Effect of shell correction energy : δE

Ignatyuk's prescription

$$a_n = \bar{a}_n \left[1 + f(E^*) \cdot \frac{\delta E}{E^*} \right]$$

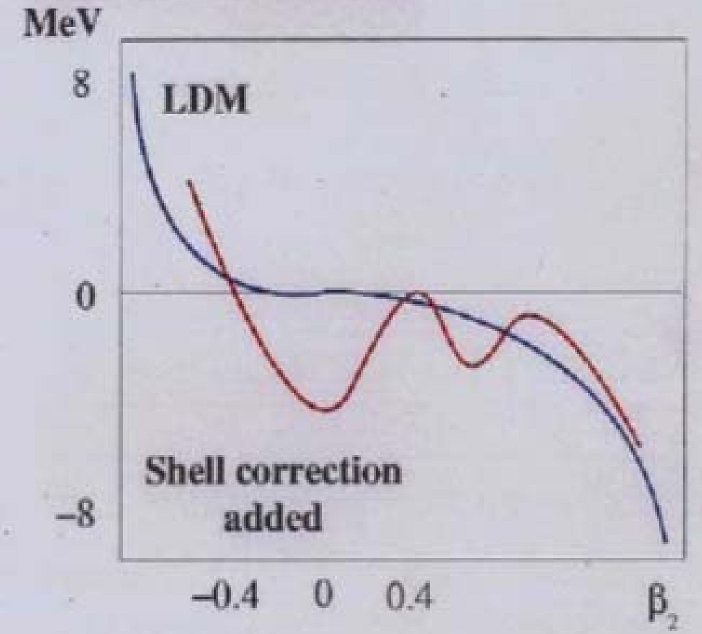
$$f(E^*) = 1 - e^{-\frac{E^*}{E_d}} \qquad E_d \simeq 18\,MeV$$

Then

$$\Gamma_f \approx e^{-B_f^{eff}/T}$$

$$\rightarrow \begin{cases} B_f + \delta E = B_f^{LDM} & E^* \gg E_d \\ B_f + E^* \cdot \delta E / E_d \rightarrow B_f & E^* \ll E_d \end{cases}$$

