AVERAGE DESCRIPTION OF DIPOLE GAMMA-TRANSITIONS IN ATOMIC NUCLEI

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1. Description of gamma-transitions by radiative (gamma-ray) strength functions

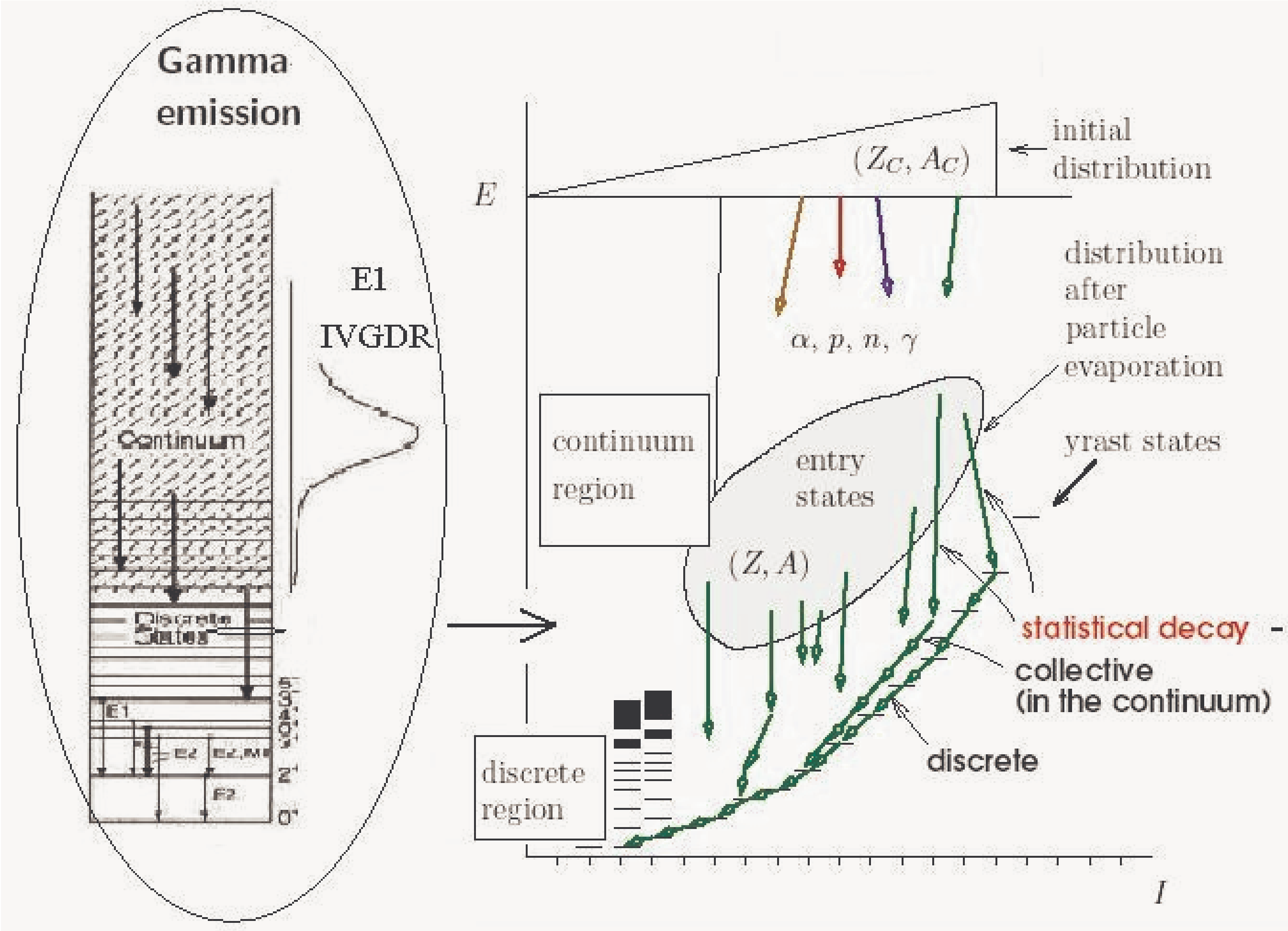
2.Closed-form models

3. Renewed data base of the GDR parameters

4. Calculations and comparisons with experimental data. Role of folding procedure in microscopic calculations of RSF

5. Conclusions

Peculiarities of gamma-transitions between different states



Radiative (photon) strength functions (RSF)

Gamma-decay strength functions

C-D gamma-transitions

$$\overleftarrow{f}_{E\lambda} = \frac{\left\langle \Gamma_{i \to f} \right\rangle_i}{E_\gamma^{2\lambda+1} D_i}$$

← average partial gamma-decay width (numerator)

← average level spacing (D_i)

C-C gamma-transitions (E1 example)

$$\overleftarrow{f}_{E1}\left(E_\gamma\right) = E_\gamma^{-3} \frac{d\Gamma_{E1}\left(E_\gamma\right)}{dE_\gamma} \frac{D_f\left(U_f = U_i - E_\gamma\right)}{3D_i\left(U_i\right)}, \quad D = 1/\rho$$

γ-ray transmission coeff.

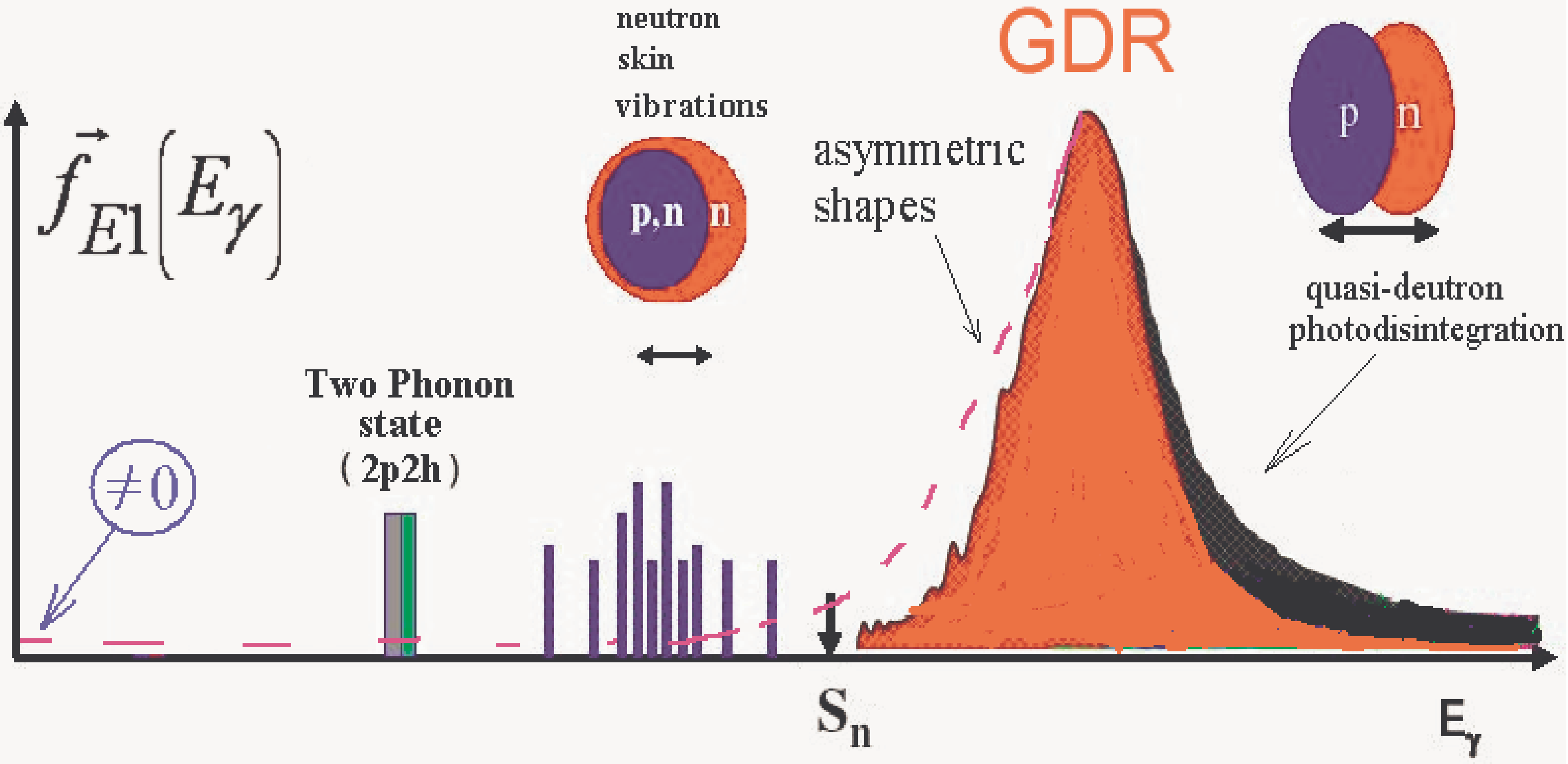
$$T_{E1}(\varepsilon_\gamma) \sim 2\pi\varepsilon_\gamma^3 \overleftarrow{f}_{E1}(\varepsilon_\gamma)$$

