Nuclear moments of isomeric states from deep-inelastic reactions. Is it doable?

Georgi Georgiev - CSNSM, Orsay

Bogdan Fornal - IFJ, Krakow

Nuclear moments – what can we learn from them?

Magnetic moment operator

$$\vec{\mu}=\sum_{k=1}^{A} g_{l}^{(k)}\vec{l}^{(k)}+\sum_{k=1}^{A} g_{s}^{(k)}\vec{s}^{(k)}$$

Free-nucleon g factors

$$g_s^{\pi} = 5.585 \qquad g_l^{\pi} = 1$$
$$g_s^{\nu} = -3.826 \qquad g_l^{\nu} = 0$$

Most sensitive to
M1 (''spin-flip'') components

$$\left| l_{l+1/2}^{n-1} l_{l-1/2}^{1}; 1^{+} \right\rangle$$

✓valence particle configuration;
✓first order core polarization (M1 excitations);

Quadrupole moment operator

$$\vec{Q}=e\sum_{k=1}^{A}(3z_k^2-r^2)$$

Spectroscopic vs. intrinsic Q
(model dependent)

$$Q_s=\frac{3K^2-I(I+1)}{(I+1)(2I+3)}Q_0$$

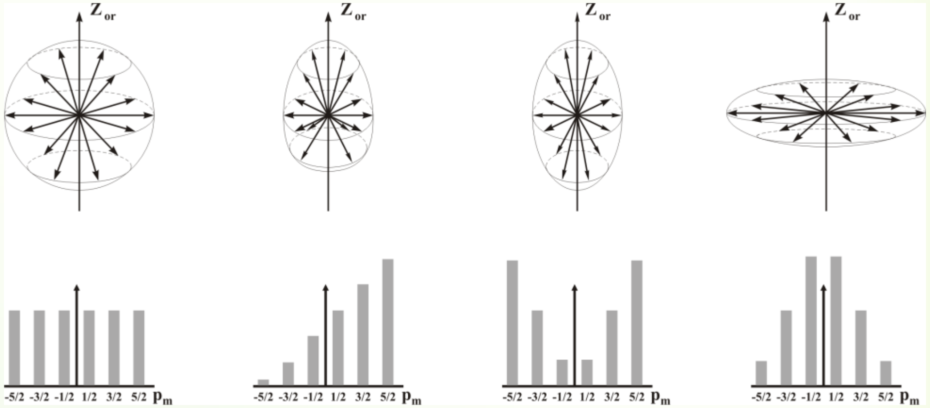
Intrinsic quadrupole moment

$$Q_0=\frac{3}{\sqrt{5\pi}}eZR^2\beta\left\{1+\pi^2\left(\frac{a}{R}\right)^2+\frac{2}{7}\sqrt{\frac{5}{\pi}}\beta\right\}$$