$$B_f = B_f^{LDM} - \delta E \approx |\delta E|$$

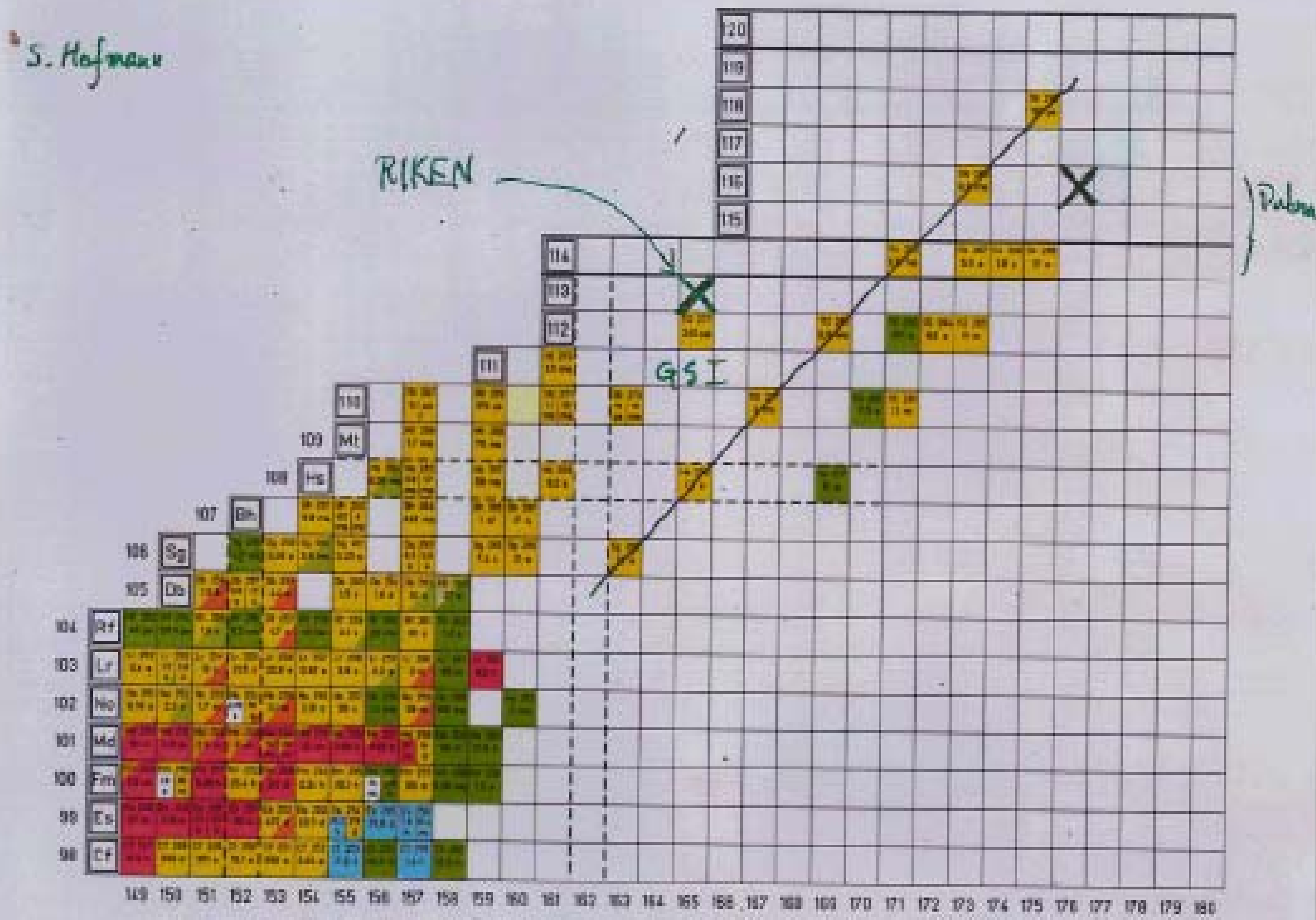


Original table of Mendelev

Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. Von D. Mendelejeff. — Ordnet man Elemente nach zunehmenden Atomgewichten in verticale Reihen so, dass die Horizontalreihen analoge Elemente enthalten, wieder nach zunehmendem Atomgewicht geordnet, so erhält man folgende Zusammenstellung, aus der sich einige allgemeinere Folgerungen ableiten lassen.

			Ti — 50	Zr — 90	? — 180
			V — 51	Nb — 94	Ta — 182
			Cr — 52	Mo — 96	W — 186
			Mn — 55	Rh — 104,4	Pt — 197,4
			Fe — 56	Ru — 104,4	Ir — 198
			Ni — Co — 59	Pd — 106,6	Os — 199
H — 1			Cu — 63,4	Ag — 108	Hg — 200
	Be — 9,4	Mg — 24	Zn — 65,2	Cd — 112	
	B — 11	Al — 27,4	? — 68	Ur — 116	Au — 197?
	C — 12	Si — 28	? — 70	Sn — 118	
	N — 14	P — 31	As — 75	Sb — 122	Bi — 210?
	O — 16	S — 32	Se — 79,4	Te — 128?	
	F — 19	Cl — 35,5	Br — 80	J — 127	
Li — 7	Na — 23	K — 39	Rb — 85,4	Cs — 133	Tl — 204
		Ca — 40	Sr — 87,6	Ba — 137	Pb — 207
		? — 45	Ce — 92		
		?Er — 56	La — 94		
		?Yt — 60	Di — 95		
		?In — 75,6	Th — 118?		