Photoexcitation strength functions (E1)

$$\vec{f}_{E1} = \frac{\sigma_{E1}}{3E_\gamma (\pi \hbar c)^2}$$

← photoabsorption cross-section

Many-body states determining γ-transitions

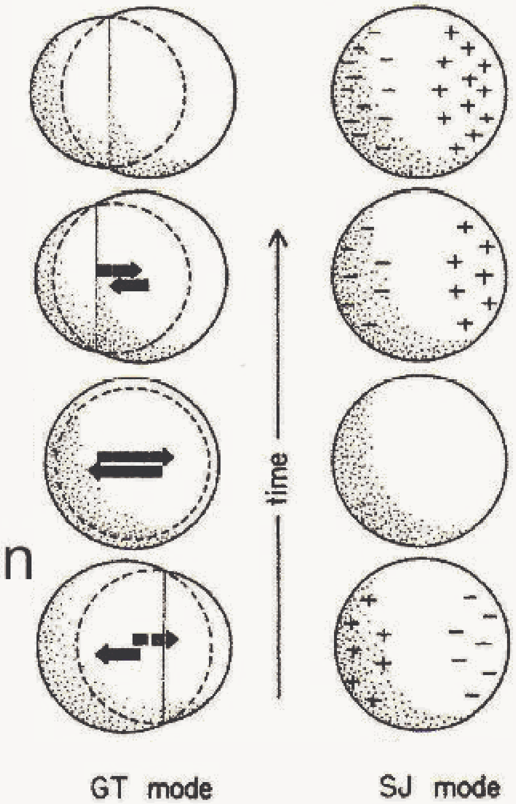


- Giant Dipole Resonance: E_γ ~ 12 -:- 20 MeV, ~ 100 % of IVEWSR
- Pygmy Dipole Resonance: $E_\gamma \sim S_n$
- Two Phonon Excitation: E_γ ~ 4 MeV

CLOSED-FORM E1 RSF

BASED ON SIMPLEST MODELS OF GDR EXCITATION

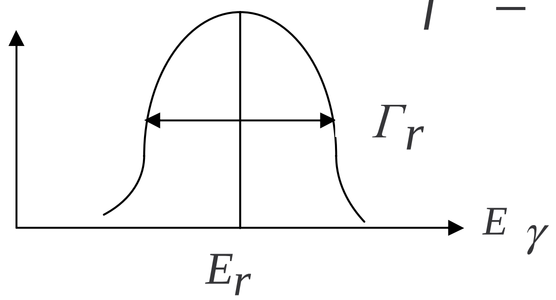
- M.Goldhaber & E.Teller (1948) Left
- M.Goldhaber & E.Teller (1948)
  H.Steinwedel & J.H.D.Jensen (1950) Right



$E_{GT} \sim \sqrt{\frac{1}{R}} \sim A^{-1/6}$ $\quad E_{SJ} \sim \frac{1}{R} \sim A^{-1/3}$

Standard Lorentzian (SLO)

[Brink& Axel]



$$\overleftarrow{f} = \overrightarrow{f} \sim \frac{E_\gamma \Gamma_r^2}{(E_\gamma^2 - E_r^2)^2 + E_\gamma \Gamma_r^2} \Rightarrow 0$$

$$E_\gamma \to 0$$

$$\Gamma_r = const \neq \varphi(E_\gamma) \sim 5 MeV \ (T = 0)$$

Enhanced Generalized Lorentzian (EGLO)

[Kopecky&Uhl]

$$\overleftarrow{f} = \frac{E_\gamma \Gamma(E_\gamma, T_f)}{(E_\gamma^2 - E_r^2)^2 + E_\gamma^2 \Gamma_\gamma^2 (E_\gamma, T_f)} + \frac{0.7 \Gamma(E_\gamma = 0, T_i)}{E_r^3}$$

$$\overleftarrow{f} \Rightarrow const \neq 0 \ [E_\gamma \to 0]$$

$$T_f = \sqrt{\frac{U - E_\gamma}{a}};$$

Infinite fermi- liquid (two-body dissipation)

$$\Gamma(E_\gamma, T_f) = \Gamma_r \frac{E_\gamma^2 + 4\pi T_f^2}{E_\gamma^2} \cdot K(E_\gamma)$$

$K(E_\gamma) \to$ empirical factor from fitting exp. data

Generalized Fermi liquid (GFL) model

(extended to GDR energies of gamma- rays)

[Mughabghab&Dunford]

$$\vec{f} = \overleftarrow{f} = 8.674 \cdot 10^{-8} \cdot \sigma_r \Gamma_r \frac{K_{GFL} \cdot E_r \Gamma_m}{\left(E_\gamma^2 - E_r^2\right) + K_{GFL}\left[\Gamma_m E_\gamma\right]^2}$$

$$\Gamma_m = \Gamma_{coll}\left(E_\gamma, T_f\right) + \Gamma_{dq}\left(E_\gamma\right)$$

$$\Gamma_{coll} \equiv C_{coll}\left(E_\gamma^2 + 4\pi^2 T_f^2\right) \qquad K_{GFL} = 0.63$$

”Fragmentation” component

$$\Gamma_{dq}\left(E_\gamma\right) = C_{dq} E_\gamma \left|\overline{\beta}_2\right| \sqrt{1 + \frac{E_2^+}{E_\gamma}}$$

Extension of expression for GDR damping via coupling with surface vibrations (J.Le Tournie, 1964,1965)

Thriaxial Standard Lorentzian (TSLO)
[Dresden-Rossendorf approach]

$$\overleftarrow{f} = \overrightarrow{f} = f$$

$$f_{E1}\left(E_\gamma\right) = const \sum_{j=1}^{3} s_{r,j} \Gamma_{r,j} \frac{E_\gamma \Gamma_j}{\left(E_\gamma^2 - E_{r,j}^2\right)^2 + \left[\Gamma_j \cdot E_\gamma\right]^2}$$

$s_{r,j}$ => fixed by TRK sum rule

$\mathrm{E}_{r,i} = \mathrm{E}_{r,0} \Phi_i(\beta,\gamma)$ – SJ model

$\Gamma_{r,j} = \Gamma_{r,0}(R_0 / R_i)^{1.6}$ => Bush&Alhassid

$\Gamma_{r,j} = \Gamma_{r,0}(\mathrm{E}_{r,i} / \mathrm{E}_0)^{1.6}$ => GT model + R_i = const / $\mathrm{E}_{r,i}$ (SJ model)

Weak points of the approximations with energy dependent width

$$\overleftarrow{f}_{E\lambda}^{\text{models}} = F\left\{ \overleftarrow{f}_{E\lambda}^{KMF}(E\gamma \to 0),\ \overleftarrow{f}_{E\lambda}^{SLO}(Er) \right\}$$

$$\Gamma\left(E_r, T\right) \;=>\; \Gamma\left(E_\gamma, T_f\right) \text{ ???}$$

Inconsistence of RSF shape with general relation between gamma-decay RSF of heated nuclei and nuclear response function on electromagnetic field

Modified Lorentzian approach(MLO)

(based on expression for gamma-width averaged on microcanonical ensemble of initial states)

$$\overline{\Gamma}(J_i, E_\gamma) = \sum_{\substack{\nu_f, J_f \\ \Delta Z, \Delta N, M_i, \Delta \nu_i}} \frac{d\Gamma_{if}}{dE_\gamma} / N_{Ji}$$

$$N_{Ji} = \rho(E, N, Z, J_i)(2J_i + 1)\Delta E \Delta Z \Delta N$$

$$\Downarrow$$

microcanonical ensemble

$$\Downarrow$$

most appropriate for closed systems like nuclei

General expression for gamma-decay RSF

Transformations by Green-function method with the use of saddle point approximation lead to

$$\overleftarrow{f}\left(E_\gamma, T_f\right) = 8.674\cdot 10^{-8}\frac{1}{1-\exp\left(-E_\gamma/T_f\right)}s\left(\omega = \frac{E_\gamma}{\hbar}, T_f\right),\ \ \mathrm{MeV}^{-3}$$

$$s\left(\omega, T_f\right) = -\frac{1}{\pi}\chi''\left(\omega, T_f\right)$$

Peculiarity – presence of low-energy enhancement factor

$$N_{1p1h} \equiv \frac{1}{\hbar\omega}\int d\varepsilon_1 d\varepsilon_2 f_0\left(\varepsilon_1\right)\left(1-f_0\left(\varepsilon_2\right)\right)\delta\left(\varepsilon_1-\varepsilon_2+\hbar\omega\right) = \frac{1}{1-\exp\left(-E_\gamma/T_f\right)} = \left(E_\gamma \to 0\right) = \frac{T_i}{E_\gamma} \gg 1$$

Zero-energy limit

$$\overleftarrow{f}_{E1}(E_\gamma = 0, T_f = T_i) \sim \cdot T_i \cdot \Phi''_{E1}(\omega -> +0),\qquad \Phi''_{X\lambda}(\omega) \equiv \chi''_{X\lambda}(\omega)/\omega$$

Photoexcitation strength functions (E1)

(Alhassid&al. for cold nuclei)

$$\overleftarrow{f}_{E1}\left(E_\gamma, T_i = 0\right) = -\frac{1}{\pi} 8.674 \cdot 10^{-8} \chi''\left(\omega = \frac{E_\gamma}{\hbar}, T_i = 0\right), \quad \mathrm{MeV}^{-3}$$

Heated nuclei

$$\vec{f}_{E\lambda} = \vec{\Phi}\left(E_\gamma, T_i\right), \qquad \overleftarrow{f}_{E\lambda} = \overleftarrow{\Phi}(E_\gamma, T_f)$$

$T_i,\ T_f = \varphi(T_i, E_\gamma)$ - **the temperatures of initial and final states**

Response function within semiclassical Landau-Vlasov approach is used in approximation of one strong collective state

(spherical nuclei)

$$\operatorname{Im}\chi\left(\omega,T_f\right)\propto\frac{E_\gamma\Gamma\left(E_\gamma,T_f\right)}{\left(E_\gamma^2-E_r^2\right)^2+\left[\Gamma\left(E_\gamma,T_f\right)E_\gamma\right]^2}$$

$\Gamma\left(E_\gamma=\hbar\omega,T\right)$ **- parameter of line spreading ("energy-dependent width")**

$$\Gamma(E_\gamma=E_r,T=0)=\Gamma_r$$

METHOD OF INDEPENDENT SOURCES OF LINE SPREADING

$$\Gamma\left(E_\gamma=\hbar\omega,T\right)=\Gamma_{coll}\left(E_\gamma=\hbar\omega,T\right)+\Gamma_{frag}$$

