Эксперименты с лазерным ионным источником на установке ISOLDE (CERN; *RILIS-IDS collaboration*)

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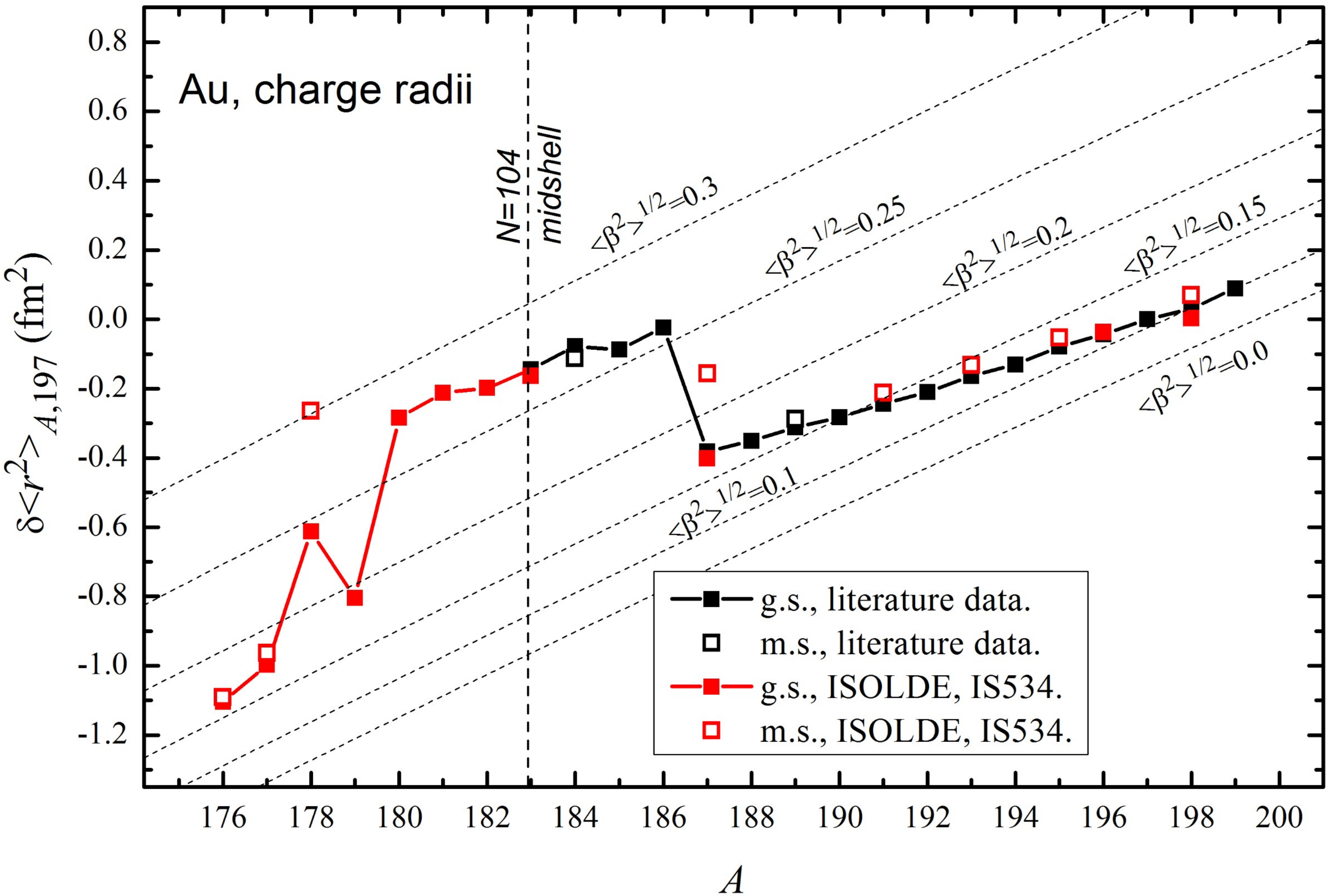
М. Д. Селиверстов, Д. В. Федоров