D. Mendelejeff, Z. Chemie 12 (1869) 405


S. Hofmann
RIKEN
GSI
Dubna
120
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109 Mt
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107 Bh
106 Sg
105 Db
104 Rf
103 Lr
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98 Cf
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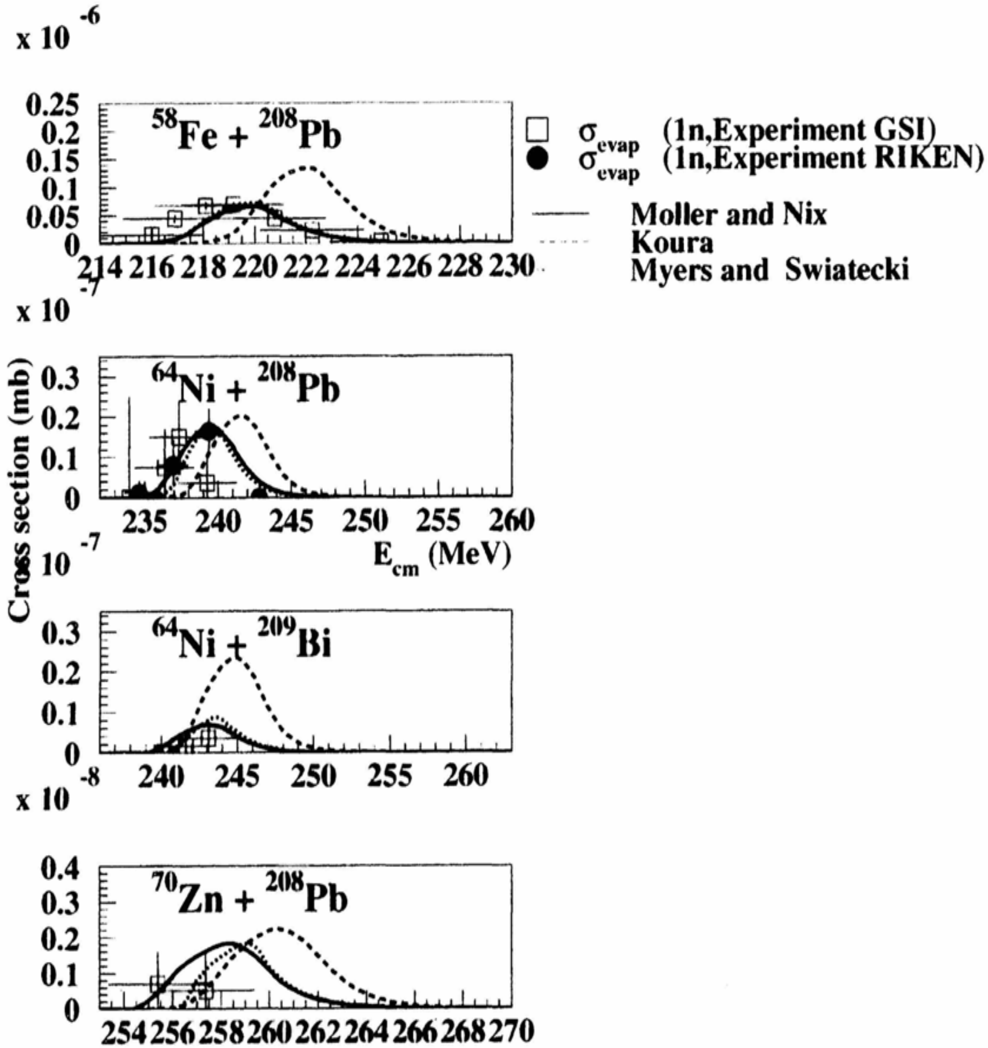


Figure 7. Comparisons of the theory and the experiments are made on the excitation funcions of $1n$ residue cross section for the systems of the cold fusion path.

B. Bouriquet, G. Kosenko and Y. Abe, Eur. Phys. J. A22(2004)9.

Fission-like Phenomena

- Fission
- Quasi-Fission

  Traditional and Dubna's definition
- Pre-equilibrium Fission
- Fast-Fission
- Deep-Inelastic Collisions
- New reaction processes ?

