MB31

BOLOGNA SECTION

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ILLUSTRISSIMO SENATVI BONONIENSI
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I. BLAEV.
Density Functional Theory
Pairing
Particle-Vibration Coupling
Optical Potentials
Electron Scattering
Collective modes
Parity Violation
Hypernuclei

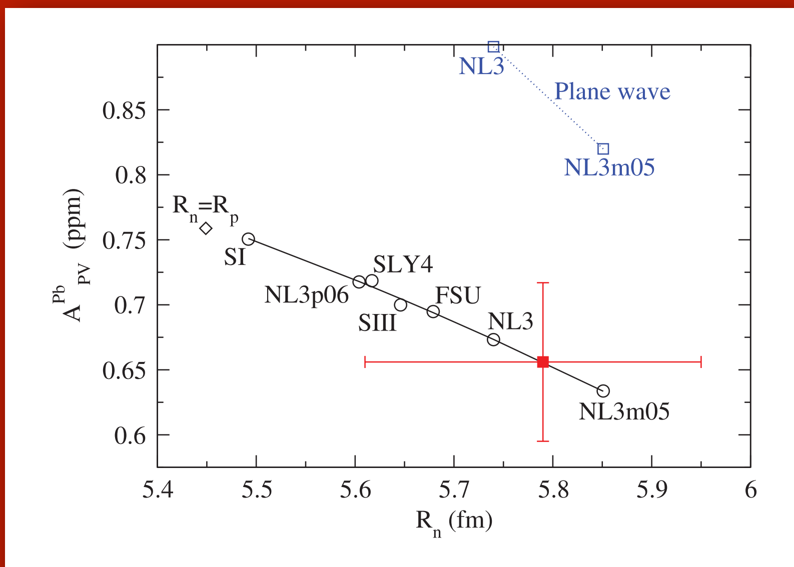
Electron scattering & Parity violation

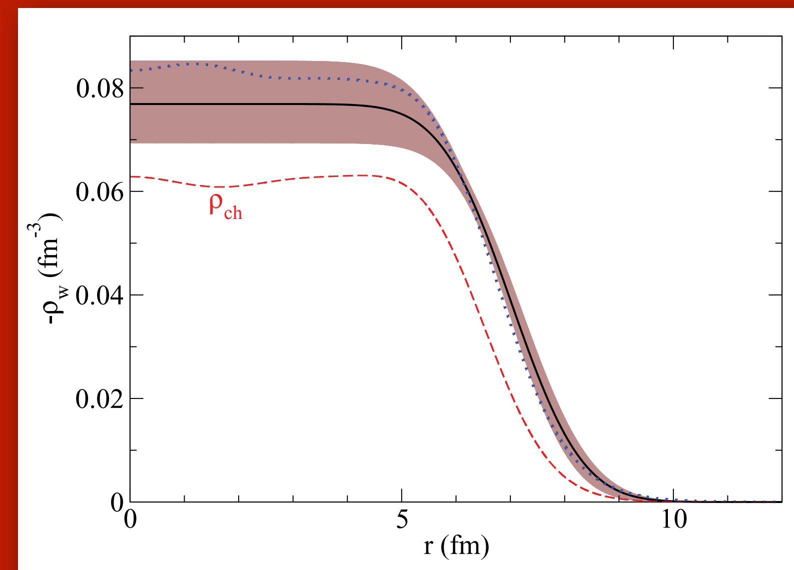
PRL **108,** 112502 (2012) PHYSICAL REVIEW LETTERS week ending 16 MARCH 2012

Measurement of the Neutron Radius of ^{208}Pb through Parity Violation in Electron Scattering

PHYSICAL REVIEW C **85**, 032501(R) (2012)

Weak charge form factor and radius of ^{208}Pb through parity violation in electron scattering





$$A_{pv} = \frac{d\sigma/d\Omega_+ - d\sigma/d\Omega_-}{d\sigma/d\Omega_+ + d\sigma/d\Omega_-}$$

$$A_{pv} = \frac{G_F Q^2}{2\pi\alpha\sqrt{2}} \frac{F_W(Q^2)}{F_{\rm ch}(Q^2)}$$

$$F_W(Q^2) = \int d^3r \frac{\sin(Qr)}{Qr} \rho_W(r)$$

In collaboration with Pavia (see Vorabbi)