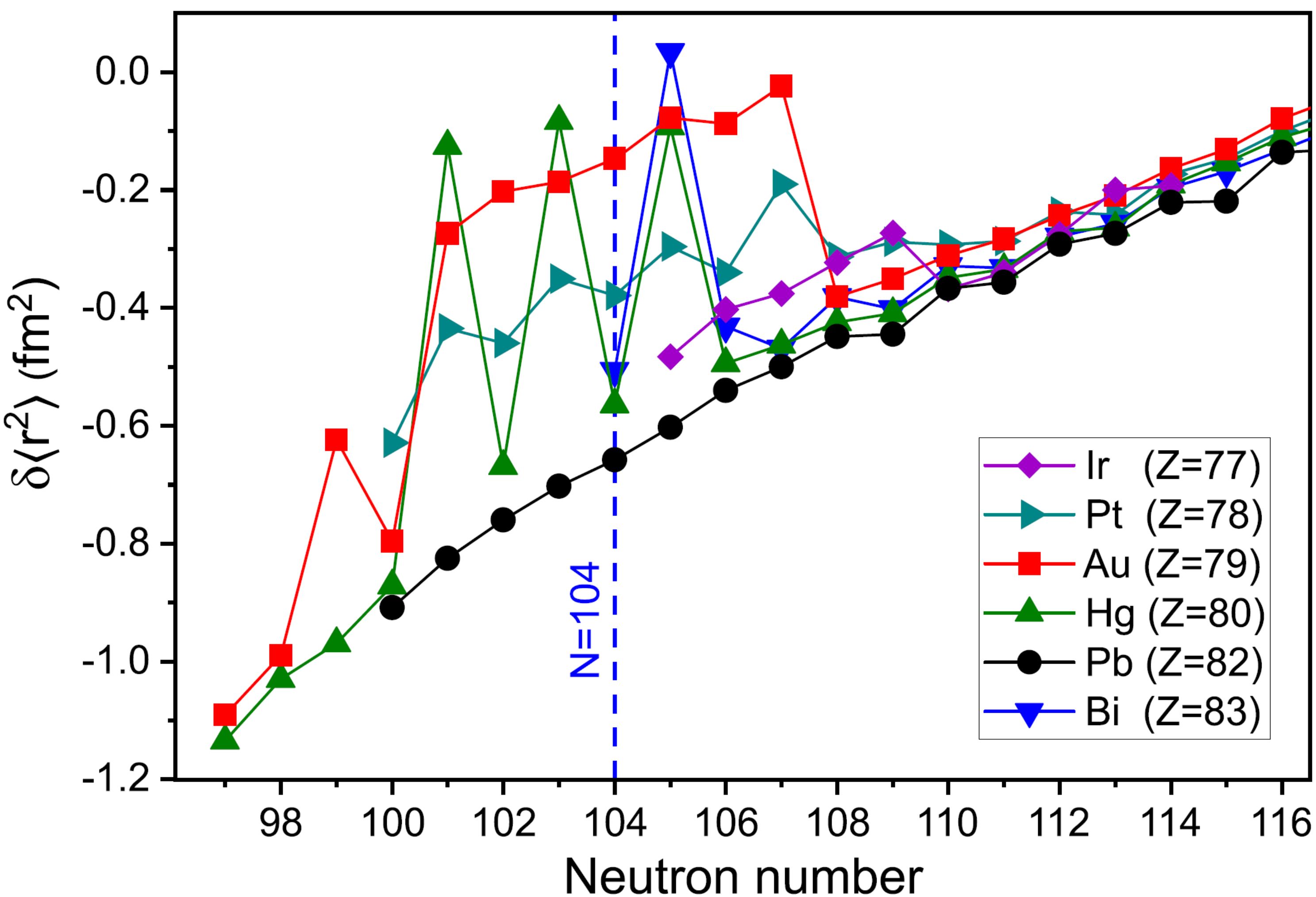
Au IS/hfs study; charge radii

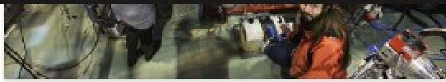
(Phys. Rev. Lett. 131, 202501 (2023))

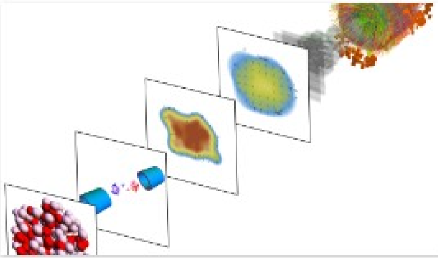
Au: In total 10 papers (PRC, PRL, PLB, NIM)



Different patterns of radii (deformation) behavior near midshell



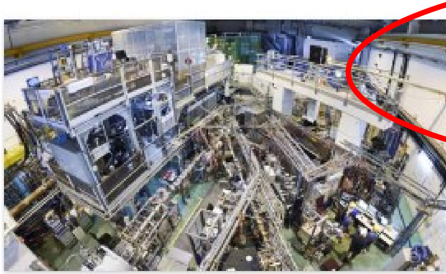




Thick-skinned: Scientists determine the thickness of neutron "skin" in lead-208 nuclei

This is the first measurement of the neutron skin of lead-208 using exchanges predominantly involving gluons and it can provide insight into the structure of nuclei and neutron stars

News | Physics | 15 November, 2023



ISOLDE sees shape shifting in gold nuclei

The finding comes a little more than 50 years after the phenomenon was first discovered at the facility in mercury nuclei

News | Physics | 15 November, 2023

CMS presents its latest search for new exotic particles

This search for exotic long-lived particles looks at the possibility of "dark photon" production, which would occur when a Higgs boson decays into muons displaced in the detector

PHYSICAL REVIEW LETTERS **131,** 202501 (2023)

Editors' Suggestion

Deformation versus Sphericity in the Ground States of the Lightest Gold Isotopes

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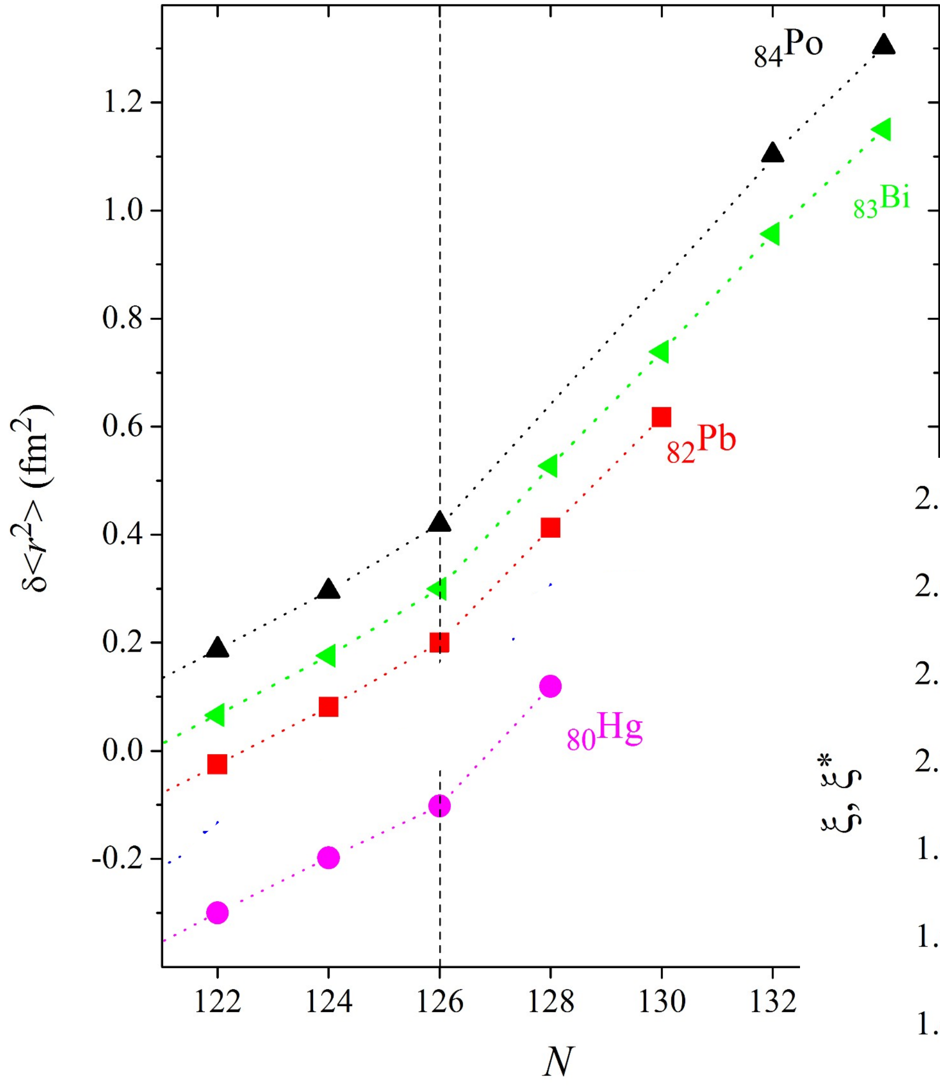
N. A. Althubiti,[7,8] B. Andel,[9] S. Antalic,[9] D. Atanasov,[10,11] K. Blaum,[10] T. E. Cocolios,[7,4] T. Day Goodacre
A. de Roubin,[10,‡] G. J. Farooq-Smith,[7,4] D. V. Fedorov,[3] V. N. Fedosseev,[11] D. A. Fink,[11,10] L. P. Gaffney,[4]