✓nuclear deformation and effective charges;
✓collective properties

Experimental requirements for moment measurements of isomeric states

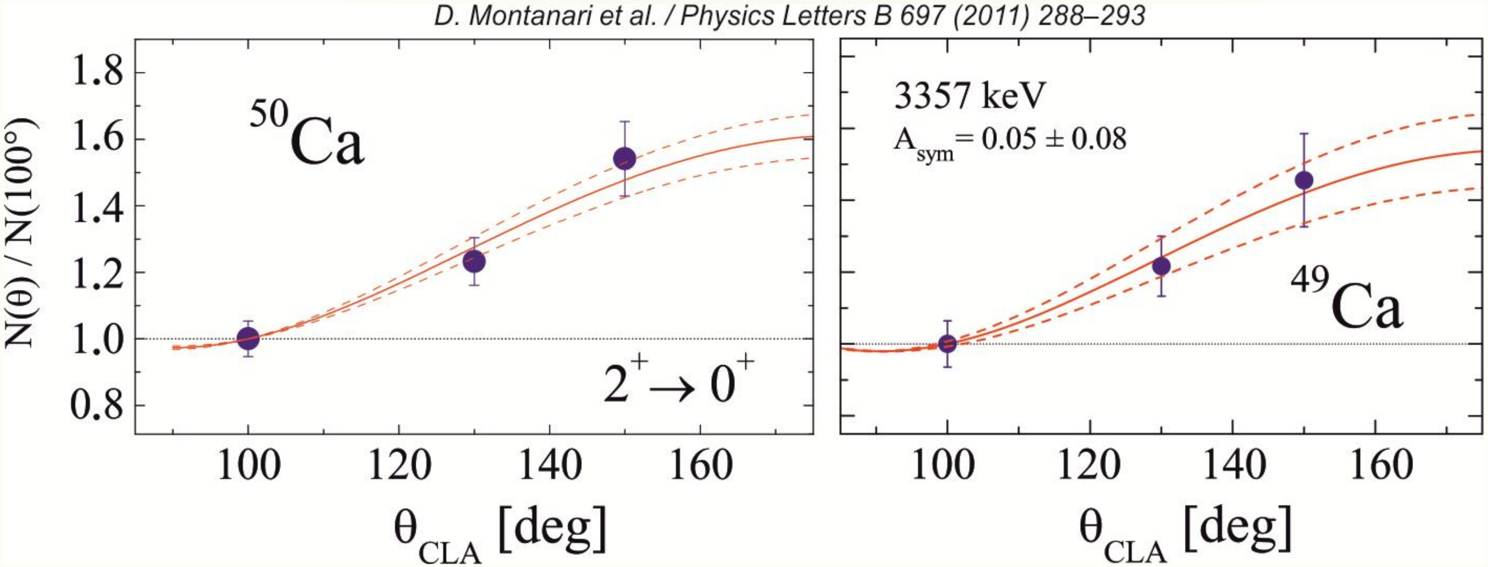
- Spin-aligned nuclear ensemble



- Fusion-evaporation reactions - alignment, well studied
- Projectile - fragmentation reactions – both alignment and polarization observed
  - ^{43m}Sc - W.-D. Schmidt-Ott *et al.*, ZPA350, 215 (1994)
    ^{67m}Ni, ^{69m}Cu – G. Georgiev *et al.*, JPG 28, 2993 (2002)
    ^{61m}Fe – I. Matea *et al.*, PRL93, 142503 (2004)…
  - ^{12}B – K. Asahi *et al.*, PLB 251, 488 (1990)
- Deep-inelastic reaction – what spin orientation could one get?

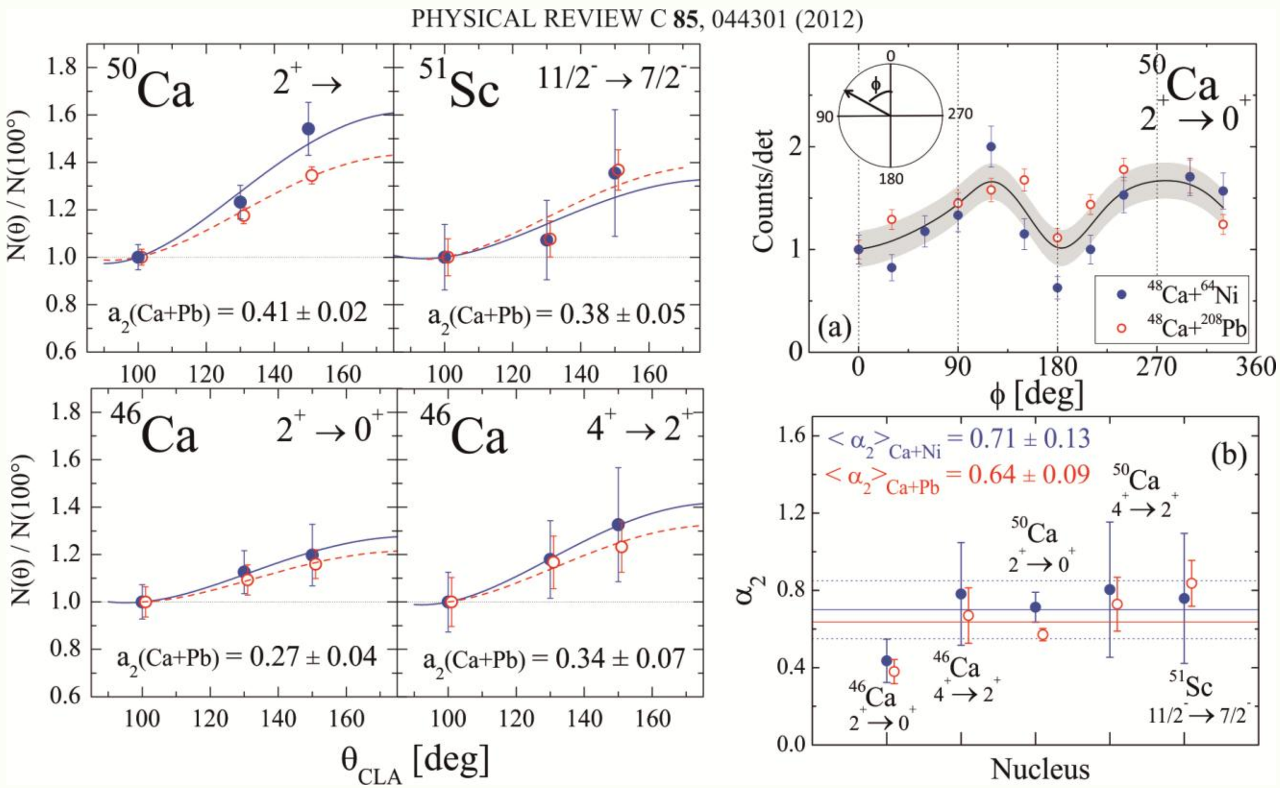
Spin-alignment in deep-inelastic reactions?