Quasi - Fission

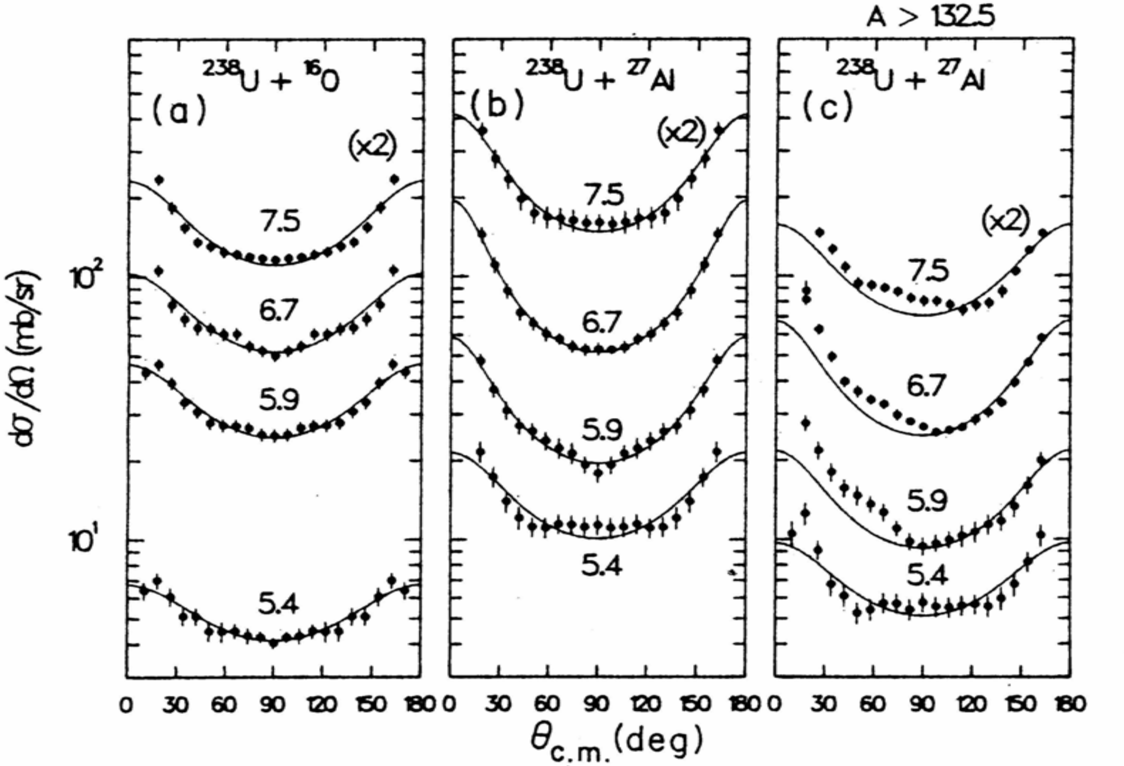


FIG. 10. Angular distribution of fission-like products are ıown as solid points for the $^{238}U+^{16}O$ and $^{238}U+^{27}Al$ reactions . panels (a) and (b), respectively. Solid curves represent best fits ı the data using Eq. (3). In panel (c) the angular distribution of ssion-like products with masses $A > 132.5$ u are shown. The ılid curves represent the best fits to the backward part, $\theta > 90°$, ꞉ the angular distributions.

W.Q. Shen et al., Phys. Rev. C36 (1987)115

K – distribution deduced

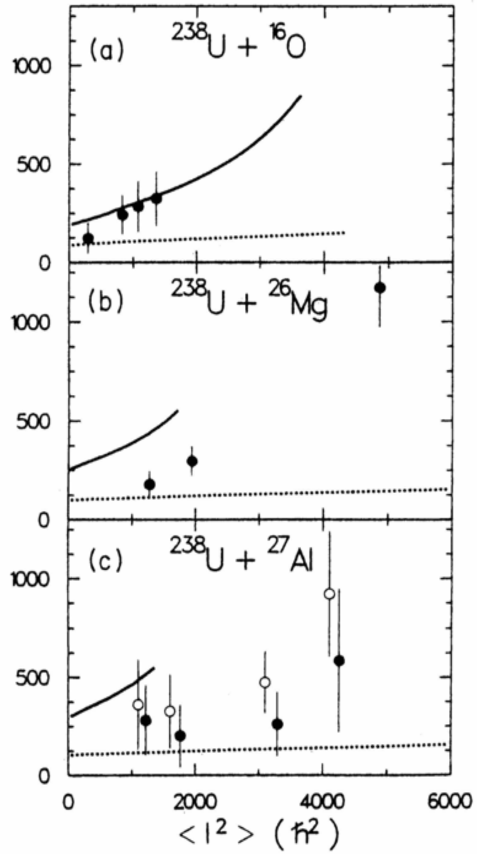


FIG. 11. The variances of the K distributions are shown (solid points) as a function of the mean square spin of the fissioning system for the reactions $^{238}U+^{16}O$, $^{238}U+^{26}Mg$, and $^{238}U+^{27}Al$ in panels (a), (b), and (c), respectively. The solid curves represent the predictions of the saddle point model based on the saddle shapes given by the rotating liquid drop model