Collisional energy-dependent component (spreading width)

$$\Gamma_{coll}\left(E_\gamma=\hbar\omega,T\right)=\sum_{j\geq 1} a_j E_\gamma^j + b\,g(T) \;\; \text{=> GDR ->2p2h}$$

Energy dependence resulted from frequency dependence of the energy conservation law in external field due to possibility of energy exchange between the particles and field

$$\delta\left(\Delta\varepsilon\equiv\varepsilon_1+\varepsilon_2-\varepsilon_3-\varepsilon_4\right) \;\; \text{=>} \;\; \delta\left(\Delta\varepsilon\pm\hbar\omega\right)$$

Fragmentation (“ almost energy-independent”) component

Γ_{frag} => GDR ->1p1h(wall formala)+β-vibrations

Line shape parameter within MLO4

$$\Gamma_{r,j} = a_1 \cdot E_\gamma + a_2 \cdot |\beta_E| \cdot E_{r,j} \cdot r_j$$

$$r_j = \begin{cases} 1, & sph.nuclei \\ \left(R_0 / R_j\right)^{1.6}, & def.nuclei(Bush \,\&\, Alhassid) \end{cases}$$

L. Esser, U. Neuneyer, R. F. Casten, P. von Brentano

$$|\beta_E| = \sqrt{1224 A^{-7/3} / E_{2_1^+}}$$

$E_{2_1^+}$ **from experimental data-base (RIPL) or systematic by Hilaire&Goriely**

$$E_{2_1^+} = 65 A^{-5/6} / (1 + 0.05 E_{shell})$$

DEFORMATION SPLITTING

$$f_{E1} = \sum_{j=1}^{n} f_{sph}\left(E_\gamma; \sigma_{r,j}; \Gamma_{r,j}; \mathrm{E}_{r,i}\right)$$

Approximation of axially- deformed nuclei (n=2)
(EMPIRE-code)

SLO, EGLO, GFL, MLO1-3, SMLO

$$\sigma_{r,j}; \Gamma_{r,j}; \mathrm{E}_{r,i} => \Phi(\beta_{2,eff}(g.s.) = \varphi(\mathrm{Q}_2[\{\beta_j(g.s.)\}])$$

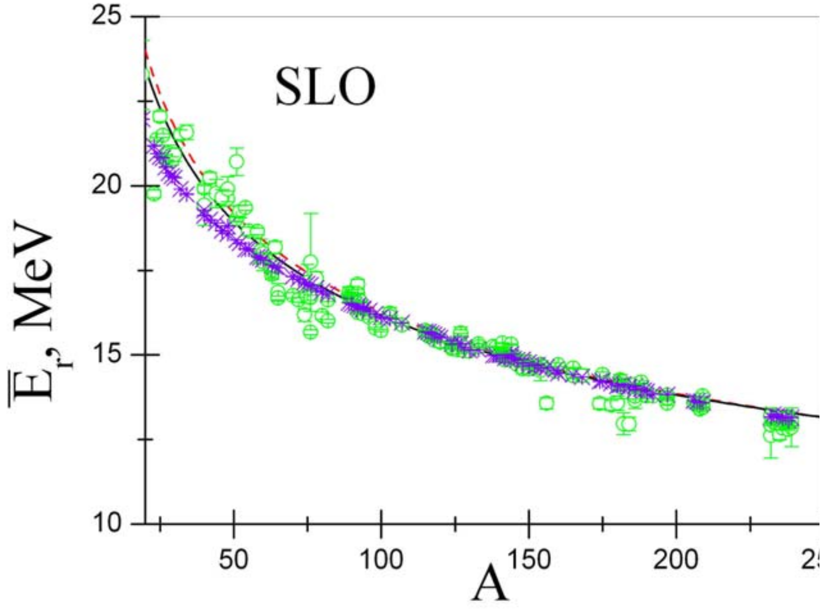
MLO4

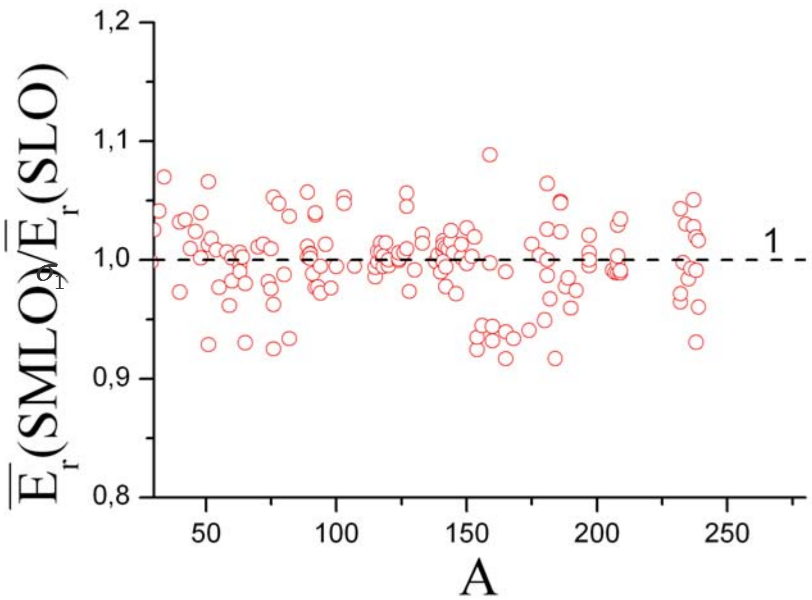
$$\sigma_{r,j}; \Gamma_{r,j}; \mathrm{E}_{r,i} => \bar{\Phi}(\beta_E = \varphi(E_{2_1}))$$

GDR parameters with uncertainties from renewed database

GDR energies

$$\bar{E}_r = \frac{E_1\sigma_1 + E_2\sigma_2}{\sigma_1+\sigma_2} = \begin{cases} (E_1+2E_2)/3; & \beta_2>0\ (\sigma_2=2\sigma_1) \\ (2E_1+E_2)/3; & \beta_2<0\ (\sigma_2=\sigma_1/2) \end{cases}$$





Systematic for renewed data : —— $\bar{E}_r = 31.2/A^{1/3} + 20.6/A^{1/6}\ (MeV)$

X – $\bar{E}_r = 4.755(1+108.0I^2)/A^{1/3} + 32.788(1-7.5899I^2)/A^{1/6}\ (MeV); I=(N-Z)/A$

- - - - S.S. Dietrich, B.L. Berman(1988), $\bar{E}_r = 27.47/A^{1/3} + 22.06/A^{1/6}\ (MeV)$

O – new values

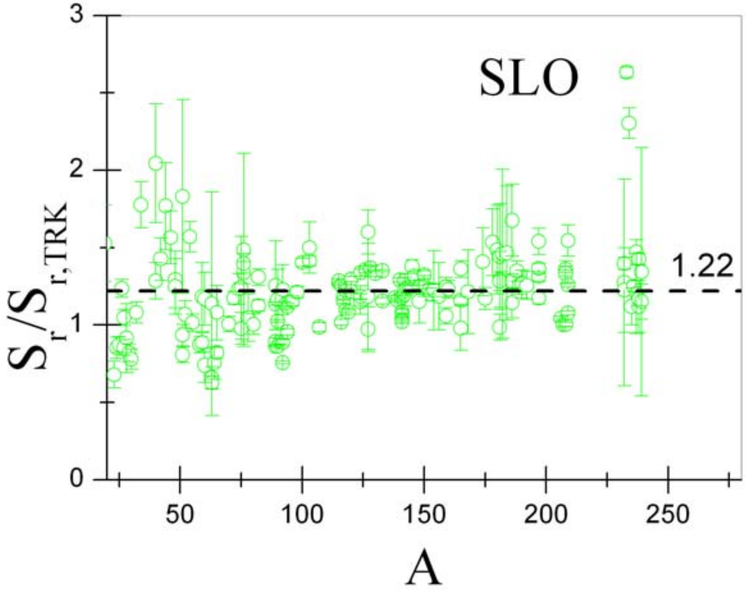
Volume(J) and surface(Q) coefficients of the symmetry energy

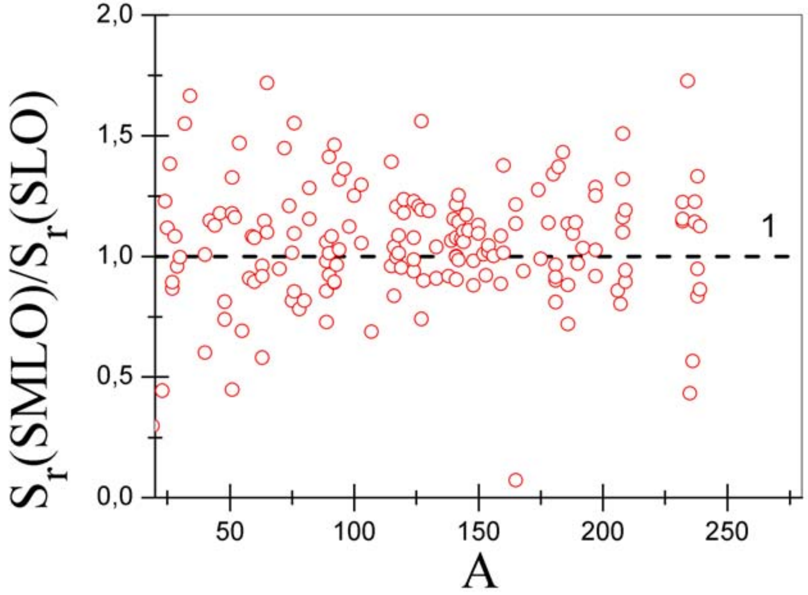
$$E_{sym} = \frac{I^2}{2} b_v / (1 + \frac{b_v}{b_s} A^{-1/3}),\ I = \frac{N-Z}{A},\ b_v = 2J,\ \frac{b_s}{b_v} = \frac{9J}{4Q}$$

$$\overline{E}_r \equiv \sqrt{\frac{m_1}{m_{-1}}} = a_1 A^{-1/3} / \sqrt{1 + a_2 A^{-1/3}},\quad a_1 = c \cdot J;\ a_2 = d \cdot J/Q$$

