A Brief History of the GMR

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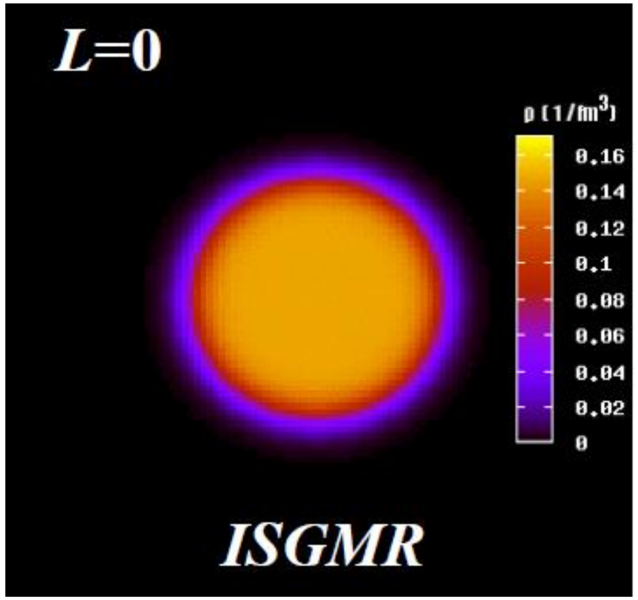
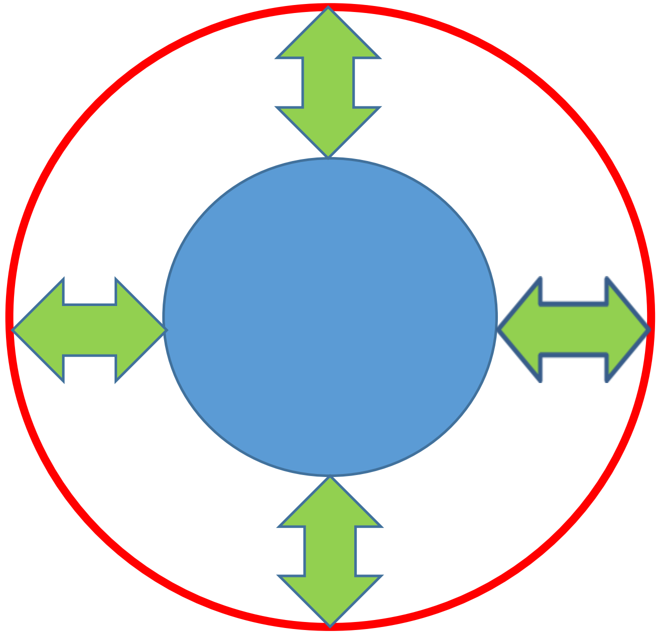
IJCLab





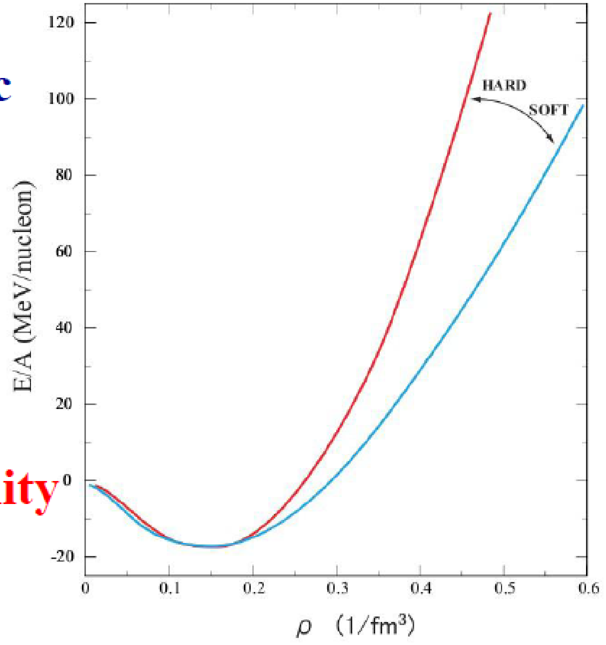
Some Basic facts

For the equation of state of symmetric nuclear matter at saturation nuclear density:

$$\left[\frac{d(E/A)}{d\rho}\right]_{\rho=\rho_0} = 0$$

and one can derive the incompressibility of nuclear matter:

$$K_{nm} = \left[9\rho^2 \frac{d^2(E/A)}{d\rho^2}\right]_{\rho=\rho_0}$$



E/A: **binding energy per nucleon**

ρ : **nuclear density**

ρ₀ : **nuclear density at saturation**

J.P. Blaizot, Phys. Rep. 64 (1980) 171

Some Basic facts (continued)