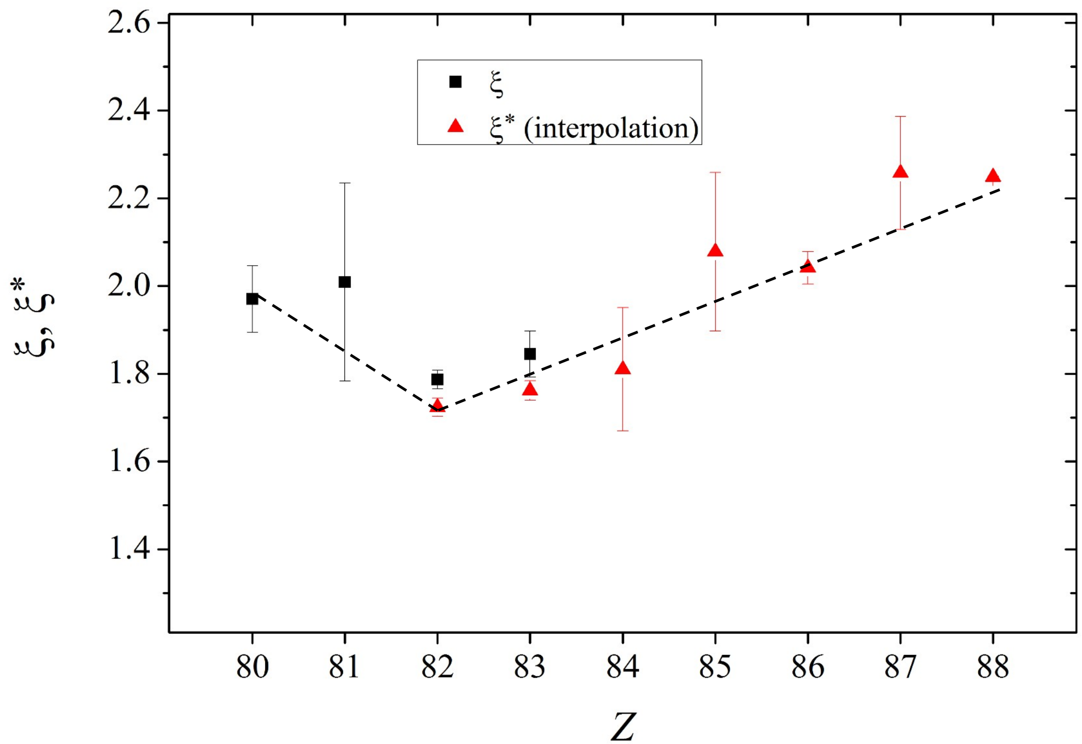
Shell effect in charge radii: Experiment



Kink indicator:

$$\xi_{even} \equiv \frac{\delta\langle r^2\rangle_{128,126}}{\delta\langle r^2\rangle_{126,124}} = \frac{\delta\nu^F_{128,126}}{\delta\nu^F_{126,124}}$$

$$\xi^*_{even} \equiv \frac{2}{N_0-126}\frac{\delta\langle r^2\rangle_{N_0,126}}{\delta\langle r^2\rangle_{126,124}} = \frac{2}{N_0-126}\frac{\delta\nu^F_{N_0,126}}{\delta\nu^F_{126,124}}$$



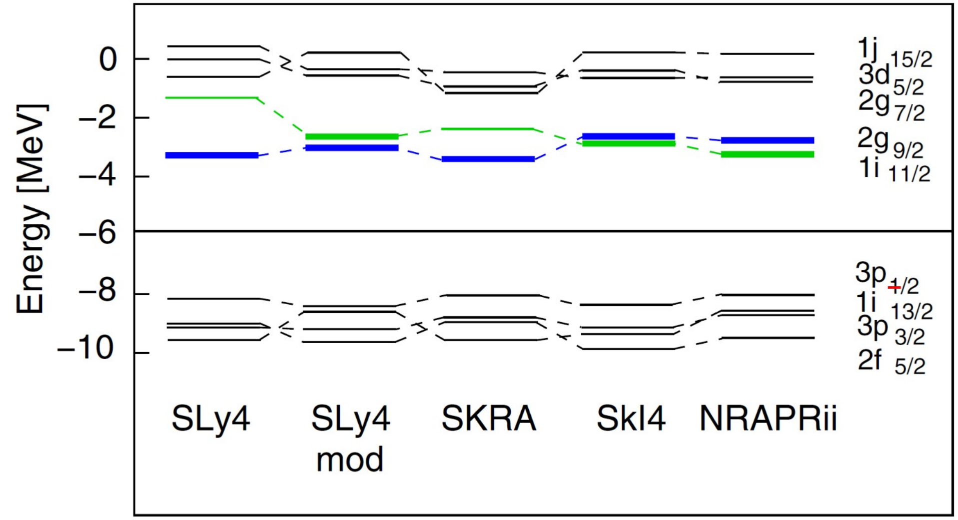
Shell effect in charge radii: Theory

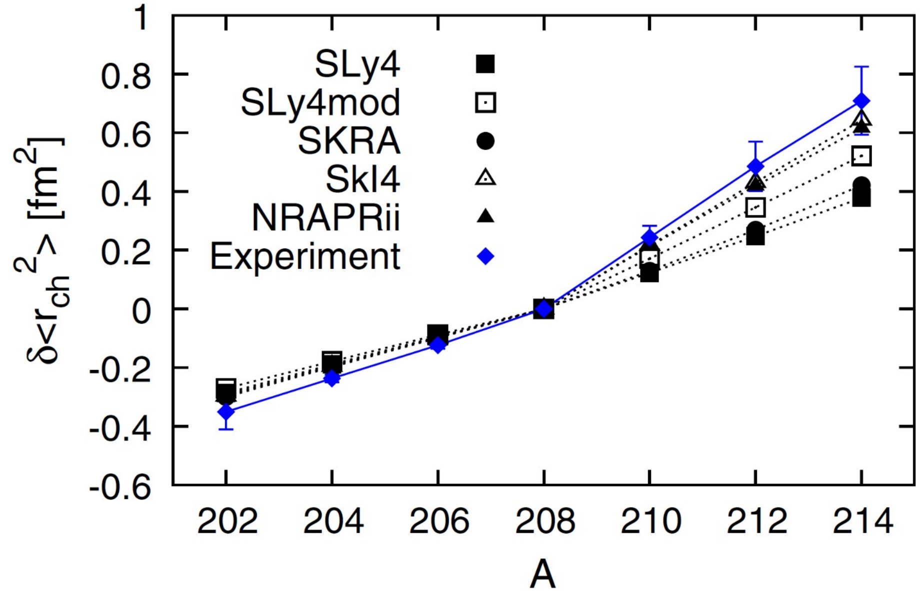
Theory (kink and OES):

RMF
Fayans functional
NR-HF (Nakada) with modified
spin-orbital interaction from
the chiral effective field theory

Different mechanisms:
RMF — Single-particle structure,
inessential smearing effect
of pairing;
Fayans — Pairing with additional
dependence on density gradient
Nakada — Density dependence
of SO interaction.