J, J/Q	***Myers et al.*** **(c=3)**	***Lipparini et al.*** **(c=15/4)**
Used previously	36.8, 2.18	32.5, 1.00
Sph. + axial def. nuclei (MLO)	34.0, 2.03	38.8, 1.6

Energy weighted sum rule
for isovector E1 transitions





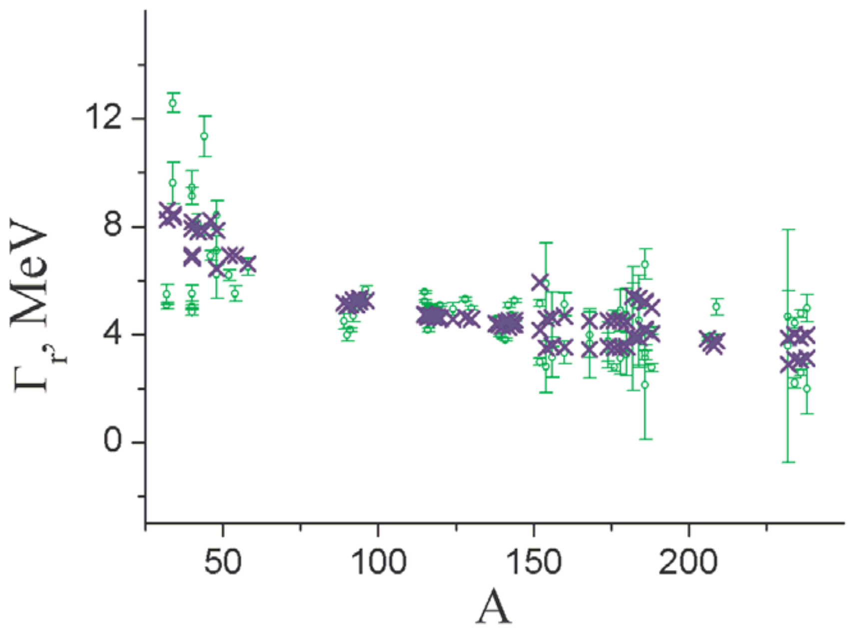
$$S_{EWSR} \equiv m_1 = \text{const} \cdot S_r, \quad S_r = \int_0^{\infty} \sigma(E_\gamma) dE_\gamma, \quad S_r(\text{SLO}) = \pi/2 \sum_{j=1}^{n} \sigma_{r,j} \Gamma_{r,j}$$

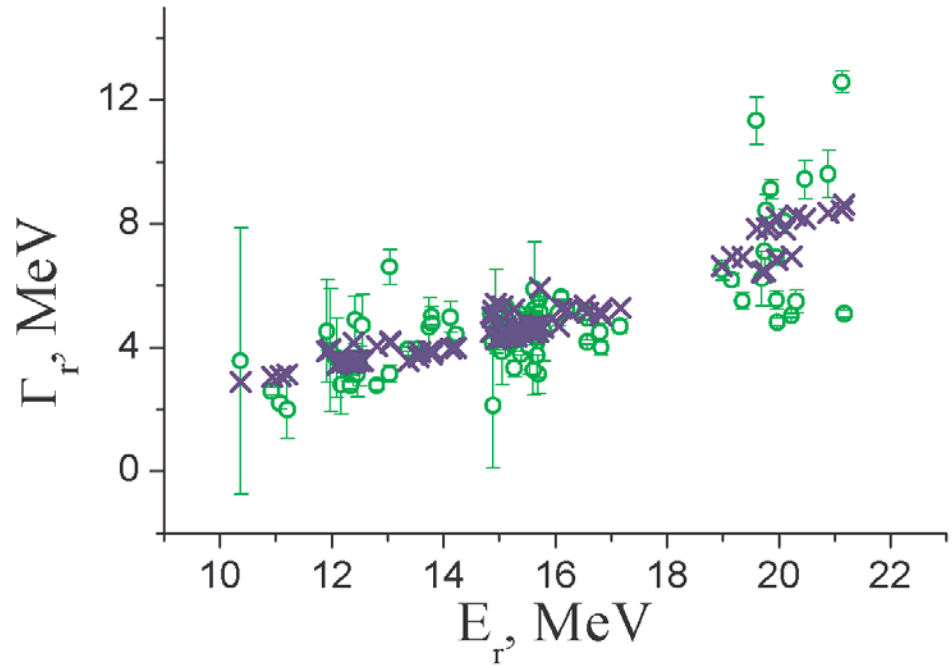
$$S_r(\text{SMLO}) = \int_0^{50\,MeV} \sigma(E_\gamma) dE_\gamma \qquad S_r(\text{TRK}) = 60 \cdot NZ/A \ (\text{mb} \cdot \text{MeV})$$

Mean value of enhancement factor to TRK sum rule ~ 1.22 and is not contradictory to Gell-Mann- Goldberger-Thirring (GGT) sum rule (Eisenberg&Greiner)

GDR widths

for spherical and axially deformed nuclei





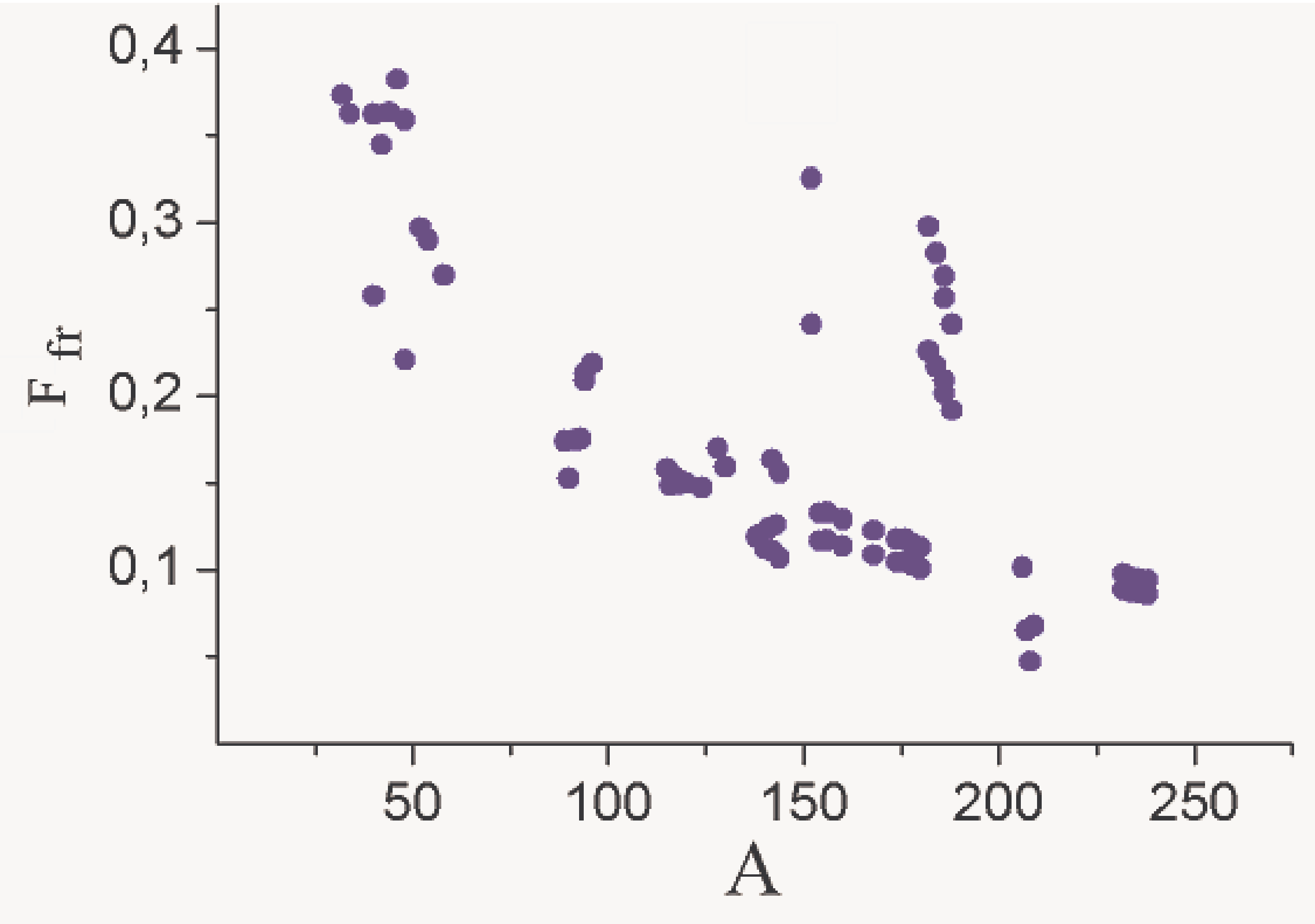
Curves: **x** - $\Gamma_{r,j} = 0.255 \cdot E_{r,j} + 12.94 \cdot |\beta_E| \cdot E_{r,j} \cdot r_j$

O – experimental values (extracted by SLO model)