The compressibility of a nucleus A, K_A , is related to the energy of the GMR by

$$E_{ISGMR} = \hbar\sqrt{\frac{K_A}{m\langle r^2\rangle}} \qquad \text{with} \qquad K_A = \left[r^2(d^2(E/A)/dr^2)\right]_{r=R_0}$$

The GMR (like every GR) is defined by E_{ISGMR}, Γ and %EWSR
To define precisely E_{ISGMR} one needs to observe a large %EWSR
To obtain experimentally the %EWSR one compares data with a reaction model (DWBA) which includes the transition density (scaling model):

ISGMR Satchler, Nucl. Phys. A472 (1987) 215

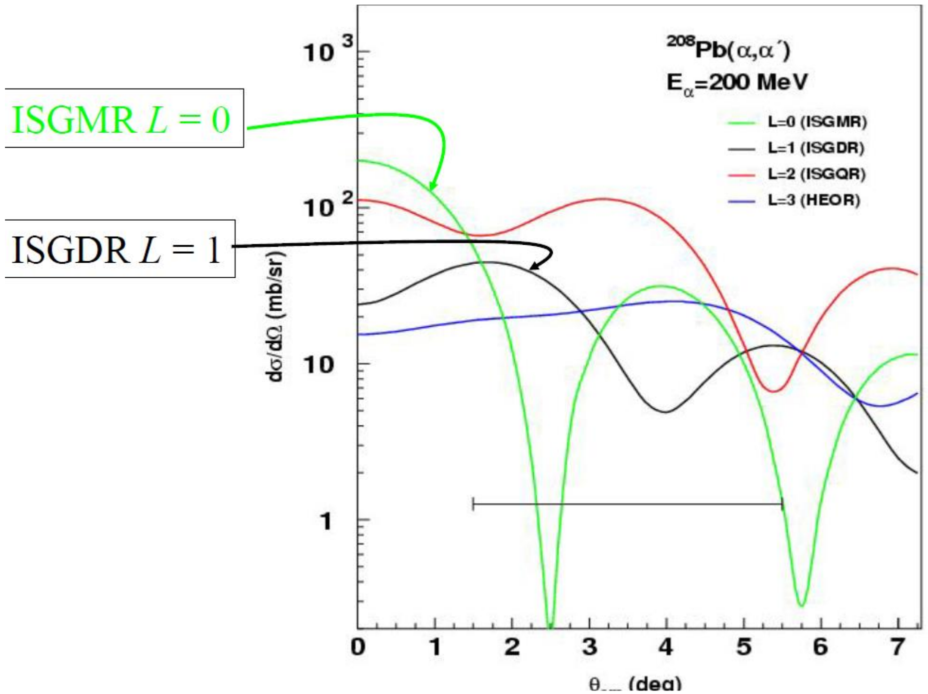
$$\delta\rho_0(r,E) = -\alpha_0[3 + r\frac{d}{dr}]\rho_0(r)$$