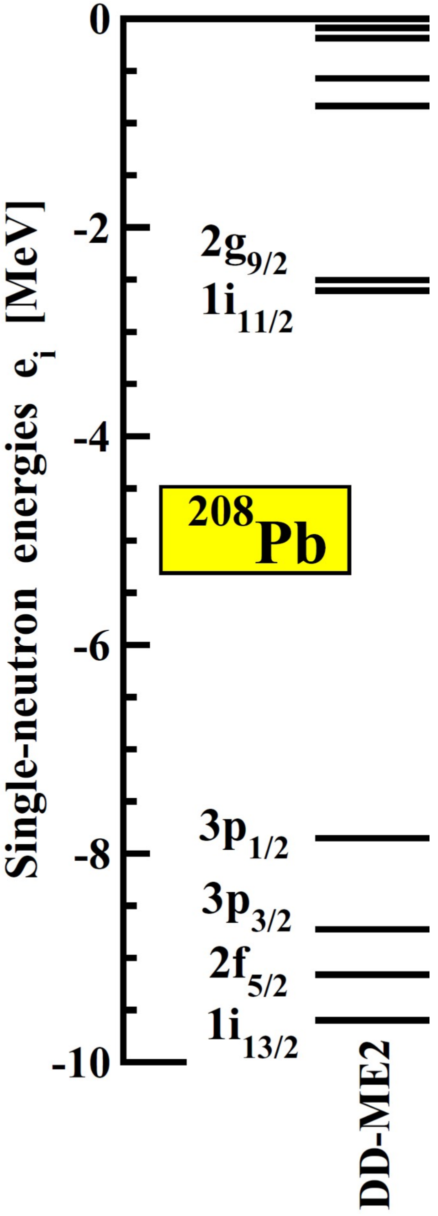
All: crucial role of $\nu i_{11/2}$ occupation





P. M. Goddard, P. D. Stevenson, and A. Rios, PRL 110, 032503 (2013)

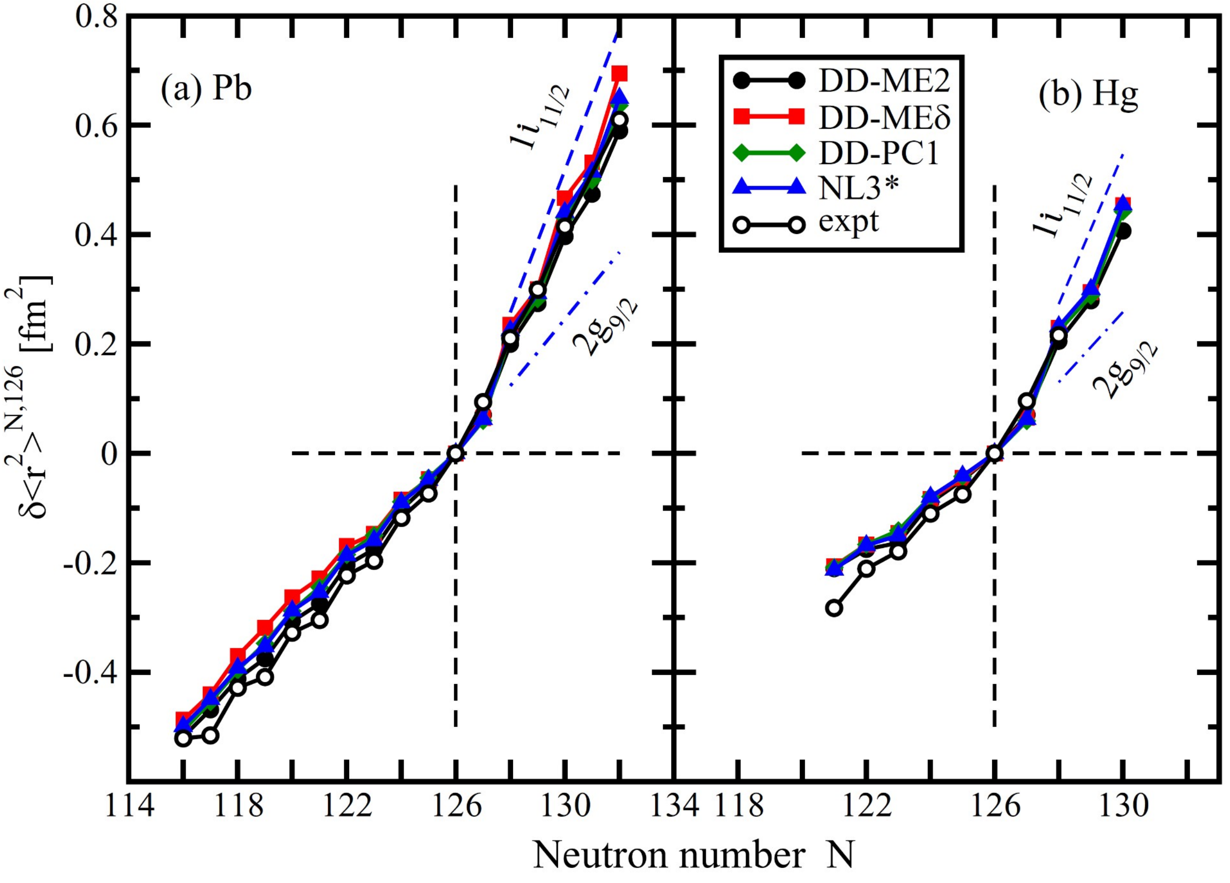
Shell effect in charge radii: Theory



Relativistic Hartree-Bogoliubov calculations with the DD-ME2 functional

$\Delta\varepsilon = \varepsilon_j\,(g_{9/2}) - \varepsilon_j\,(i_{11/2}) = +370$ keV (RMF)

instead of experimental –780 keV



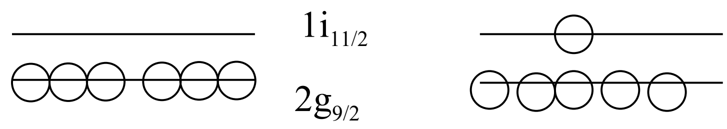
Shell effect in charge radii: test of the theory

$^{215}\mathrm{Bi}^{g}\ [\pi h_{9/2}]$

$^{215}\mathrm{Bi}^{m}\ [\pi h_{9/2} \times (\nu g_{9/2} \times \boldsymbol{\nu i_{11/2}})]_{27/2}$