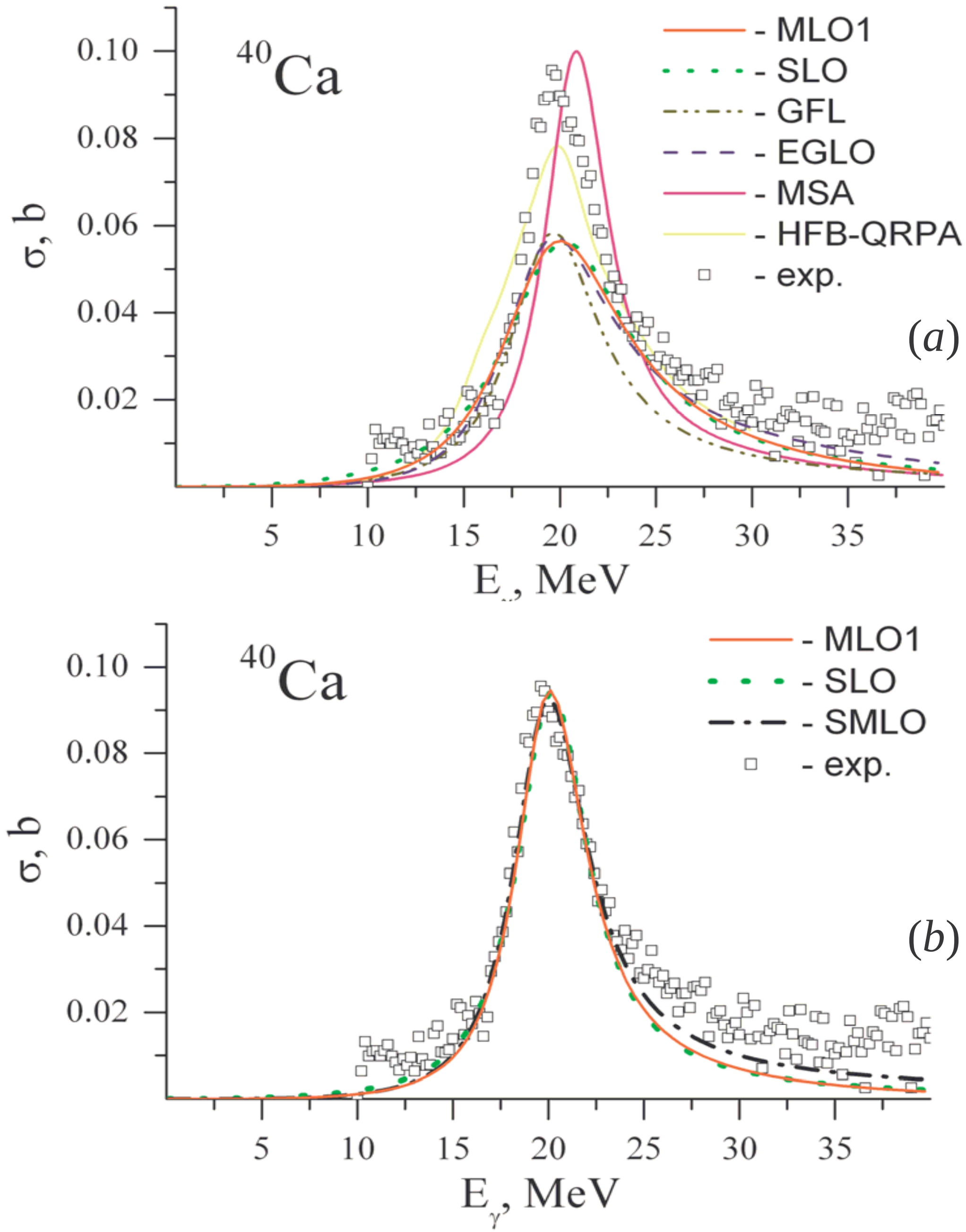
$$\beta_E = \sqrt{1224 A^{-7/3} / E_{2_1^+}} \qquad r_j = 1 (s.n.) \; or \; \left(R_0 / R_j\right)^{1.6} (a-d.n.) (Bush \,\&\, Alhassid)$$

Contribution of the fragmentation component

$$F_{fr} = (\Gamma_{r,j} - \Gamma_{r,j}^{coll}) / \Gamma_{r,j}$$



The photoabsorption cross sections and RSF



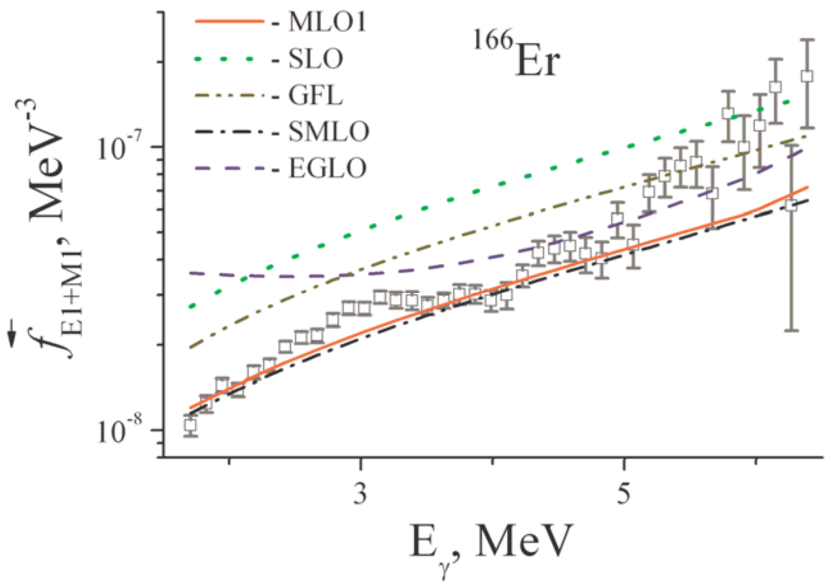
Comparison of the photoabsorption cross section calculated with different database for GDR parameters: (*a*) - old systematics (Berman&Fultz); (*b*) - renewed GDR parameters.

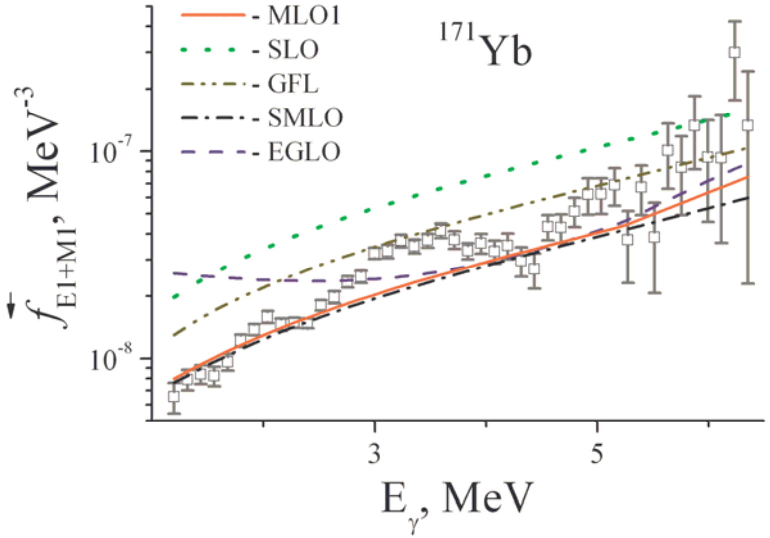
Averaged HFB-QRPA microscopic approach by S. Goriely et al NP A706 (2002) 217; A739 (2004) 331

MSA - semiclassical moving surface method by V.I. Abrosimov, O.I.Davidovskaya Izvestiya RAN. 68 (2004)200; Ukrainian Phys. Jour. 51 (2006)234

Exp.data - V.A. Erokhova et al Izvestiya RAN. Seriya Fiz. **67** (2003) 1479

Comparisons of gamma-decay RSF

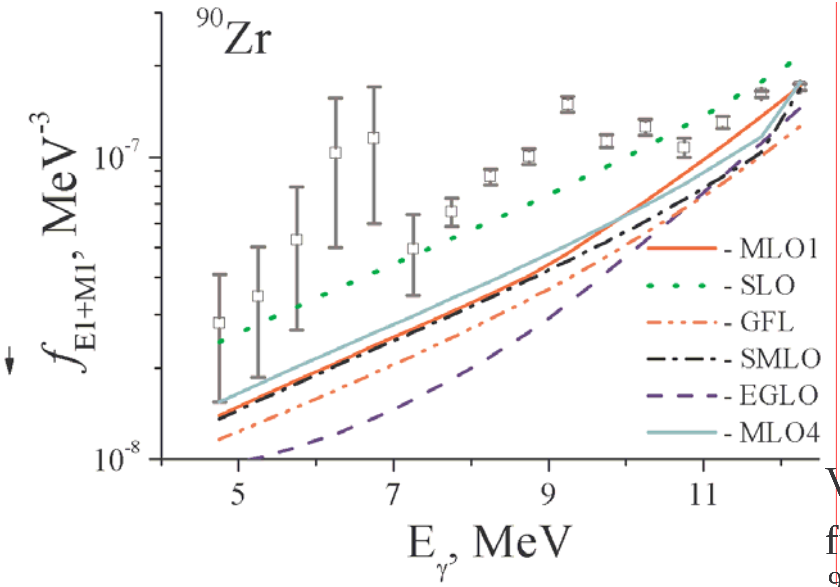




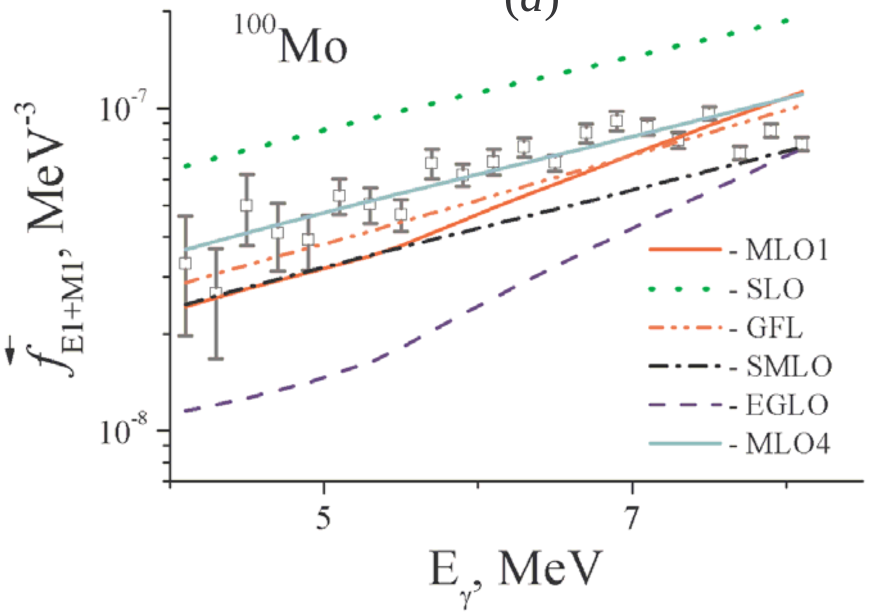
Dipole strength functions of $E1$ and $M1$ gamma-decay for ^{166}Er and ^{171}Yb : $U = S_n$. Experimental data are taken from *E. Melby, M. Guttormsen, J. Rekstad, A. Schiller, and S. Siem* // Phys. Rev. **C63**, 044309 (2001) and *U. Agvaanluvsan, A. Schiller, J. A. Becker, L. A. Bernstein, et al.* // Phys. Rev. **C70**, 054611 (2004)

Values of χ^2 deviation of calculated gamma-decay strength functions from experimental data for nuclei ^{160}Dy, ^{162}Dy, ^{166}Er, ^{171}Yb, ^{172}Yb.