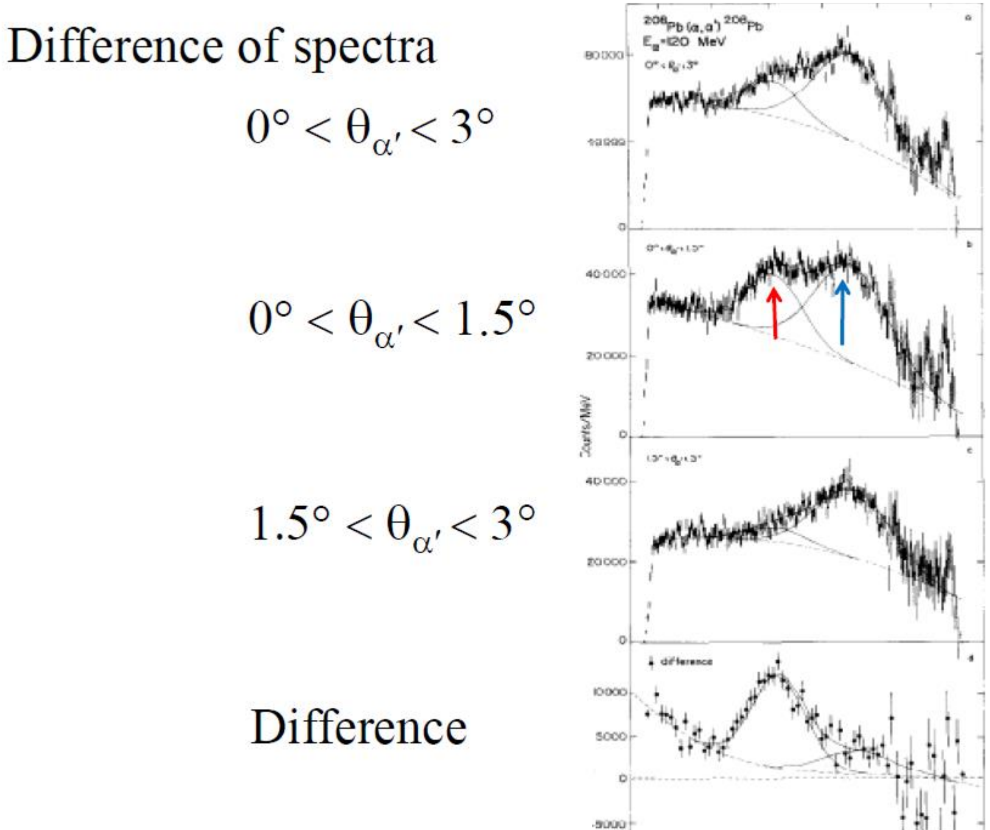
$$\alpha_0^2 = \frac{2\pi\hbar^2}{mA < r^2 > E}$$

The experimental error on E_{ISGMR} comes mainly from high energy strength difficult to observe and for which the transition density may not follow the above formula

Experimental results

- Discovered in the mid-seventies
- First observation claimed at IPN Orsay synchrocyclotron but never published except in annual report (What's new?)
- (α,α') scattering at KVI Groningen (Harakeh, Van der Woude)
- ^{3}He scattering at ISN Grenoble (Buenerd)
- (α,α') scattering at Texas A&M (Youngblood)





