A global study of the electric dipole strength in heavy nuclei*

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The dipole strength function strongly influences neutron capture processes in heavy nuclei and it is of great importance for photon induced processes like electromagnetic disintegration and nuclear resonance fluorescence.

The Situation:

- Above 10 MeV: Absolute value and energy dependence are well known from (γ,n) experiments usually described by the Lorentzian shape of the Giant Dipole Resonance (GDR).
- Below the threshold: Photon scattering studies on nuclei above mass 80 indicate no decrease of the spreading width with falling energy
  → allows to describe its shape by a continuation of the GDR Lorentzian with constant width

The problem:

- The **constant width** is in accordance to primary photons observed after neutron capture in **deformed nuclei** which show a clear double peak structure
- Capture data taken for **nearly spherical nuclei** seem to show a one-component Lorentzian shape with **width varying with the square of the gamma-energy E_γ**

➔ This apparent disaccord between more or less deformed nuclei is reinvestigated with the aid of Average Resonance Capture (ARC) data measured for various transitional nuclei.

Our suggestion[$)]: A 3-fold Lorentzian for all kinds of deformation.

$$\langle\sigma_\gamma(E_\gamma)\rangle \equiv 3(\pi\hbar c)^2 \cdot E_\gamma \cdot f_1(E_\gamma) = \frac{4\cdot Z\cdot N}{\pi\cdot A}\sum_{k=1}^{3}\frac{E_\gamma^{\,2}\Gamma_k}{(E_k^2 - E_\gamma^{\,2})^2 + E_\gamma^{\,2}\Gamma_k^{\,2}}$$

- Normalization is taken from the **Thomas-Reiche-Kuhn** sum rule for the GDR integral.

Deformation β and triaxiality γ cause split of the GDR into 3 components and thus a widening (β,γ Hill-Wheeler parameters)

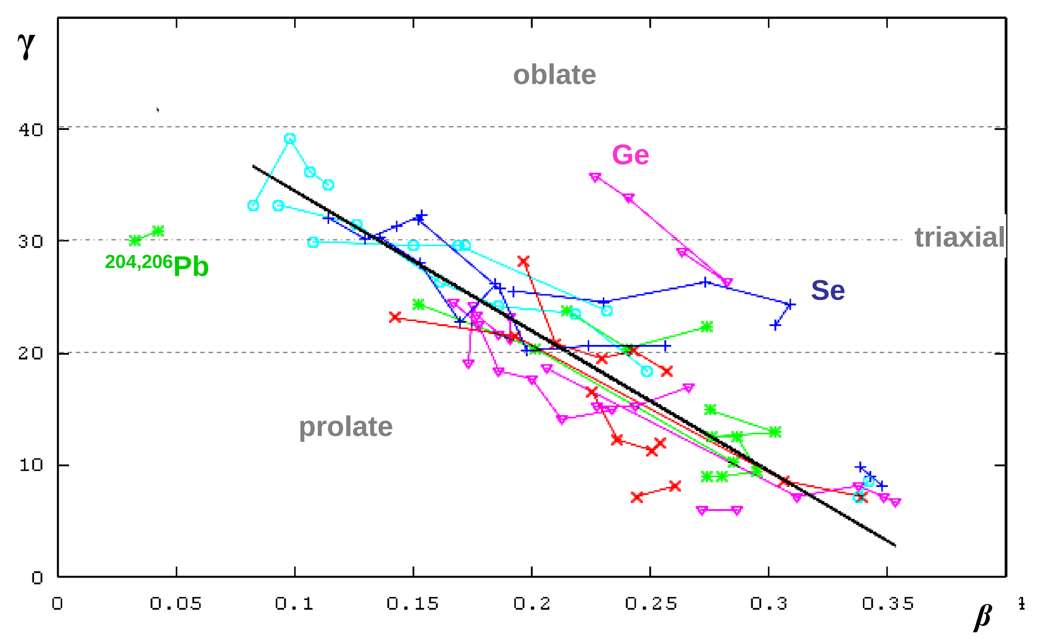
$$E_k = E_0\frac{R_0}{R_k} = E_0\cdot\exp[-\sqrt{5/4\pi}\cdot\beta\cos(\gamma - \tfrac{2}{3}k\pi)]$$

The **spreading width** Γ_k is determined by **2 parameters** valid for **all** nuclei with A>80.

$$\Gamma_k(E_k) = 0.05\cdot E_k^{\,1.6}$$

- The exponent 1.6 is predicted by the surface dissipation model [#)]. (Γ_k, E_o, E_k in MeV.)
- Γ_k only accounts for the spreading, as the nuclear deformation is already accounted for explicitly.
- Γ_k depends continuously on the resonance energy E_k and not on the photon energy E_γ, in contrast to the KMF theory[+)].
- The centroid energy E_0 is obtained from the FRDM using $m_{eff}c^2$ = 874 MeV.
- The quadrupole deformations β are taken from FRDM and spectroscopy data[°)]
  the correlation between quadrupole deformation and triaxiality is used to determine γ.

Correlation between deformation β and triaxiality γ, see Andrejtscheff et al. Coulex data (A > 70) was analyzed using rotation invariants and show that nuclei deformed weakly along major axis are likely to be triaxial.



Spreading width of the GDR. Fitting only one Lorentzian results in a strong variation with the mass number. A fit with 3 Lorentzians yields to a smooth behavior.