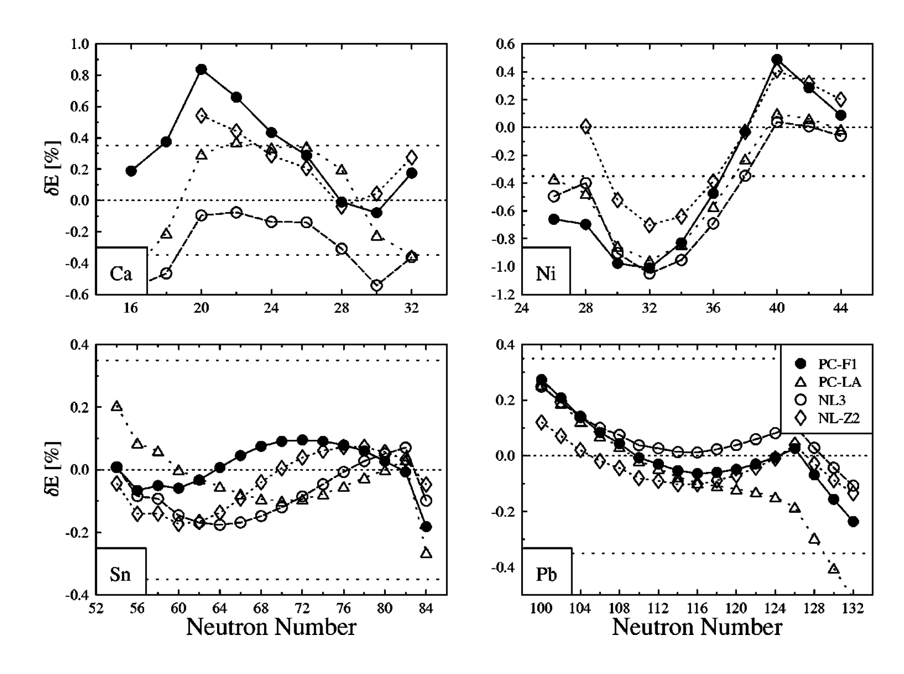
Density functional: ground & collective states