M. N. Harakeh *et al.*, Phys. Rev. Lett. 38, 676 (1977)

Systematics

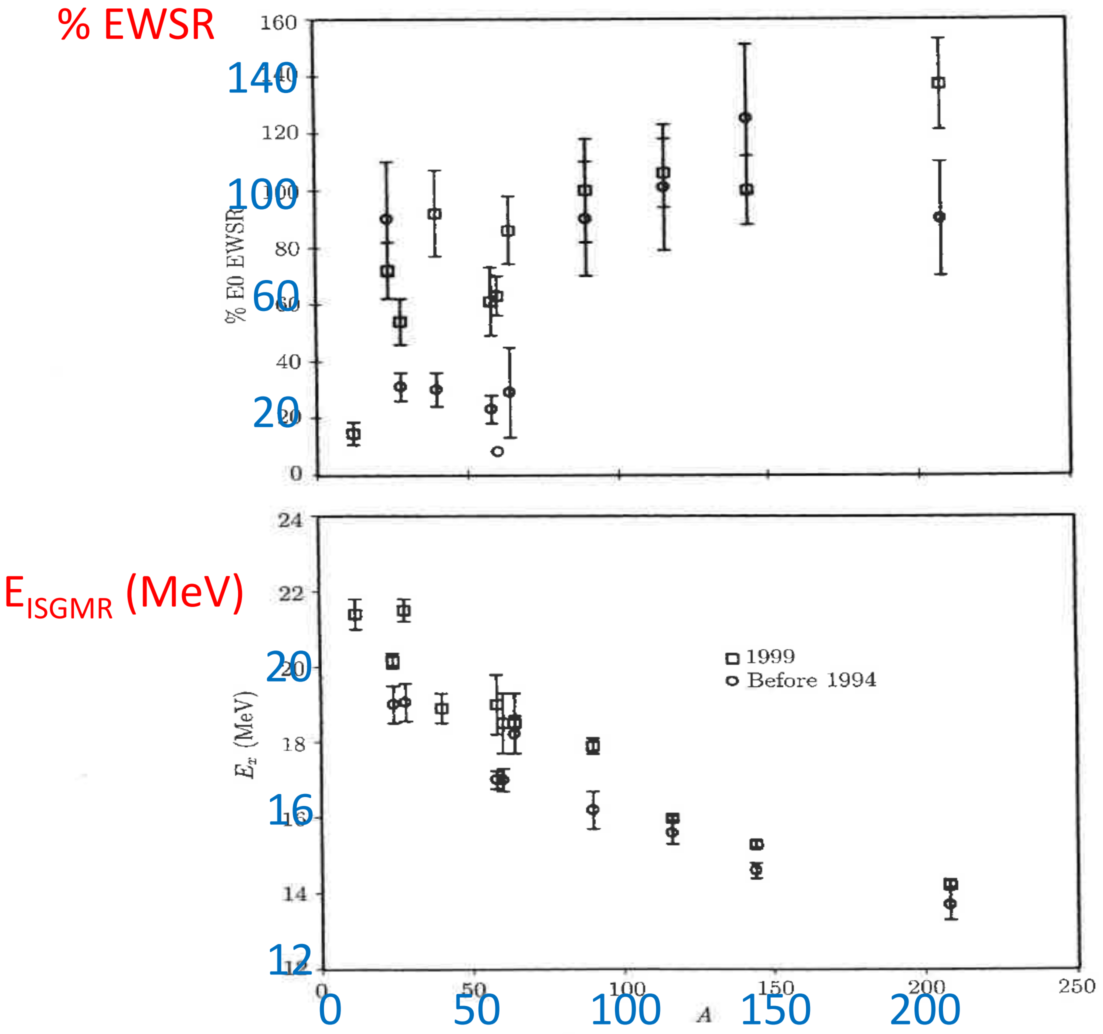


FIG. 4.1. Overview of ISGMR data on GMR centroid energies and fractions of EWSR versus *A*. Data indicated by open squares are from the summary in (YOU99c) and the open circles from (SHL93). Adapted from (YOU99c).

How do we get K_∞?