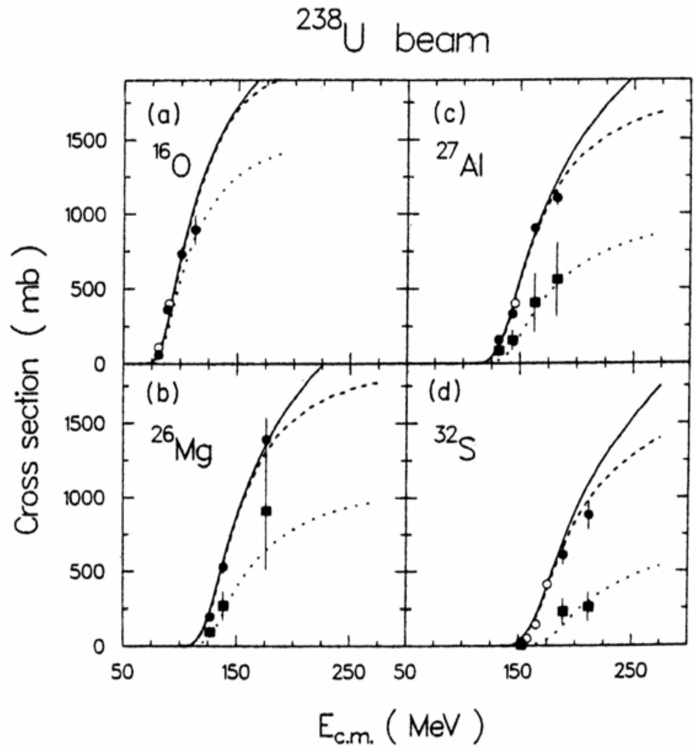


FIG. 12. Cross sections for fission-like processes are shown as solid circles for the reactions $^{238}U+^{16}O$, ^{26}Mg, ^{27}Al, and ^{32}S as a function of the center-of-mass energy $E_{c.m.}$ in panels (a), (b), (c), and (d), respectively. Open circles are taken from Refs. 13 and 55. The solid squares represent the cross section for complete fusion followed by fission. The solid, dashed, and dotted lines represent theoretical predictions of the cross section for touching, capture, and complete fusion processes, respectively.

Fast – Fission

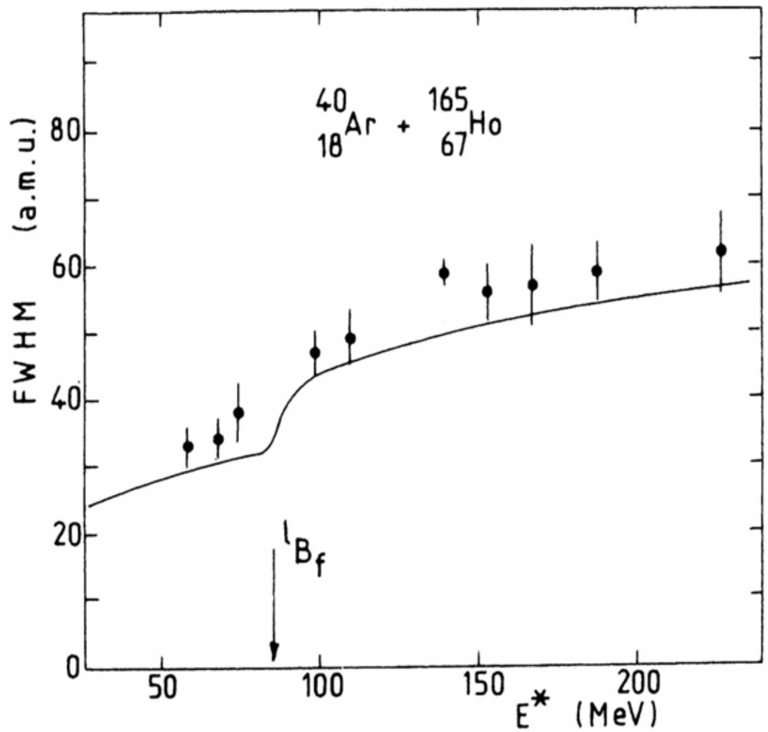


Fig. 11. Evolution of the FWHM of the symmetric fragmentation mass distribution as a function of the excitation energy. The dots are experimental data of ref. [2]). The full curve corresponds to our dynamical calculations.