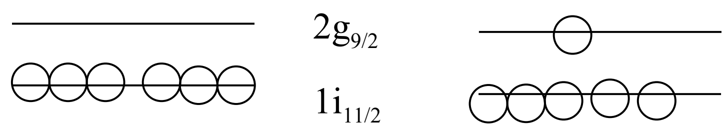
$^{215}\mathrm{Bi}^{g}$ $^{215}\mathrm{Bi}^{m}$

$\boldsymbol{\varepsilon\ (g_{9/2}) < \varepsilon\ (i_{11/2})}$



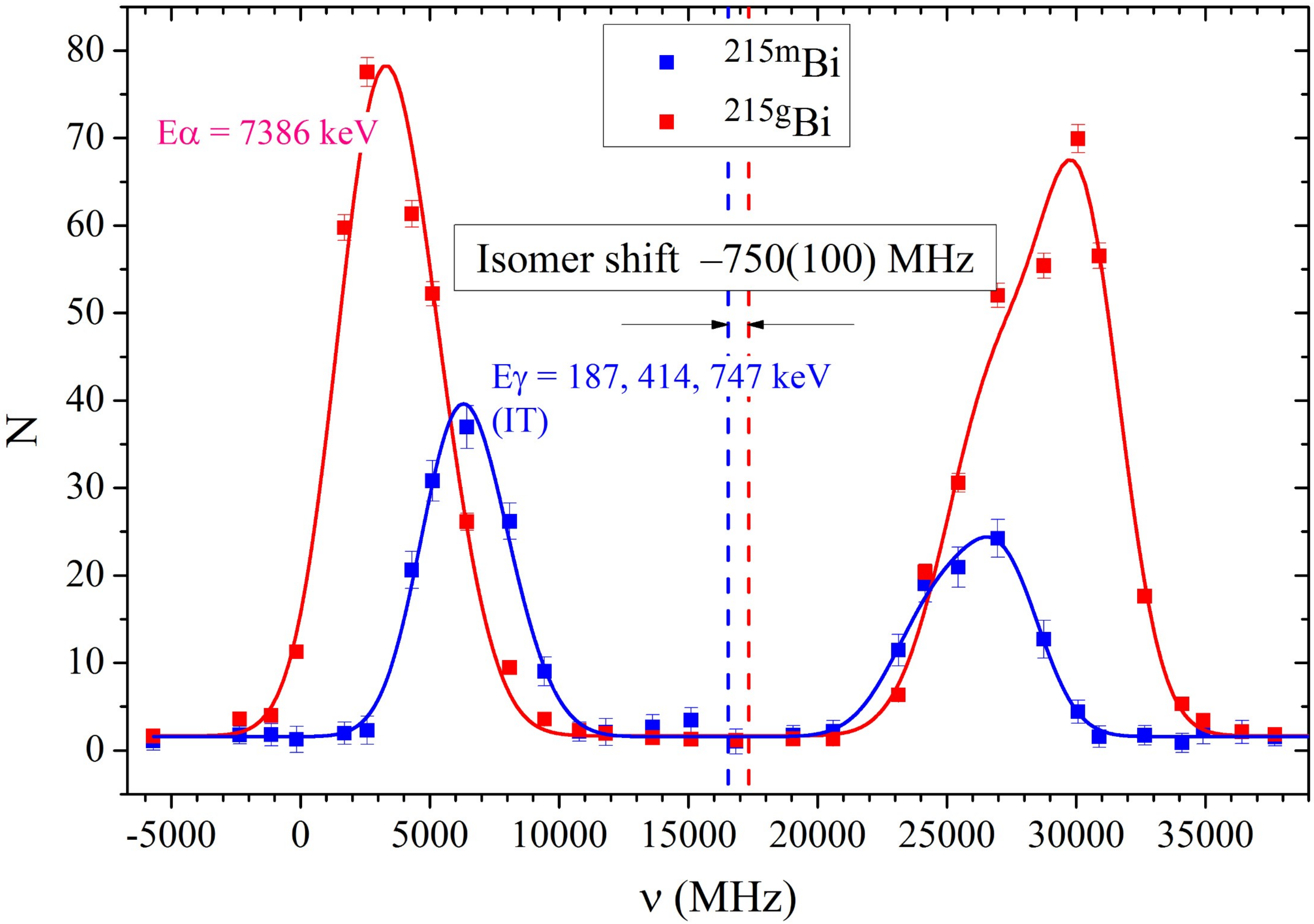
$\mathrm{occ}(i_{11/2}, g) < \mathrm{occ}(i_{11/2}, m) \Rightarrow \delta\langle r^2\rangle(m, g) > 0$