Model	EGLO	SLO	GFL	MLO1	SMLO
^{160}Dy	187.9	159.8	45.8	5.1	5.4
^{162}Dy	74.3	201.6	55.4	5.2	6.3
^{166}Er	119.8	201.1	47.9	3.6	5.0
^{171}Yb	58.6	184.1	31.2	5.6	6.7
^{172}Yb	62.6	292.7	78.3	4.5	5.3
average	100.5	207.9	51.7	4.8	5.7



(*a*)

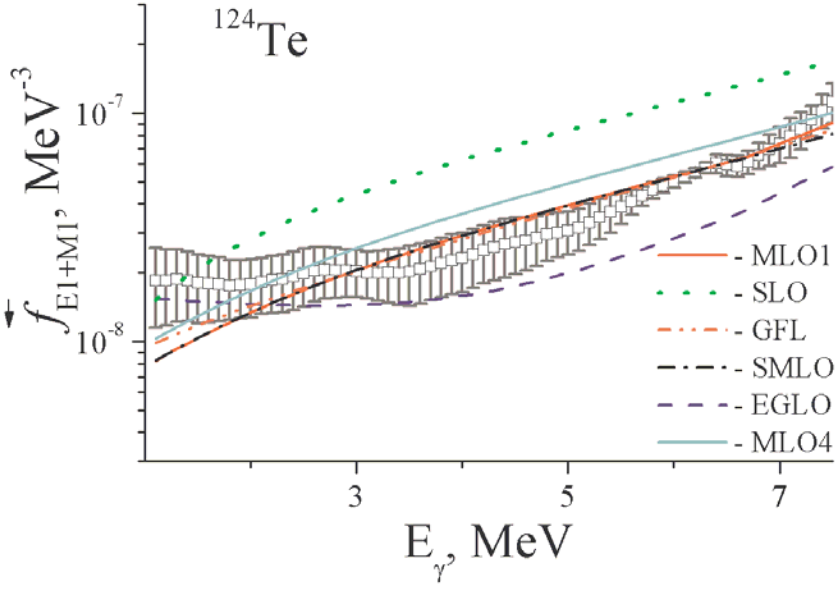


(*b*)

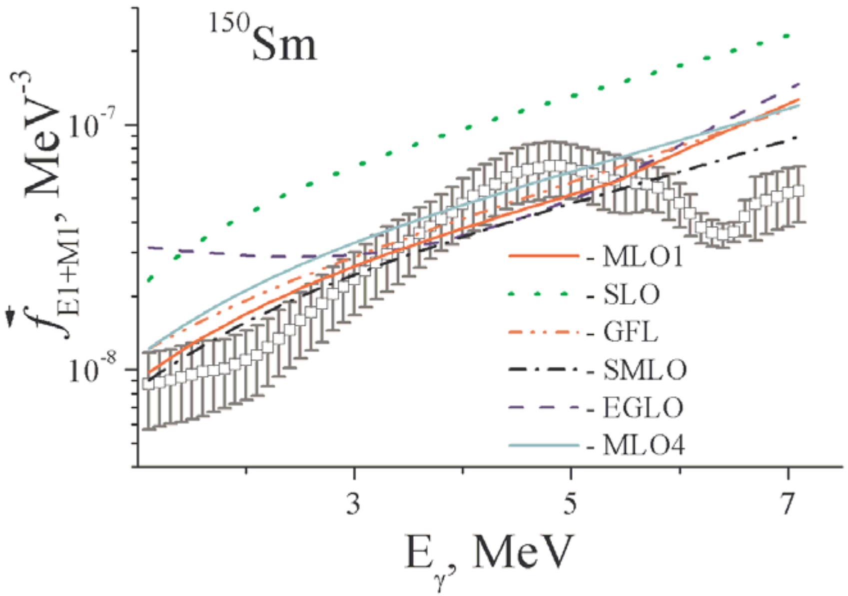
Dipole strength functions of $E1$ and $M1$ gamma-decay for ^{90}Zr (*a*) and ^{100}Mo (*b*): $U = S_n$. Experimental data are taken from *R. Schwengner, et al.* // Phys. Rev. **C78**, 064314 (2008); Phys. Rev. **C81**, 034319 (2010)

Values of χ^2 deviation of calculated gamma-decay strength functions from estimated experimental data for nuclei ^{90}Zr, ^{92}Mo, ^{94}Mo, ^{96}Mo, ^{98}Mo, ^{100}Mo.

Nucleus	EGLO	SLO	GFL	MLO1	MLO4	SMLO
^{90}Zr	69.7	17.9	72.0	36.8	41.6	55.5
^{92}Mo	21.9	3.6	26.5	11.6	13.7	19.4
^{94}Mo	10.2	5.5	5.3	4.2	2.9	5.1
^{96}Mo	11.8	25.5	2.9	3.7	2.4	3.4
^{98}Mo	16.8	10.5	6.4	6.0	4.6	11.5
^{100}Mo	38.3	191.2	7.7	13.5	9.1	15.1
average	28.1	42.4	20.1	12.6	12.4	18.3



(*a*)



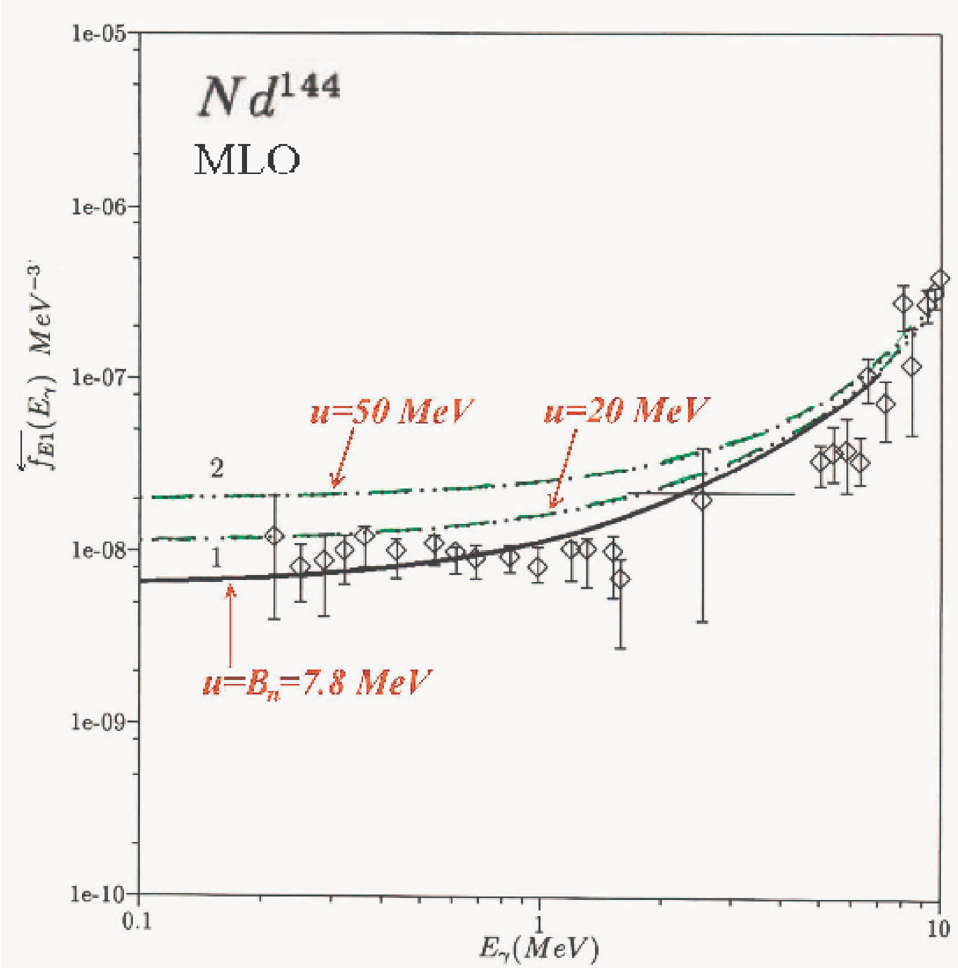
(*b*)

Dipole strength functions of $E1$ and $M1$ gamma-decay for ^{124}Te (a) and ^{150}Sm (b): $U = S_n$. Experimental data are taken from *Vasilieva E.V., Sukhovoj A.M., Khitrov V.A. // Physics of Atomic Nuclei, Vol. 64, No. 2, 2001, p.153–168*

Values of χ^2 deviation of calculated gamma-decay strength functions from experimental data for nuclei ^{118}Sn, ^{138}Ba, ^{150}Sm, ^{168}Er, ^{124}Te.