C. Gregoire, C. Ngo and B. Remaud, Nucl. Phys. A383(1982) 392.

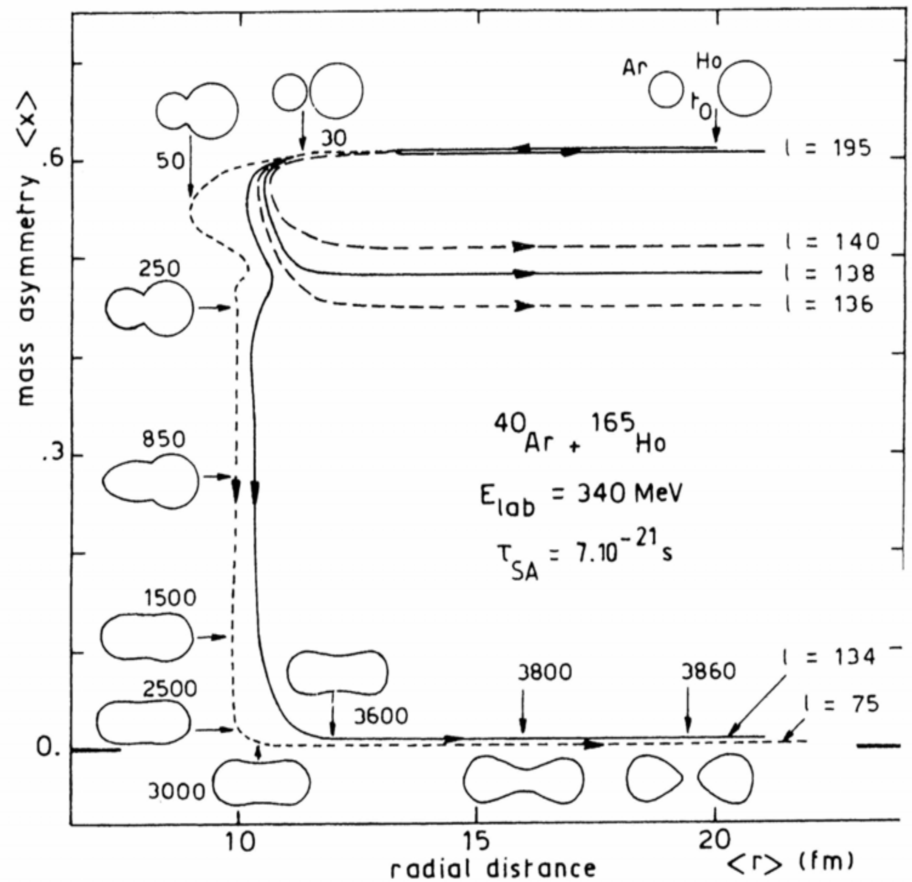


Fig. 7. Typical classical trajectories in the ($\langle r \rangle$, $\langle x \rangle$) plane for the 340 MeV $^{40}Ar + ^{165}Ho$ system. They result from calculations with a long reorganization time $\tau_{SA} = 7 \times 10^{-21}$ s (see text). Depending on the angular momentum value l, three kinds of mechanisms are distinctly displayed: (i) quasi-elastic process for $l = 195$, (ii) deep inelastic collision for $l > 136$ and (iii) fast fission for $72 < l < 136$ (72 in the limit of stability for the ^{205}At nucleus). For the $l = 75$ trajectory, the corresponding sequence of shapes is sketched with the time scale expressed in units of 10^{-23} s.