$\boldsymbol{\varepsilon\ (g_{9/2}) > \varepsilon\ (i_{11/2})}$



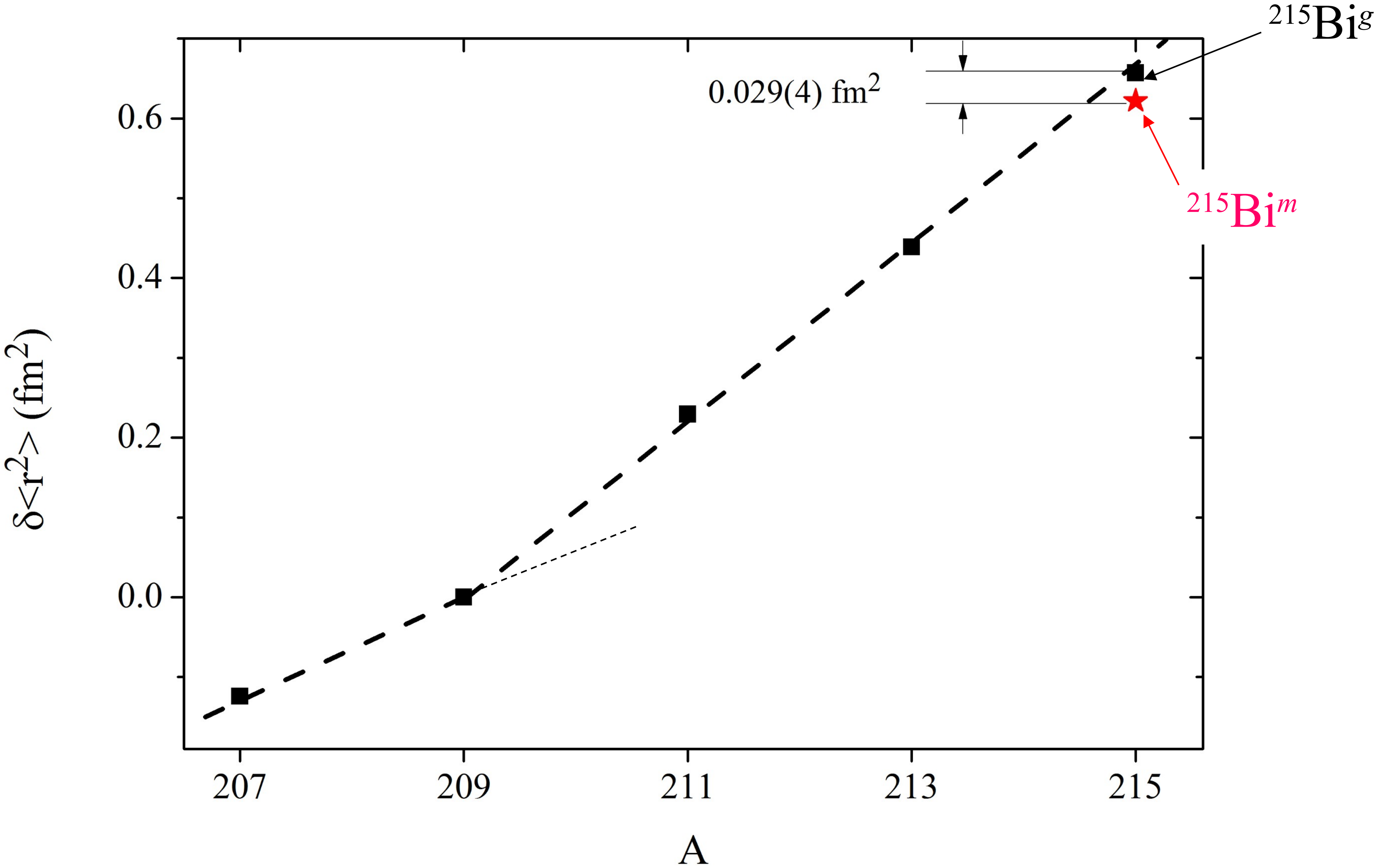
$\mathrm{occ}(i_{11/2}, g) > \mathrm{occ}(i_{11/2}, m) \Rightarrow \delta\langle r^2\rangle(m, g) < 0$

Isomer shift in ^{215}Bi



$\delta\langle r^2\rangle(^{215m}\mathrm{Bi}, {}^{215g}\mathrm{Bi}) = -0.029(4)\ \mathrm{fm}^2 \rightarrow \nu i_{11/2}$ is lower than $\nu g_{9/2}$!

Isomer shift in ^{215}Bi



Isomer shift in ^{215}Bi as a test of the shell-effect theory

μ_{exp} = 3.13(3) n.m.

additivity relation: ⇨ for configuration $[\pi h_{9/2} \times (\nu g_{9/2} \times \nu i_{11/2})]_{27/2}$:

μ_{add} = 3.19 n.m.

confirmation of the assignment of the configuration with the unpaired $\nu i_{11/2}$ neutron

Schematic calculations:

$$v_j^2 = \frac{1}{2}\left[1 - \frac{\varepsilon_j - \lambda}{\sqrt{(\varepsilon_j - \lambda)^2 + \Delta^2}}\right]$$

$$\Delta \approx 0.68\ \mathrm{MeV}$$

$$N = \sum_n (2j_n + 1) v_{j_n}^2$$

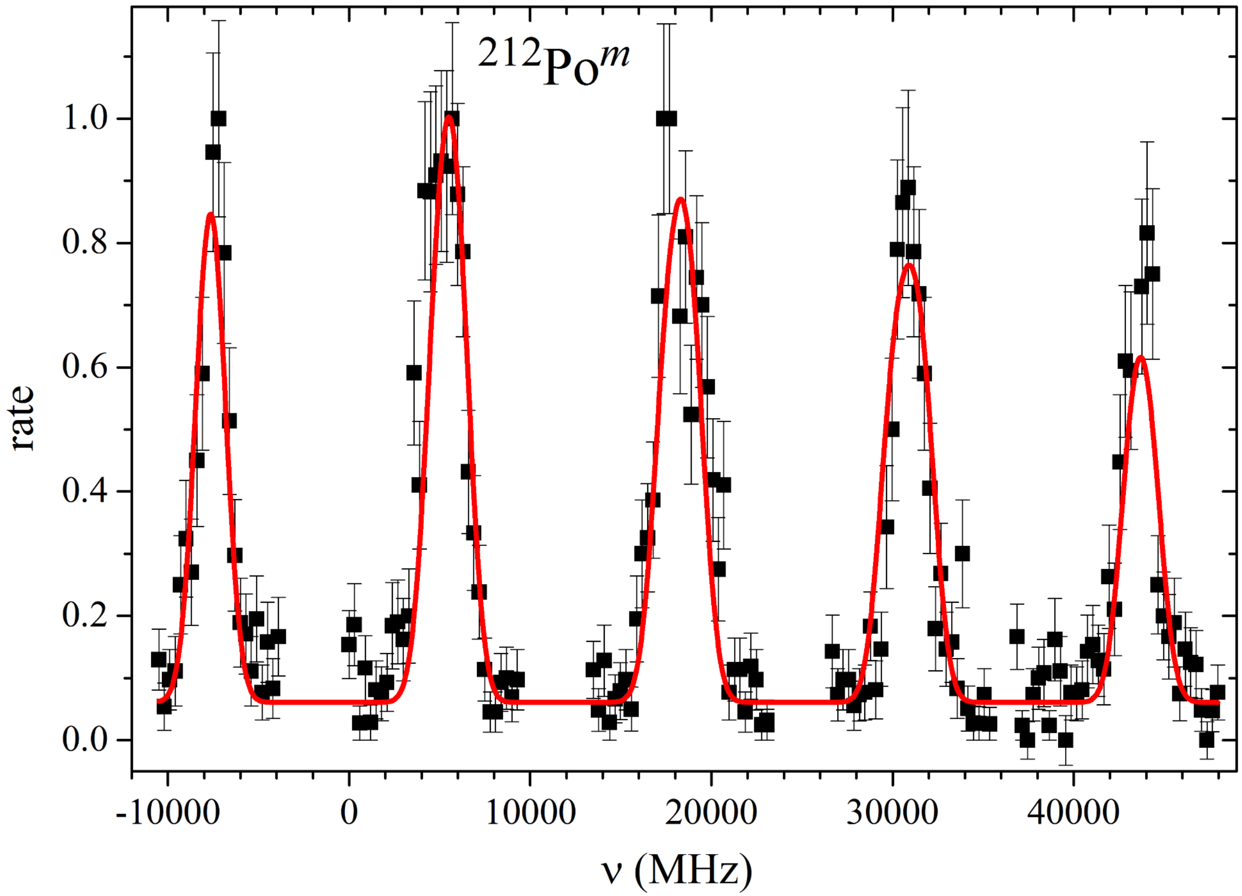
$\Delta\varepsilon = \varepsilon_j\,(g_{9/2}) - \varepsilon_j\,(i_{11/2})$ = +370 keV (RMF); experimental –780 keV

$$\delta\left\langle r^2\right\rangle_{128,126}(ni_{11/2}) = \delta\left\langle r^2\right\rangle_{128,126} - \delta\left\langle r^2\right\rangle_{126,124}$$