- By 2008 - some initial reports: T. Pawlat *et al.*, LNL Annual Report (1994) 8
- More recent results:
  - D. Montanari *et al.*, PLB 697, 288 (2011)
    - ^{48}C beam on ^{64}Ni target; **$E_{beam} = 2*E_{CB}$**
    - ^{49}Ca and ^{50}Ca detected in PRISMA



  - ***- θ_{CLA}- with respect to PRISMA entrance!!!***
    - grazing angle = 20°

- D. Montanari *et al.*, PRC 85, 044301 (2012)
  - - ^{48}C beam on ^{208}Pb target; **E_{beam} ~ 1.3*E_{CB}**



- Alignment ~70% of the maximum possible
- Azimuthal angular distribution (?)

Nuclear moments in DIC at LNL – the attempt

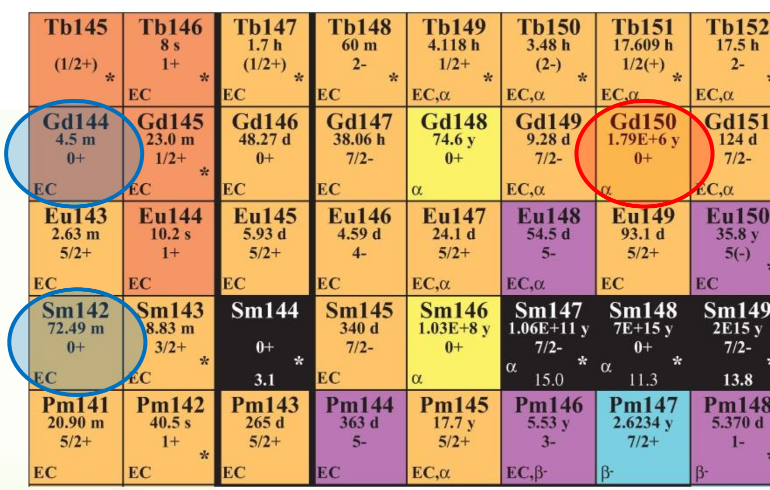
^{80}Se beam 338 MeV (1.3 E_{CB})

^{70}Zn – thick target

4 coaxial Ge detectors

GAMIPE setup

Aiming at: ^{69m}Cu; ^{79m}As



Observed: ^{144m}Gd and ^{142m}Sm

No traces of ^{69m}Cu or ^{79m}As

Conclusions

- Significant spin alignment available from deep-inelastic reactions - both with thin target (+spectrometer) and thick target experiments (see talk of N. Cieplicka)
- Tick-target experiment not possible without gamma-gamma coincidences even for lighter beam/target combination (no fission contribution)
- Still to be investigated what are the limits and the best approach for similar experiments

Collaboration

- CSNSM, Orsay – G. Georgiev, C. Sotty, E. Fiori
- IFJ, Krakow – B. Fornal, A. Maj, M. Kmiecik, N. Cieplicka, M. Matejska-Minda
- LNL, Legnaro – **C. Ur**, F. Brandolini, S. Lenzi, D. Napoli
- INRNE, Sofia – D.L. Balabanski, L. Atanasova, P. Detistov
- University of Sofia – K. Gladnishki
- IPHC, Strasbourg – R. Lozeva
- IPN, Orsay – F. Azaiez, S. Franchoo