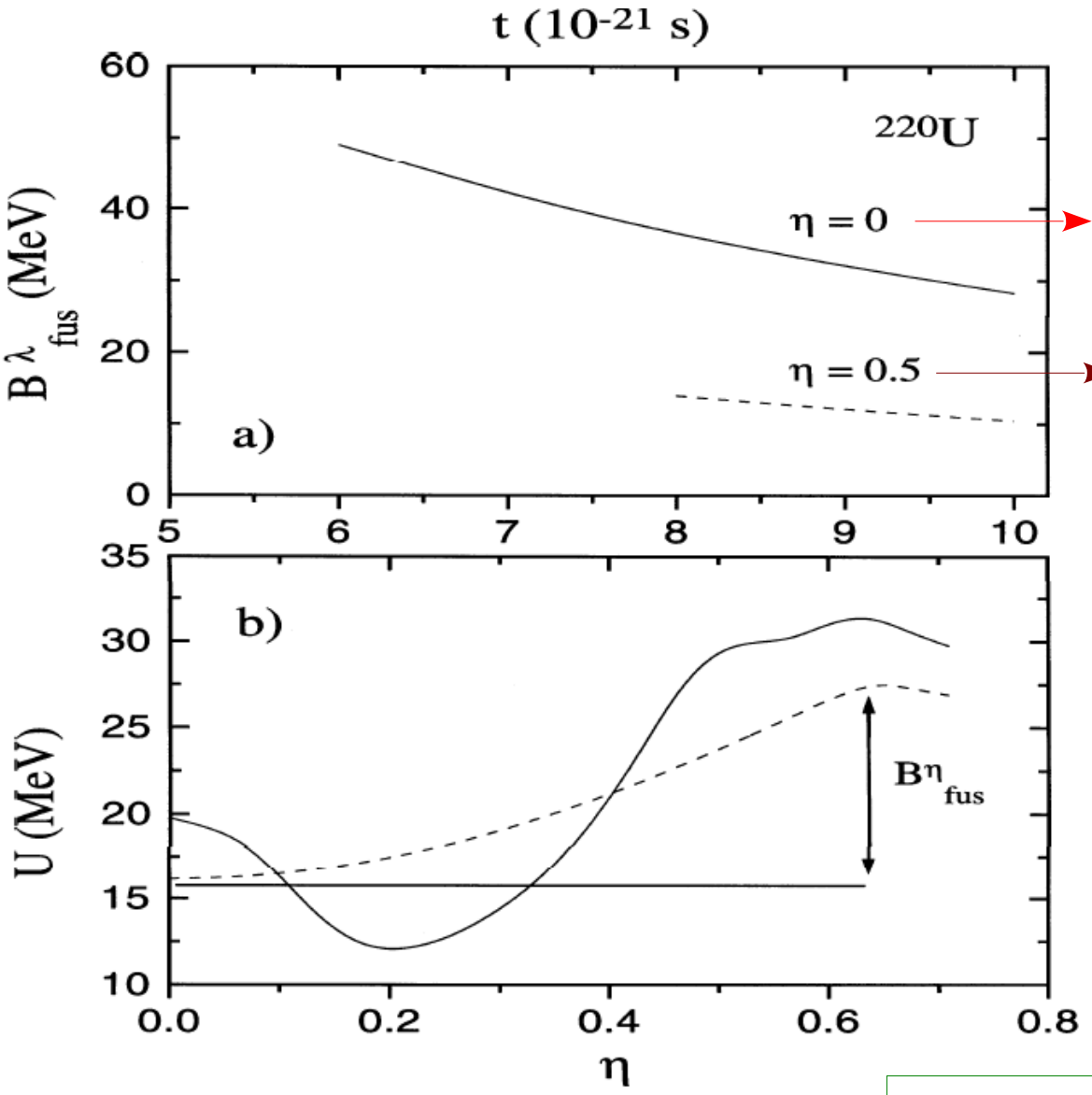
Dynamical Collective PES

AD-T, Adamian, Antonenko & Scheid, Phys. Lett. B **481** (2000) 228



Dynamical Collective PES

AD-T, Adamian, Antonenko & Scheid, Phys. Lett. B **481** (2000) 228



^{110}Pd + ^{110}Pd

^{56}Cr + ^{164}Er

(mass asymmetry) $\eta = (A_1 - A_2)/(A_1 + A_2)$

Summary

- The **diabatic picture** supports the dinuclear system model for complete fusion of heavy nuclei at low energies.