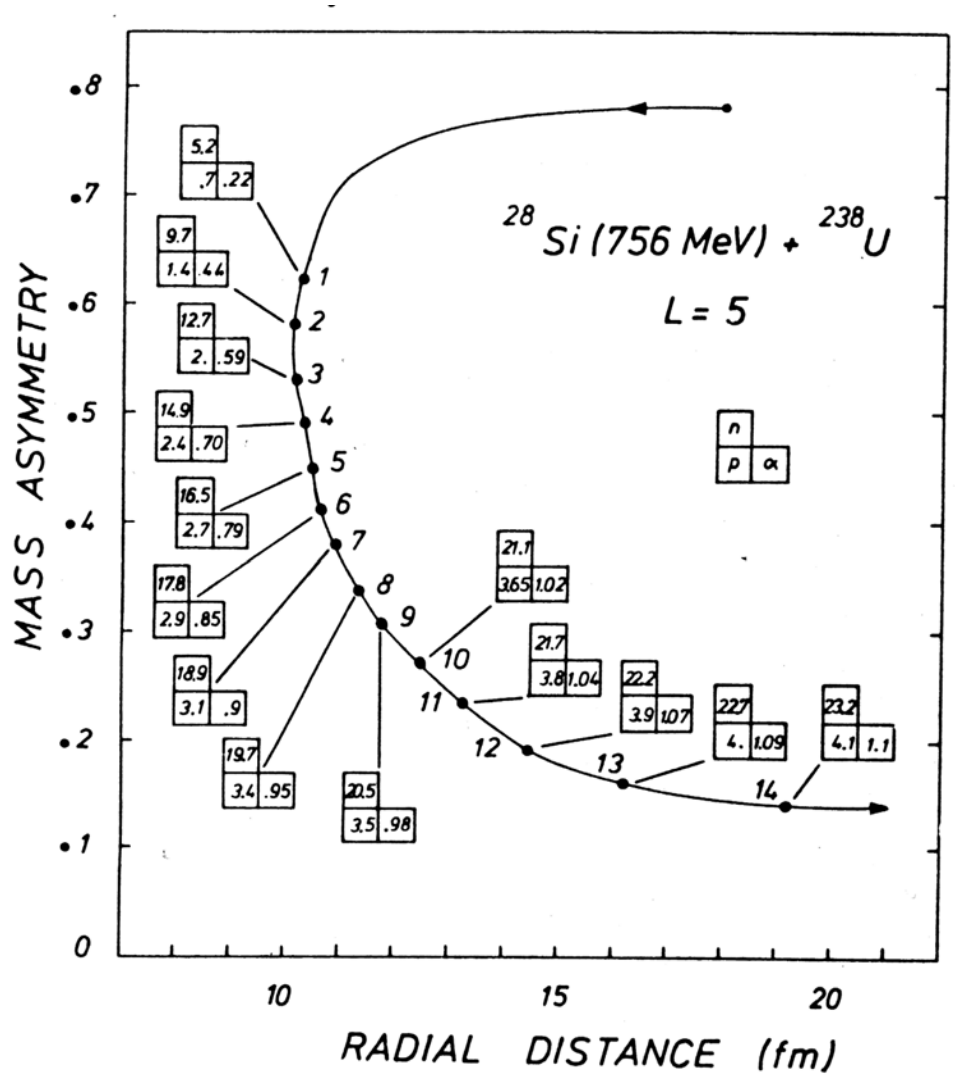
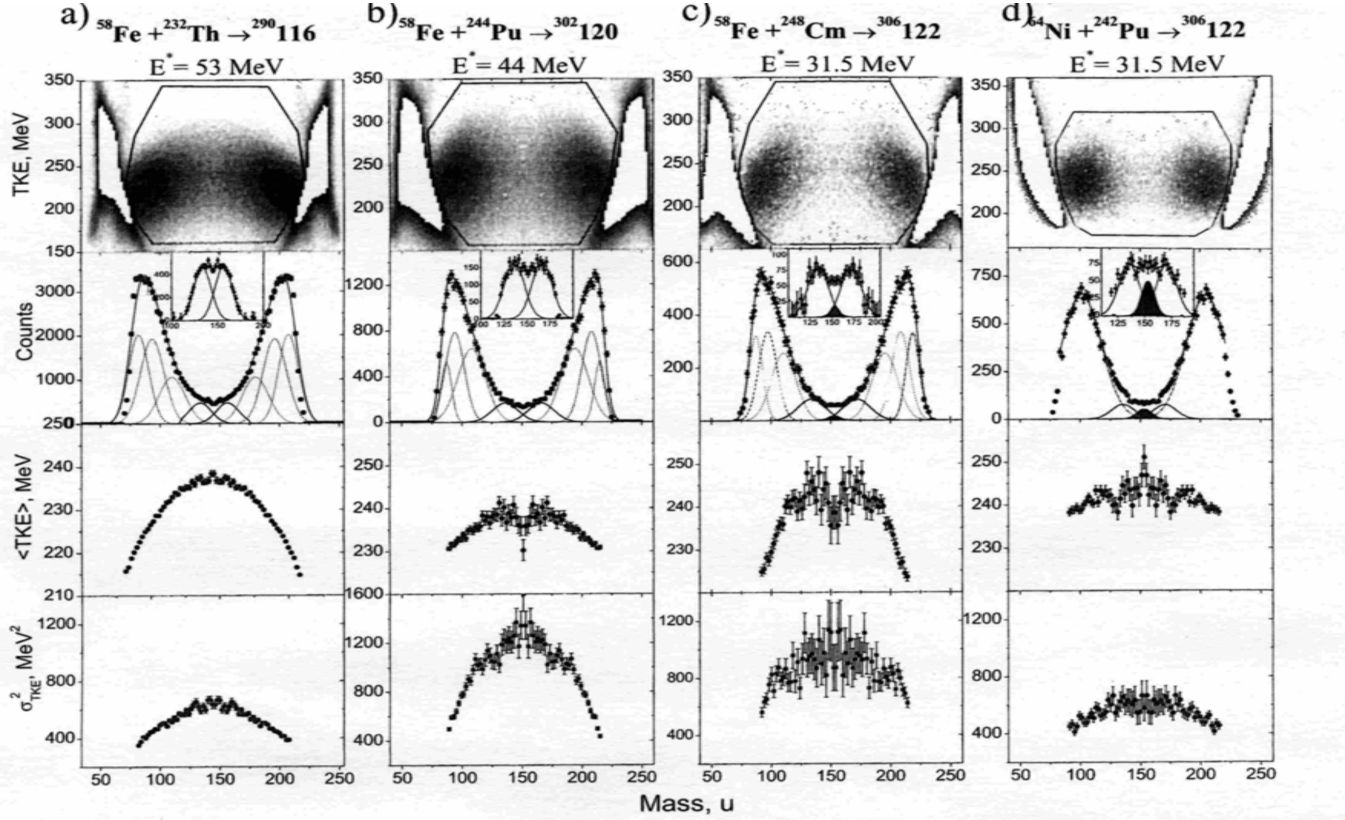


Figure 3 : Fast-fission trajectory in a radial distance-mass asymmetry map for the ^{28}Si (27MeV/u) + ^{238}U system at l = 5. At each 10^{-21}s, the mean numbers of evaporated neutron, proton and alpha particles are indicated, up to the reseparation.