$\delta\langle r^2\rangle(^{215m}\mathrm{Bi}, ^{215g}\mathrm{Bi})$: expt.		–0.029(4) fm^2
	calc. ($\Delta\varepsilon$ = +370 keV)	–0.026 fm^2
	calc. ($\Delta\varepsilon$ = –780 keV)	+0.110 fm^2
	calc. (Nakada)	+0.008 fm^2

Isomer shift in ^{212}Po as a test of the shell-effect theory

$^{212}Po^{m}$: tentative configuration $(\pi(h_{9/2}{}^{2}))_{8} \times (\nu g_{9/2} \times \boldsymbol{\nu i_{11/2}})_{10})_{18+}$



$\mu_{exp} = 7.34(10)\ \mu_N$

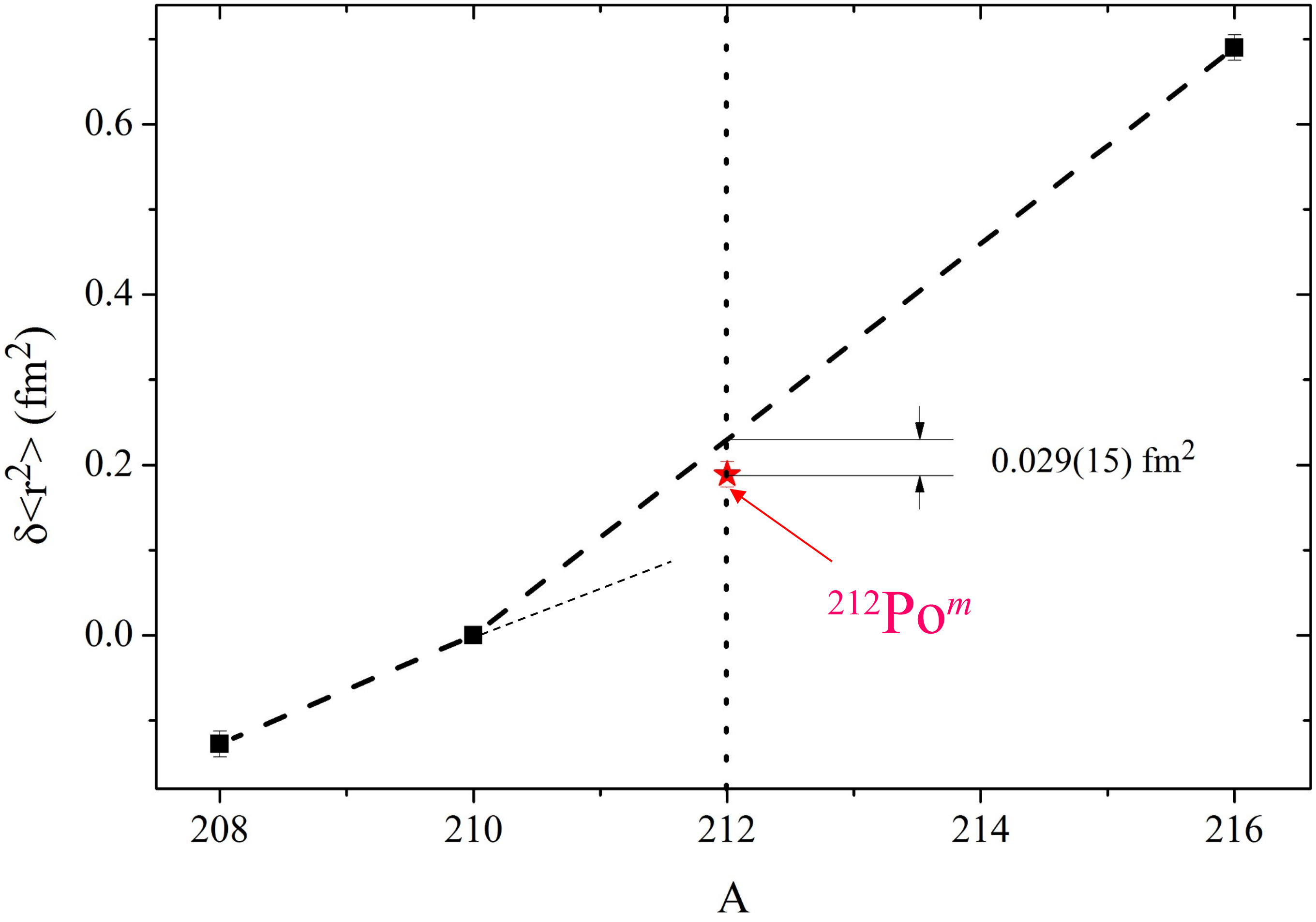
additivity relation:

$\mu_{add} = 7.3\ \mu_N$

⇓

configuration is confirmed

Isomer shift in ^{212}Po as a test of the shell-effect theory



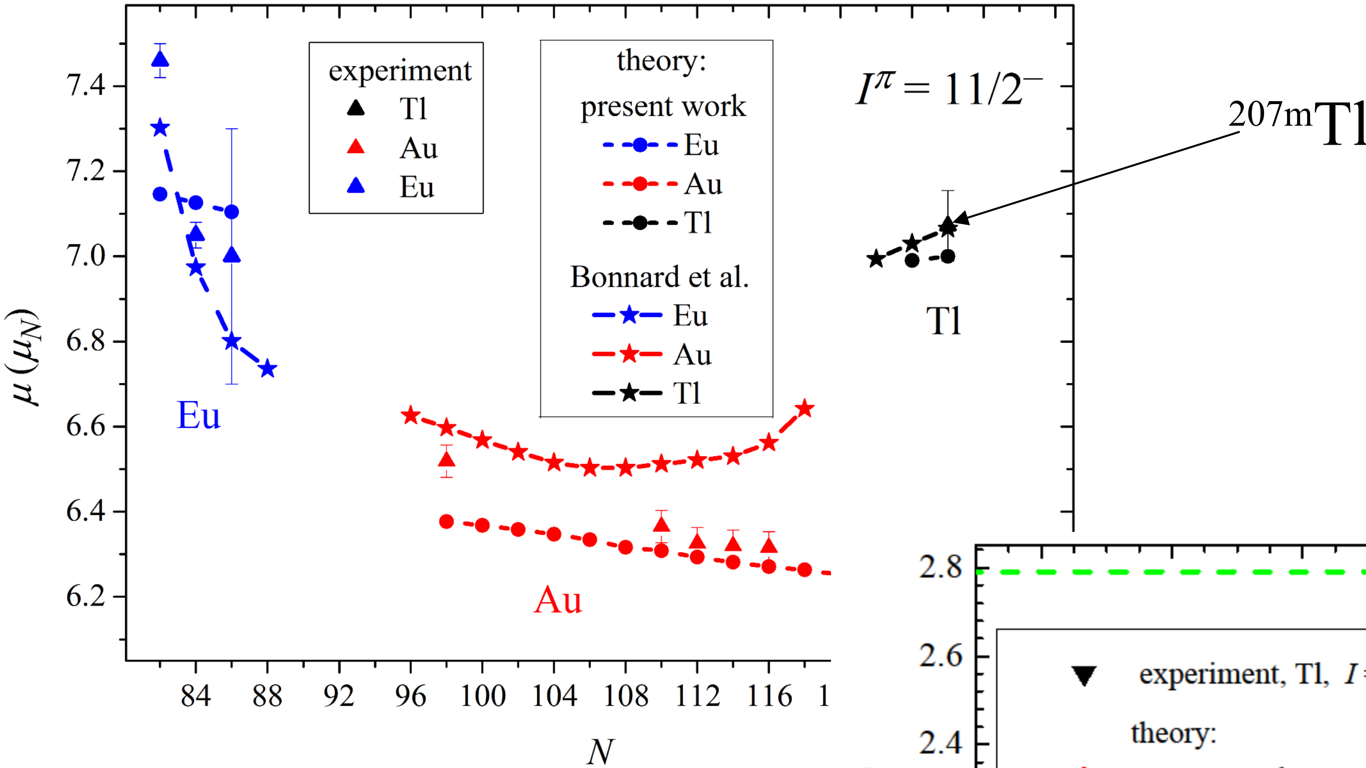
$\delta\langle r^2\rangle(^{212m}\mathrm{Po}, {}^{212g*}\mathrm{Po}) = -0.029(15)\ \mathrm{fm}^2 \rightarrow \nu i_{11/2}$ is lower than $\nu g_{9/2}$!

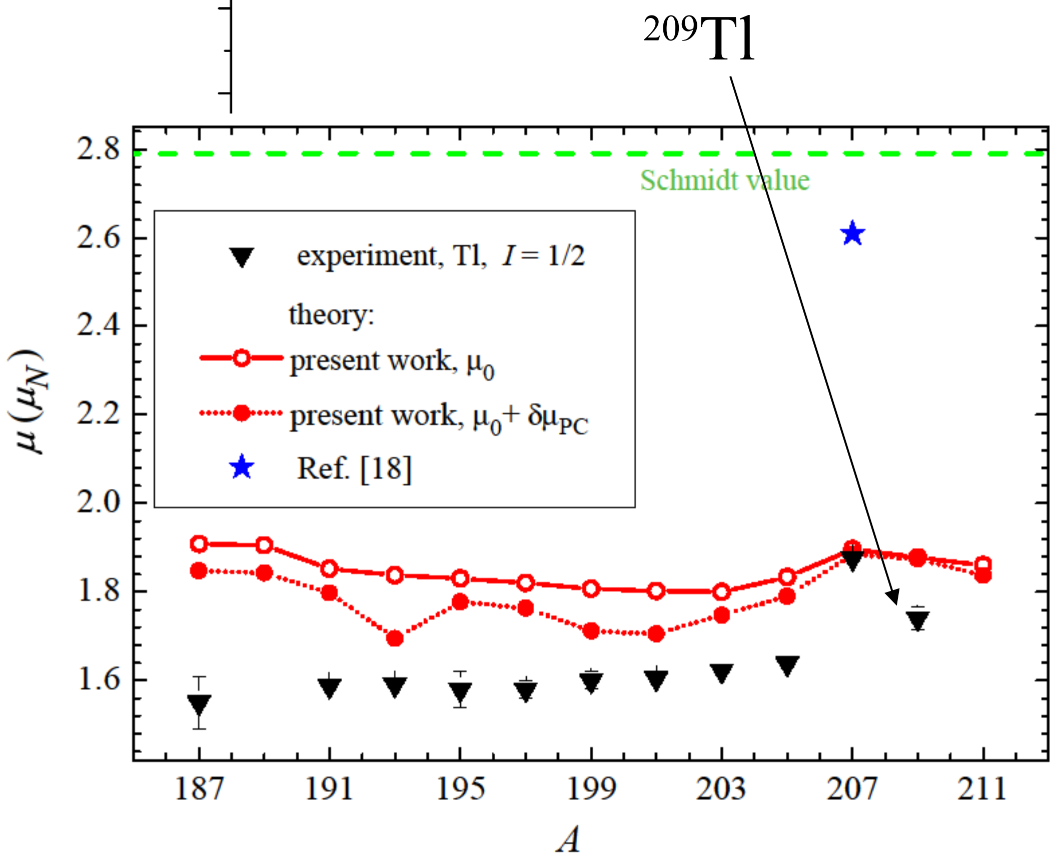
calc. ($\Delta\varepsilon$ = +370 keV) –0.026 fm²

$^{212}\mathrm{Bi}^{m2}\ [\pi h_{9/2} \times ((\nu g_{9/2})^2 \times \boldsymbol{\nu i_{11/2}})]_{18}$,

$^{213}\mathrm{Bi}^{m}\ [\pi h_{9/2} \times (\nu g_{9/2} \times \boldsymbol{\nu i_{11/2}})]_{25/2}$

Magnetic moments of Tl isotopes





an essential role of the time-odd core polarization and angular-momentum symmetry restoration.

Публикации

1. J. G. Cubiss, A. E. Barzakh, D. V. Fedorov, P. L. Molkanov, S. D. Prosnyak, M. D. Seliverstov, L. V. Skripnikov, et al., *Deformation versus Sphericity in the Ground States of the Lightest Gold Isotopes*, Phys. Rev. Lett. **131**, 02501 (2023).
2. Yu. A. Demidov, M. G. Kozlov, A. E. Barzakh, and V. A. Yerokhin, *Bohr-Weisskopf effect in the potassium isotopes,* Phys. Rev. C **107**, 024307 (2023).
3. G. Penyazkov, S. D. Prosnyak, A. E. Barzakh, and L. V. Skripnikov, *Refined theoretical values of field and mass isotope shifts in thallium to extract charge radii of Tl isotopes*, J. Chem. Phys. **158**, 114110 (2023).
4. S. Hellgartner, D. Fedorov et. al., *Axial and triaxial degrees of freedom in* ^{72}Zn, Phys. Lett. B **841** 137933 (2023).