Nucleus	EGLO	SLO	GFL	MLO1	MLO4	SMLO
^{118}Sn	19.2	8.3	11.9	10.3	8.9	11.2
^{138}Ba	28.1	503.6	77.5	93.9	114.6	80.1
^{150}Sm	30.4	156.2	16.9	16.2	19.4	6.5
^{168}Er	54.9	119.3	41.6	14.0	28.1	6.8
^{124}Te	8.3	73.08	0.58	0.78	5.085	0.82
average	28.2	172.1	29.7	27.0	35.217	21.1

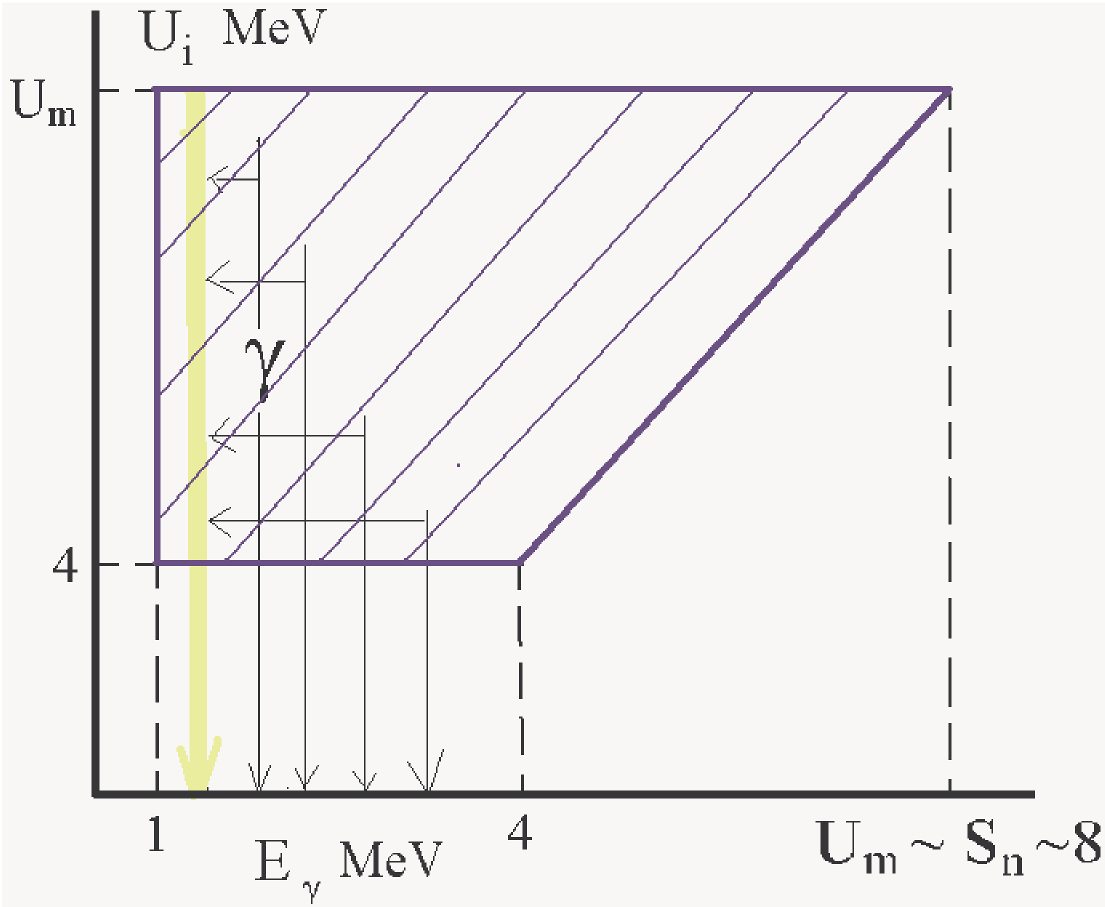
Excitation energy dependence of RSF
(Brink hypothesis violation)



Low-energy part of gamma-decay RSF is enhanced for transitions at high excitation energies

$$\overleftarrow{f}\left(E_\gamma \rightarrow 0\right) \sim T_i = const$$

Effect of RSF averaging on excitation energy

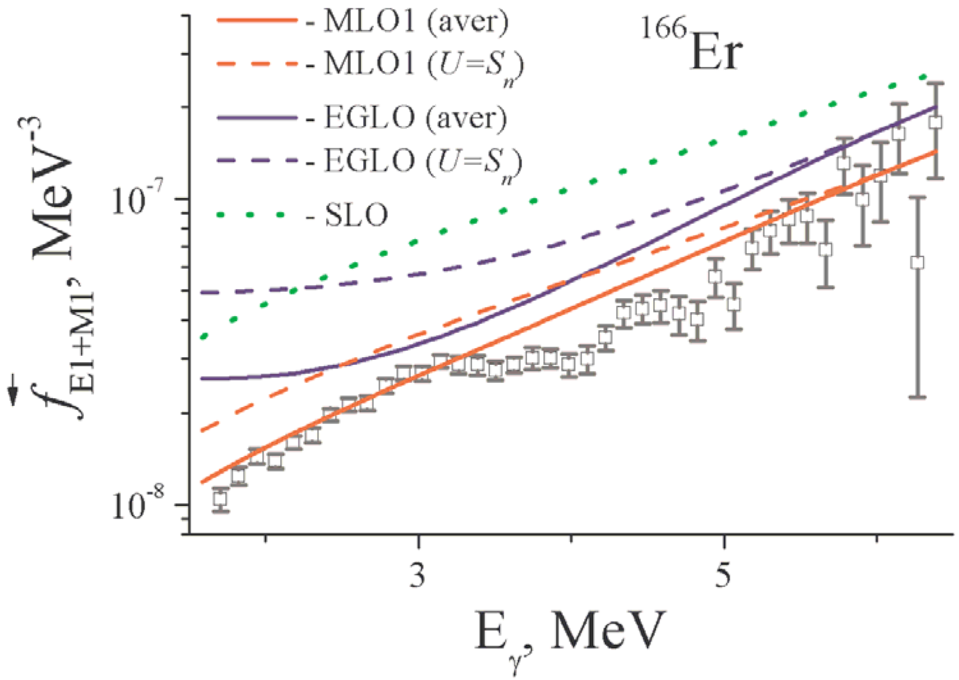


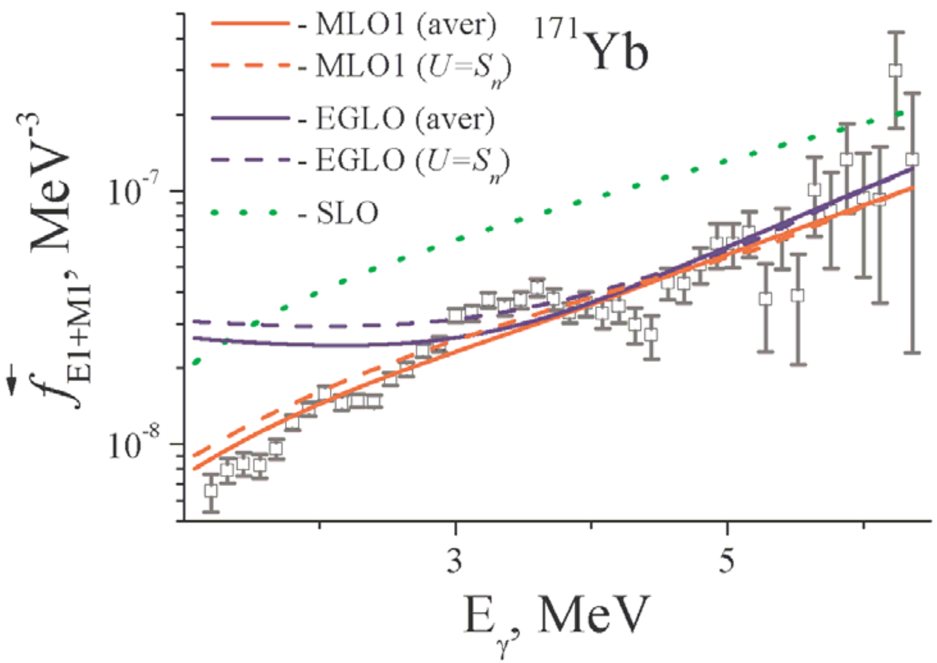
used in the Oslo method for RSF extraction
A.V.Voinov, M. Guttormsen(2009), A.Schiller(2010), private communications

Averaging procedure

$$f_{aver}\left(E_\gamma\right)=\begin{cases}\dfrac{1}{U_{\mathrm{m}}-4}\int_4^{U_{\mathrm{m}}}\overleftarrow{f}(E_\gamma,U_f=U_i-E_\gamma)dU_i, & 1<E_\gamma\le 4\\ \dfrac{1}{U_{\mathrm{m}}-E_\gamma}\int_{E_\gamma}^{U_{\mathrm{m}}}\overleftarrow{f}(E_\gamma,U_f=U_i-E_\gamma)dU_i, & 4<E_\gamma\le U_{\mathrm{m}}\end{cases}$$

$$U_{\mathrm{m}}=8\ MeV\approx S_n$$





Dipole strength functions of $E1$ and $M1$ gamma-decay for ^{166}Er and ^{171}Yb : $U = S_n$. Experimental data are taken from *E. Melby, M. Guttormsen, J. Rekstad, A. Schiller, and S. Siem* // Phys. Rev. **C63**, 044309 (2001) and *U. Agvaanluvsan, A. Schiller, J. A. Becker, L. A. Bernstein, et al.* // Phys. Rev. **C70**, 054611 (2004)

Values of χ^2 deviation of calculated gamma-decay strength functions from experimental data for nuclei ^{160}Dy, ^{162}Dy, ^{166}Er, ^{171}Yb, ^{172}Yb.