$$K_A = K_\infty + K_{surf}A^{-1/3} + K_{sym}((N-Z)/A)^2 + K_{Coul}Z^2A^{-4/3}$$

Fit the K parameters on experimental data: Very Imprecise

Base on RPA calculations and compare with experiment

J.P. Blaizot, D. Gogny and B. Grammaticos NPA265 (1976) 315

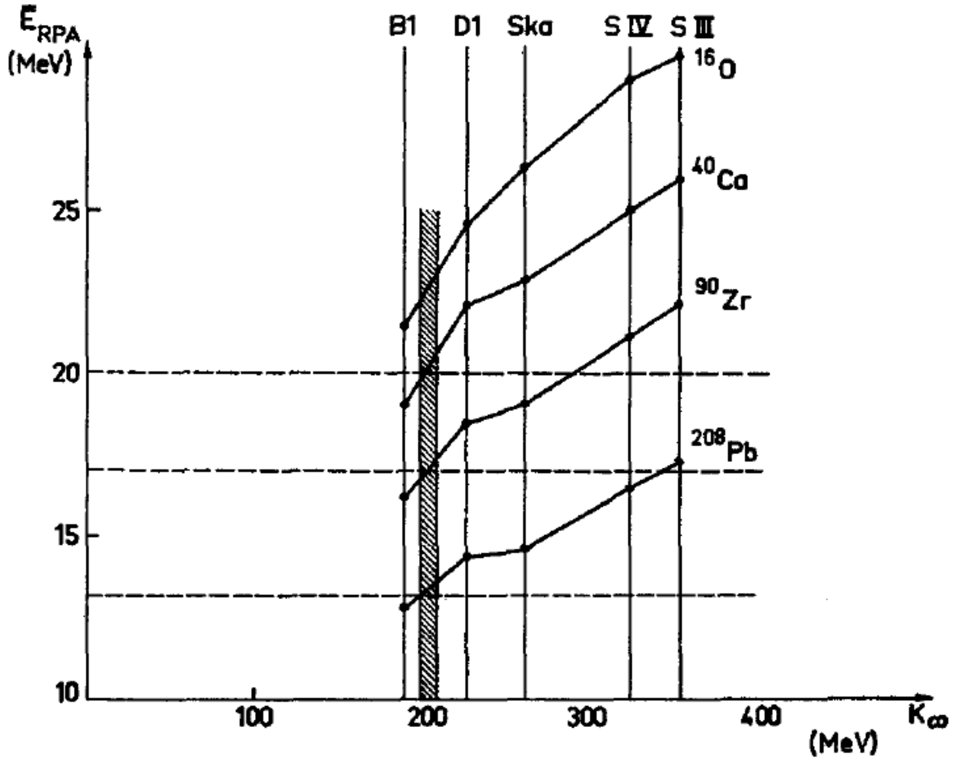
J.P Blaizot Phys. Rep. 64 (1980) 171

K_∞= 210 ± 30 MeV

Already in 1976

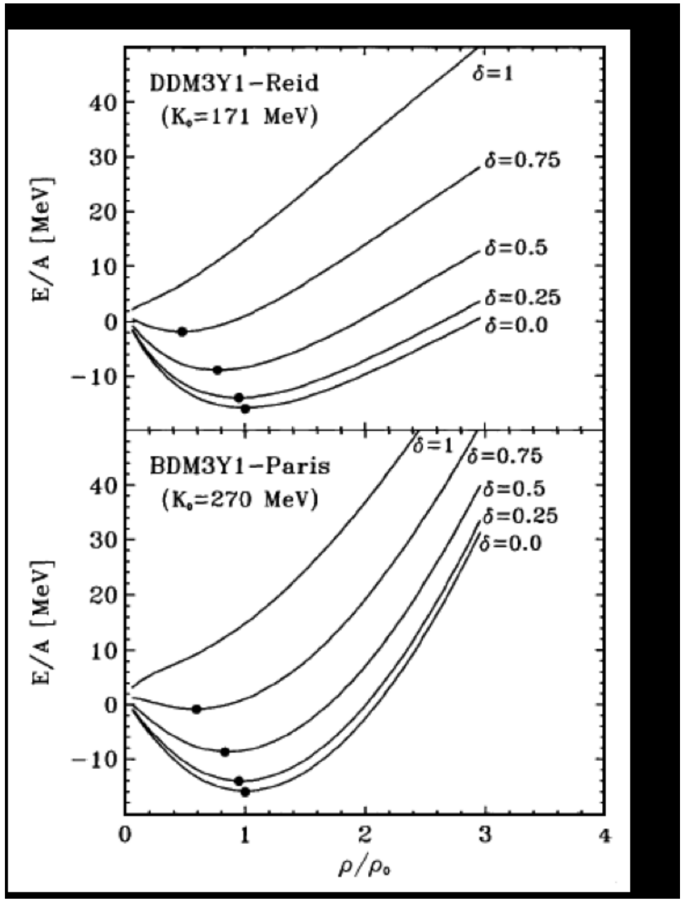
We have not done much better since with some scatter depending on the type of theory (non-relativistic or relativistic)

Colo et al (2004) give K_∞= 240 ± 10 MeV



Dependence on N-Z : Kτ

K_∞ is for symmetric nuclear matter. This is not the case for a neutron star for example. So one wants to measure the dependence on N-Z.