H. Delagrange, C. Gregoire, Y. Abe and N. Carjan, J. Physique C4, 47(1986)305

Dubna's Quasi – Fission,
Quasi – Fission or DIC?



ure 10. Two-dimensional TKE-Mass matrices, the mass yields, average TKE and the riances σ^2_{TKE} as a function of the fission fragment mass for ^{290}116, ^{302}120, ^{306}122, produced the reactions with ^{58}Fe and ^{64}Ni projectiles.

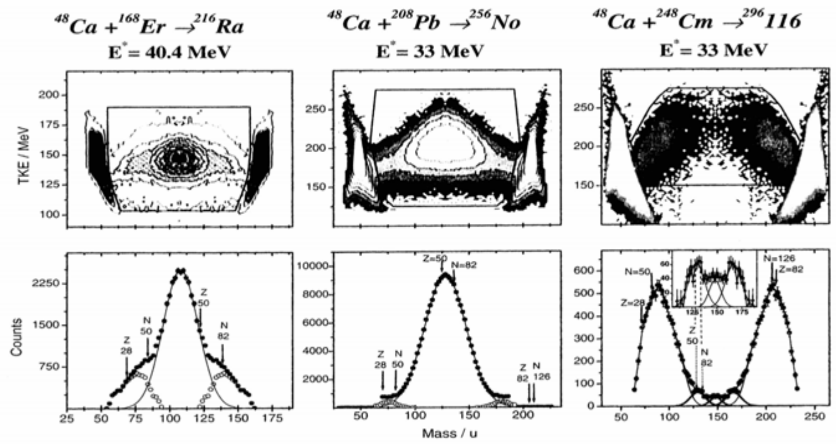


Figure 8. Two-dimensional matrices TKE-Mass (top panels) and mass yields (bottom panels) of fission fragments of ^{216}Ra, ^{256}No, ^{296}116 nuclei produced in the reactions with ^{48}Ca.

classical fission and quasi-fission "shoulders".

Angular distributions for different fragment masses were measured in order to find experimental evidence of the quasi-fission nature of the "shoulders". Fig. 2 shows the angular distributions for the symmetrical mass range ($M = A/2 \pm 10$, solid circles) and for the "shoulders" ($M = 78 \pm 10$, open circles). The solid curve shows the results of calculations made in the framework of the Transition State Model [10]. As one can see from Fig. 2, the solid line fits well into the data for the symmetrical part of mass distribution, whereas the angular distribution for the "shoulders" has a pronounced forward-backward asymmetry, which is one of

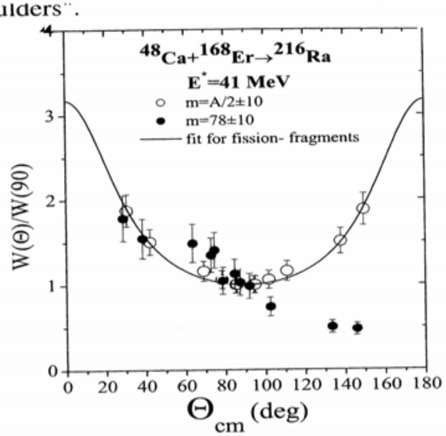


Figure 2. Experimental angular distribu-

M.G. Itkis, NATO Science Series II-166(2004)423.

新しい研究領域の存在

色々な “Fission-like”な過程が観測され、理論的解析も個別に行われているが、

“　複合原子核系の動力学　”

(Dynamics of Compound Nuclear Systems)

とでも称すべき新しい分野、領域を研究していると捉えてそれを特徴付ける包括的概念、方法を確立することがこれからの課題であろう。現在の超重元素合成の理論もその中で、意味づけられるであろう。

まず、検討すべき点としては、

1. 入射過程の動力学（Heat-up 過程）
2. 種々の自由度の熱平衡化過程と集団自由度
3. 色々な形状に対する液滴模型

等が考えられる。

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S. Yamaji et al.	Two-Center code

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