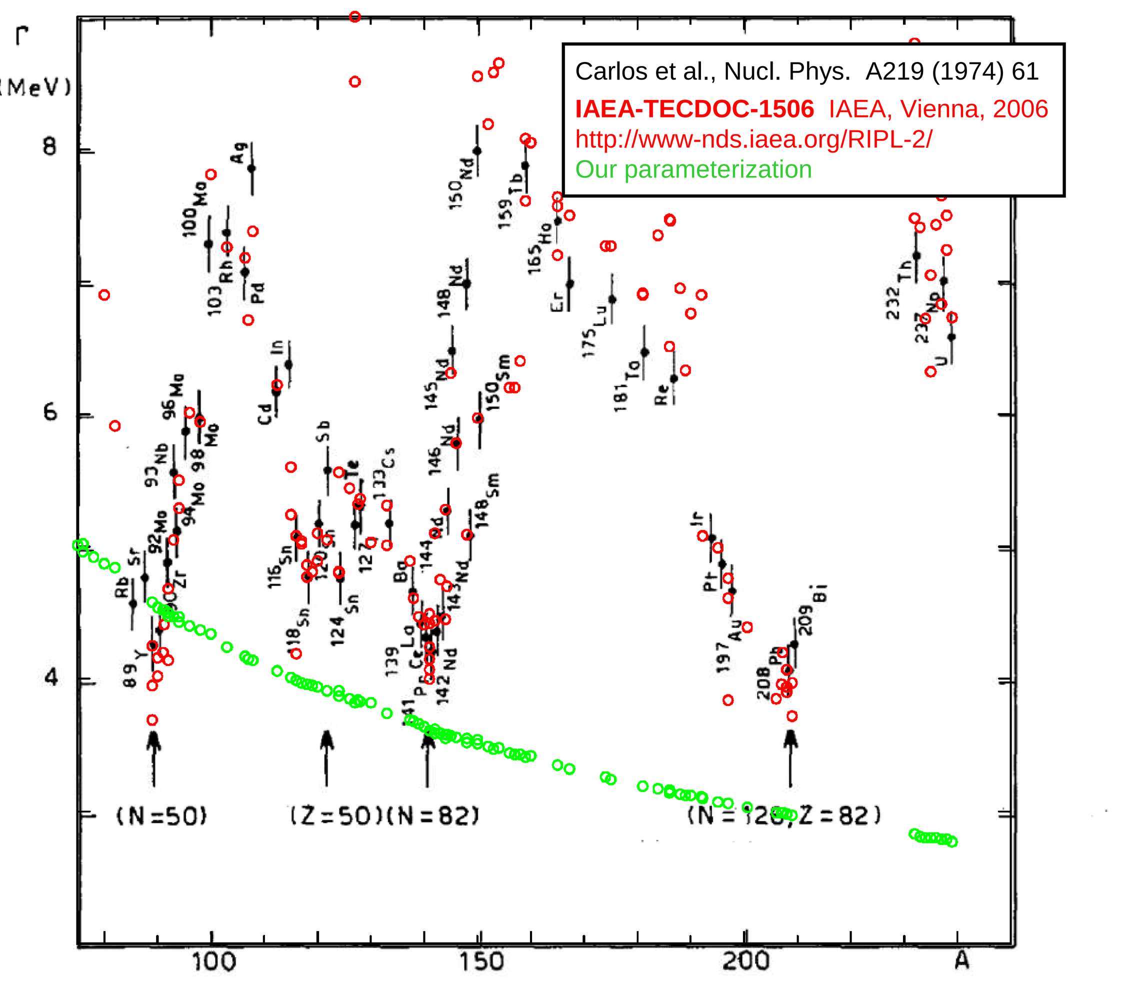
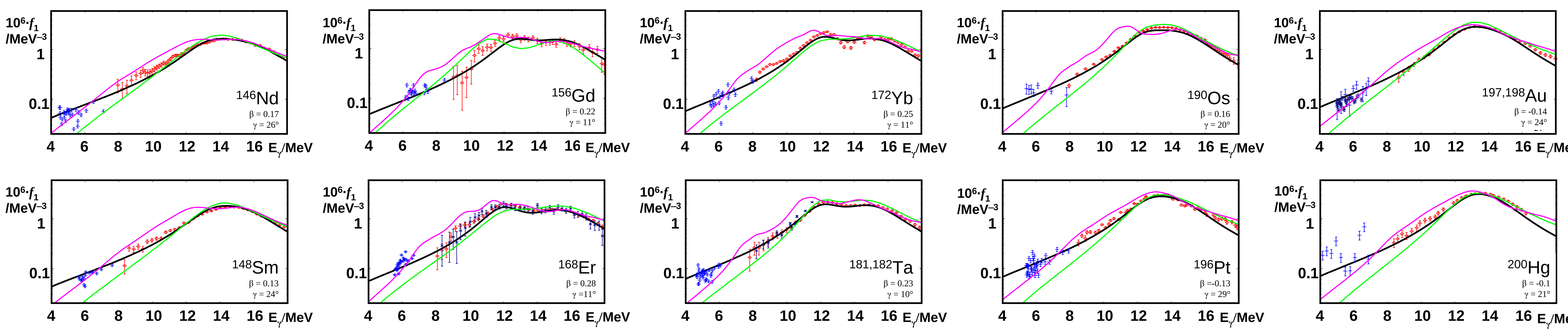


Fig. 5. Experimental FWHM values Γ of the σ/E curves for 90 ≤ A ≤ 238 as obtained at Saclay from the experimental total photoneutron cross sections σ.

*Dipole strength function measured for various transitional nuclei via (γ, n) and Average Resonance Capture (from BNL). The agreement between the data and the tables given in RIPL-2 is not good for **EGLO** (Kopecky & Uhl) or for **QRPA-SLy4** (Goriely & Khan), especially in the low energy tail, whereas our parameterization fits well.*



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