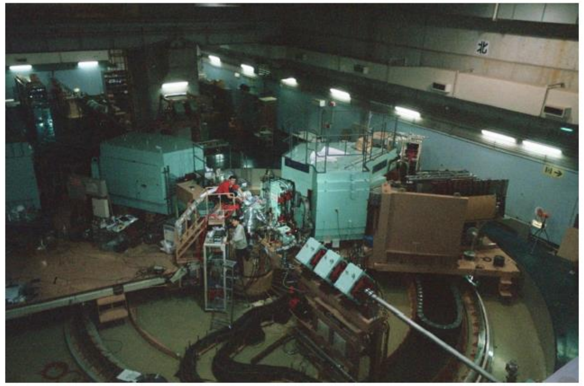


$$K_A - K_{Coul} Z^2 A^{-4/3} \sim K_{vol}(1 + cA^{-1/3}) + K_\tau((N-Z)/A)^2$$

$$\sim \text{Constant} + K_\tau((N-Z)/A)^2$$

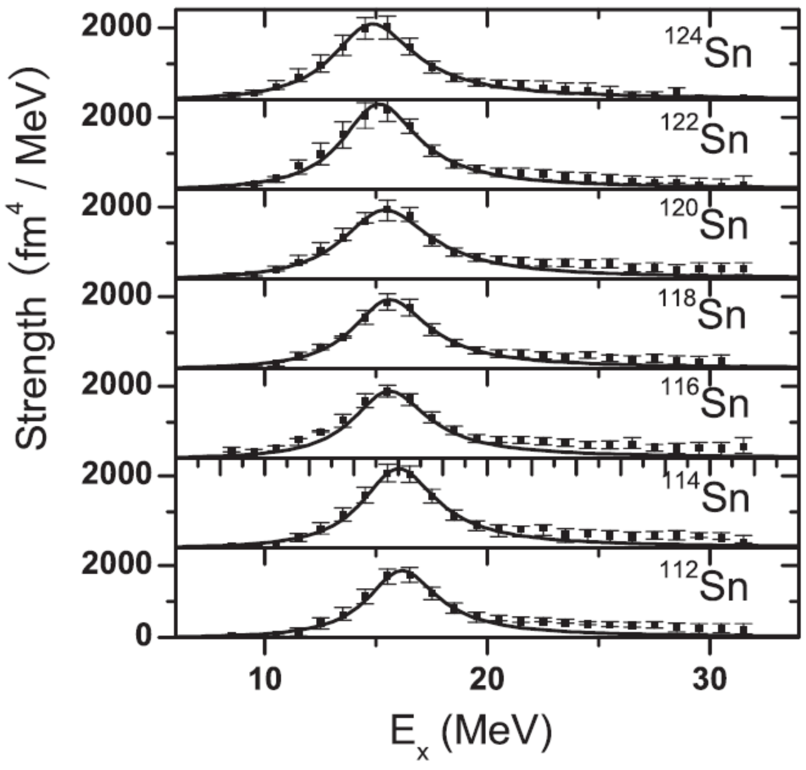
Measure along an isotopic chain

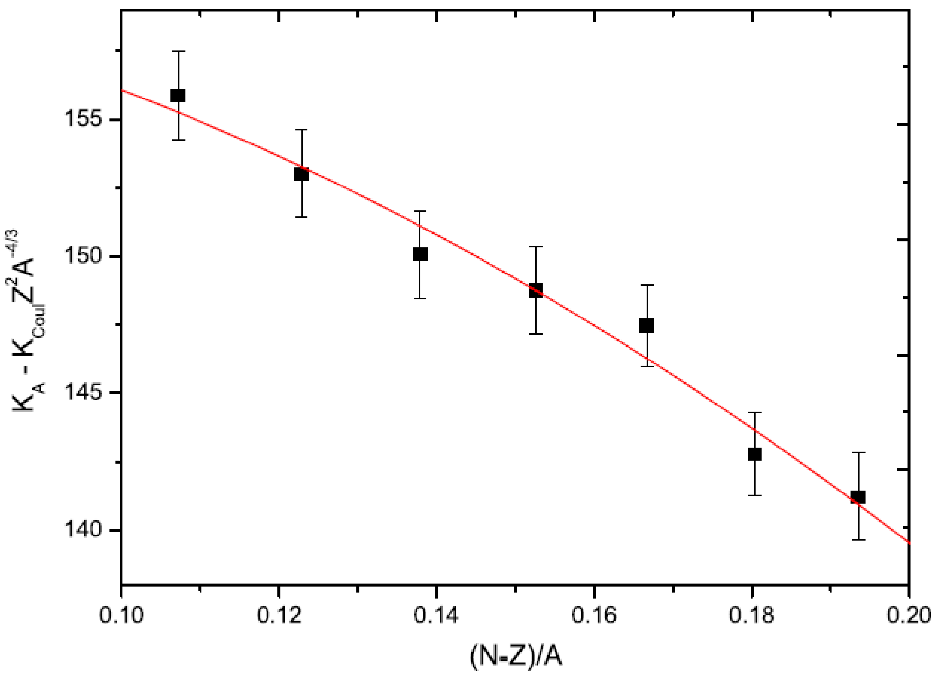
Grand Raiden Osaka



D.T. Khoa et al. NPA602 (1996) 98

Results for Kτ





$$K_\tau = -550 \pm 100 \text{ MeV}$$

T. Li, U. Garg et al. PRL 99 (2007) 162503

Similar result with Cd isotopes

Questions

- Can our knowledge of K_∞ be improved?
- Why does a nucleus like Sn yield a different K_∞? (Sn is fluffy)
- Do soft monopole modes exist? Can they teach us something about compressibility?
- Is it worth the effort to measure the GMR in unstable nuclei?
- If so, what are the best techniques and the most interesting nuclei?

Enjoy the workshop!