Model	EGLO (aver)	EGLO ($U = S_n$)	MLO1 (aver)	MLO1 ($U = S_n$)	SLO
^{160}Dy	130.7	571.0	19.5	50.7	500.3
^{162}Dy	77.4	355.4	13.7	32.6	588.8
^{166}Er	70.6	522.0	6.4	45.4	692.2
^{171}Yb	65.5	112.9	3.9	5.5	330.0
^{172}Yb	34.0	228.4	6.6	40.3	802.8
average	75.6	357.9	10.0	34.9	582.8

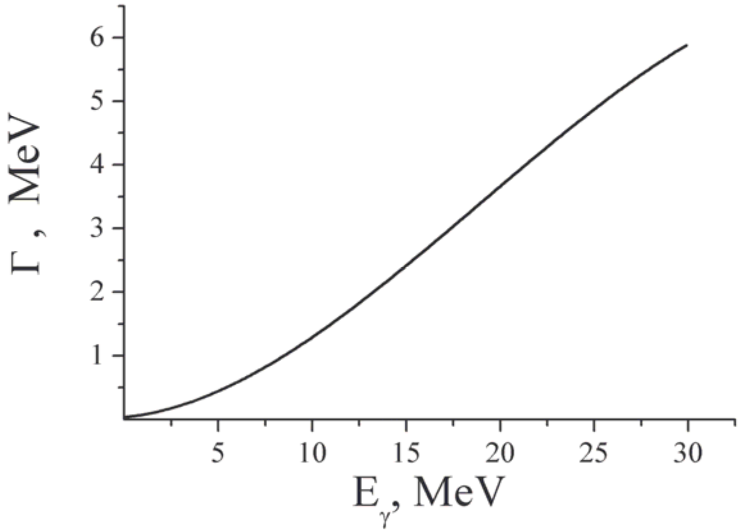
Role of folding procedure in microscopic calculations without 2p2h states

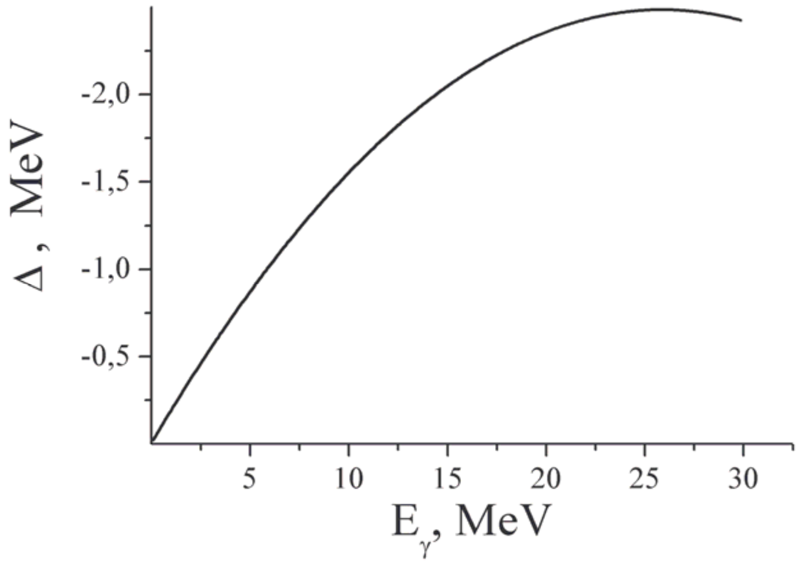
$$f_{E1}\left(E_\gamma\right) = \int_{-\infty}^{+\infty} f_L(E'_\gamma, E_\gamma)\, f_{E1}^{(Q)RPA}(E'_\gamma)\, dE'_\gamma$$

$$f_L(E'_\gamma, E_\gamma) = \frac{1}{2\pi}\frac{\Gamma(E_\gamma)}{\left(E'_\gamma - E_\gamma - \Delta(E_\gamma)\right)^2 + \Gamma^2(E_\gamma)/4}$$

R.D. Smith et al. P R**C38** (1988)100; *S.Drozdz et al*. P Rep. **197** (1990)1; *F.T.Baker et al*. P Rep. **289** (1997)235

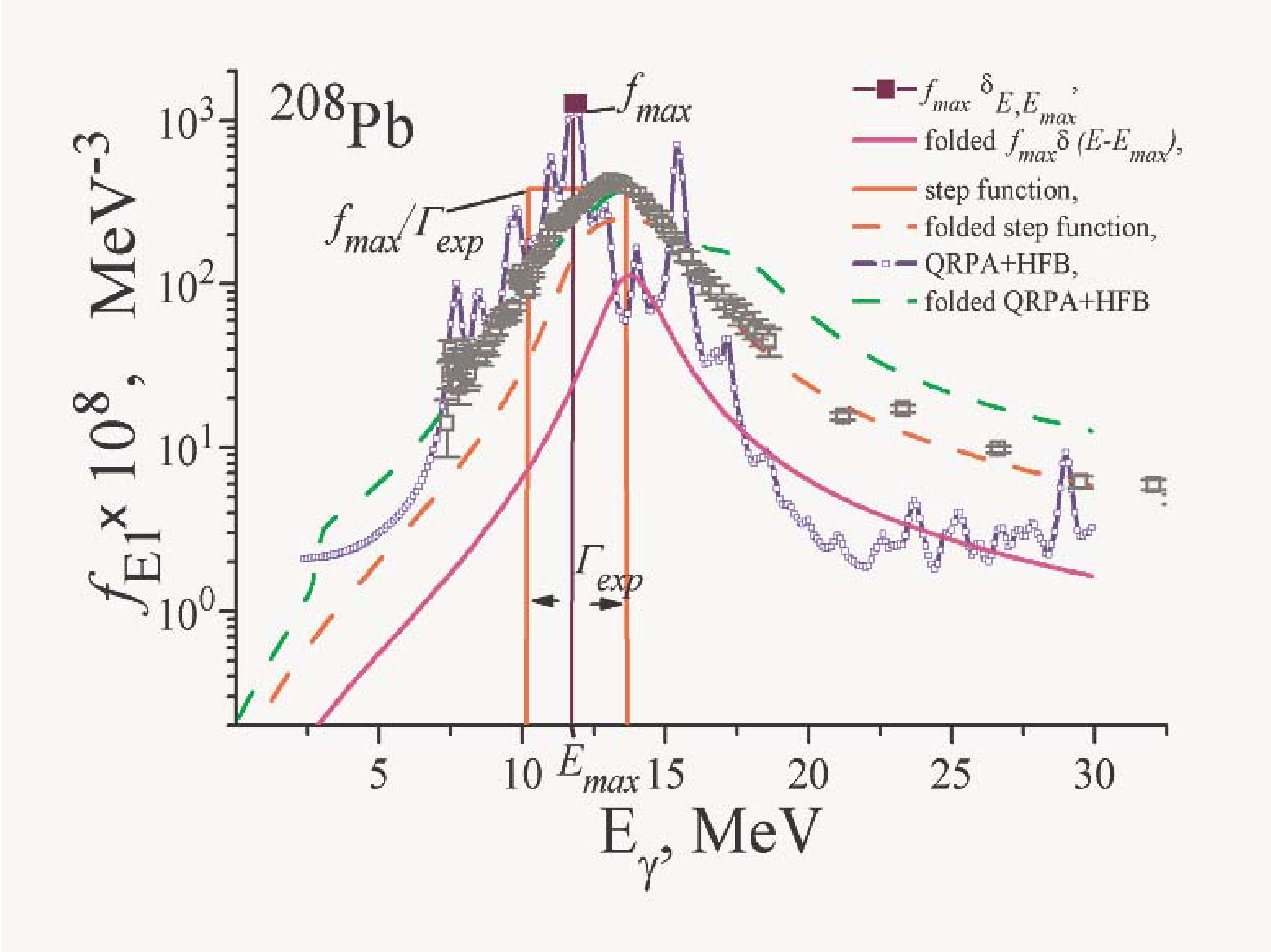
Width and energy shift for averaging HFB+QRPA results





$$\Gamma(E_\gamma) = a_0 + a_1 E_\gamma + a_2 E^2{}_\gamma + a_3 E^3{}_\gamma \qquad \Delta(E_\gamma) = b_0 + b_1 E_\gamma + b_2 E^2{}_\gamma$$

S. Goriely et al. NPA **706**, 217 (2002); **739**, 331 (2004);
S. Goriely, private communication



Calculations beyond QRPA are necessary for careful investigation of contribution of the processes on slops of the GDR peak

Main conclusions

- **Different experiments of RSF at fixed gamma-ray energy can provide different experimental data due to dependence probability gamma-transitions on excitation energy.**

- **Most reliable simple description of E1 RSF for gamma-decay can be obtained by the use of models with dependence of line spreading on excitation&gamma-ray energy. It seems that the best of the model is MLO4 with allowance for fragmentation damping due to coupling with surface vibrations (MLO4).**

- **Deformation splitting (triaxiality effects, deformation parameter values in excited states) as well as the energy dependence of parameter of line spreading should be considered more carefully.**

Main conclusions

- **Renewed values of GDR parameters and their systematics should be used for more reliable description of gamma-transitions and extractions of contributions of different two-body states in the RSF by the use of the simple models.**
- **To better understand role of the temperature and energy dependence of the RSF, experimental data are necessary as the functions of gamma-ray energy and excitation energy , especially at low gamma-ray energy.**

R.Capote, M.Herman, P.Oblozinsky, P.G.Young, S.Goriely, T.Belgya, A.V.Ignatyuk, A..J..Koning, S. Hilaire, V.A.Plujko et al., M. Avrigeanu, O. Bersillon, M. B. Chadwick, T. Fukahori, Zhigang Ge, Yinlu Han, S. Kailas, J. Kopecky, V. M. Maslov, G. Reffo, M. Sin, E. Sh. Soukhovitskii and P. Talou, **Nucl. Data Sheets 110 (2009) 310; http://www-nds.iaea.or.at/ripl3/**

V.A.Plujko, R.Capote, O.M. Gorbachenko, **At.Data Nucl.Data Tables, 2011, in press**

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THANK YOU !!!