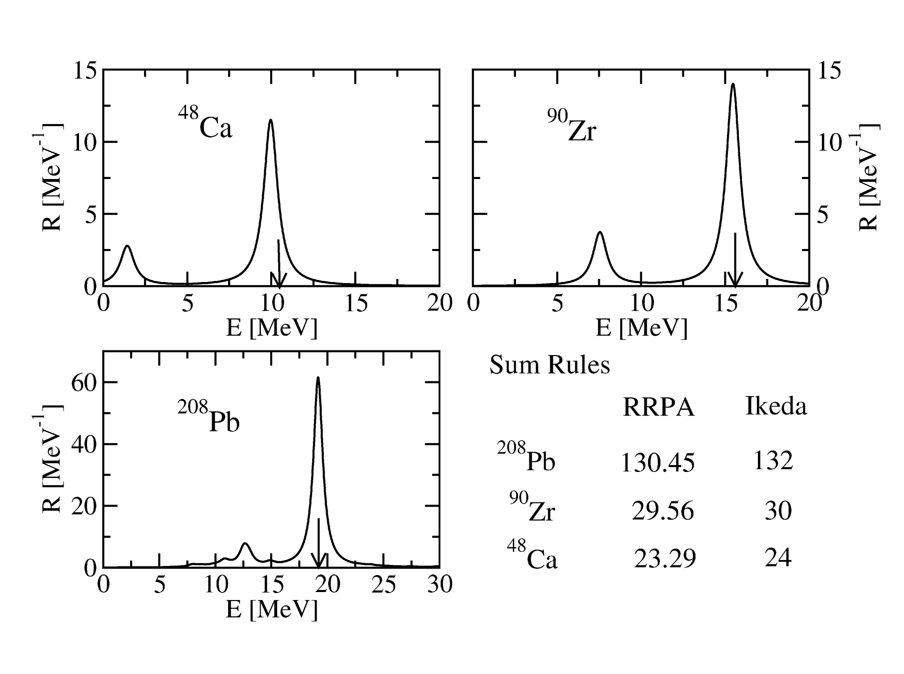
Meson-exchange

- Non linear
- Density dependent

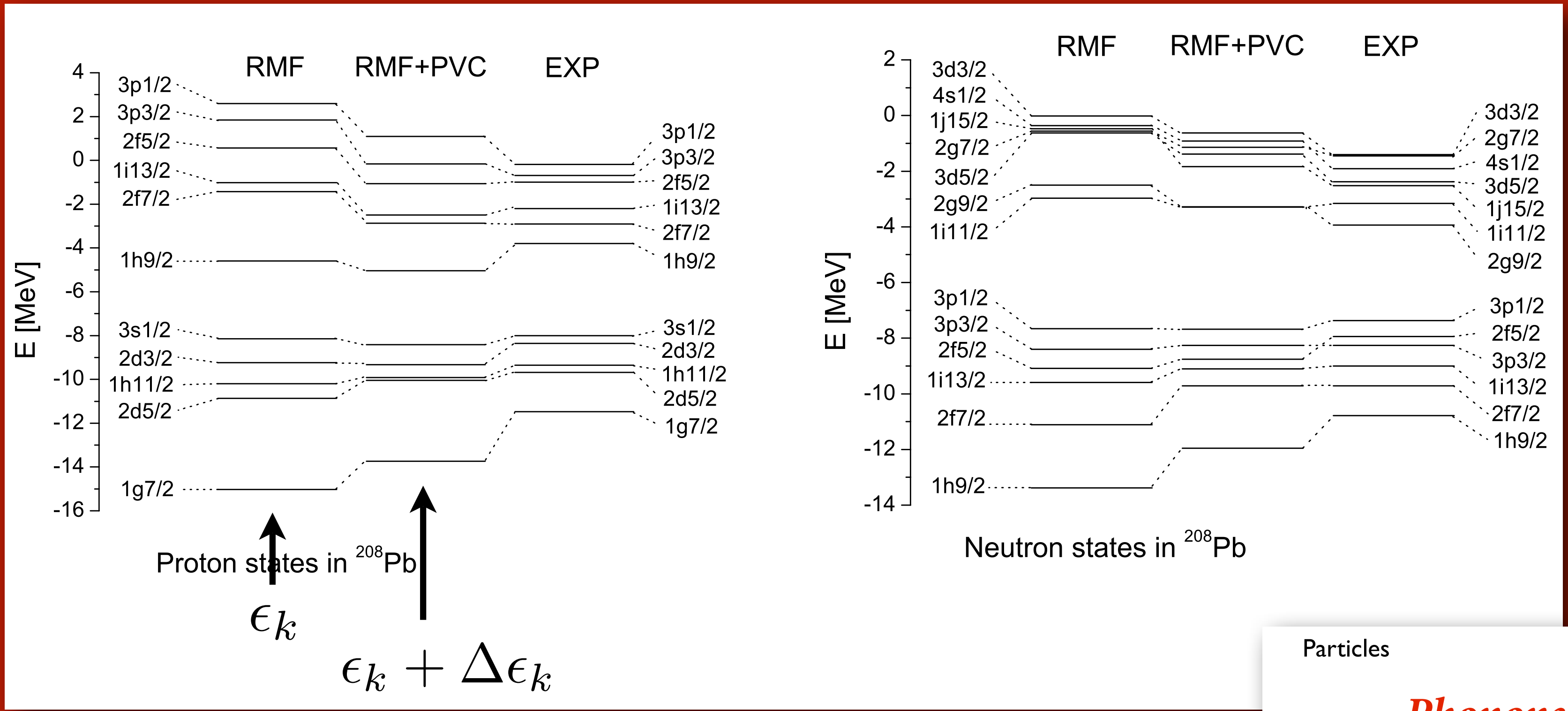
Point coupling

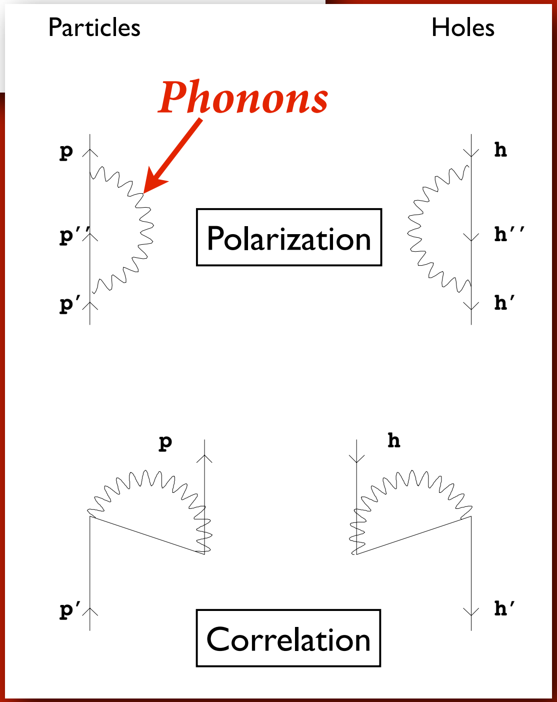
- Non linear
- Density dependent
  - -phenomenological
  - -chiral dynamics inspired





Particle-vibration coupling





Particle-vibration coupling is still an open issue: so far no theoretical approach is self-consistent

Corrections are always on top of the mean-field calculation

Particle-vibration coupling

Total energy

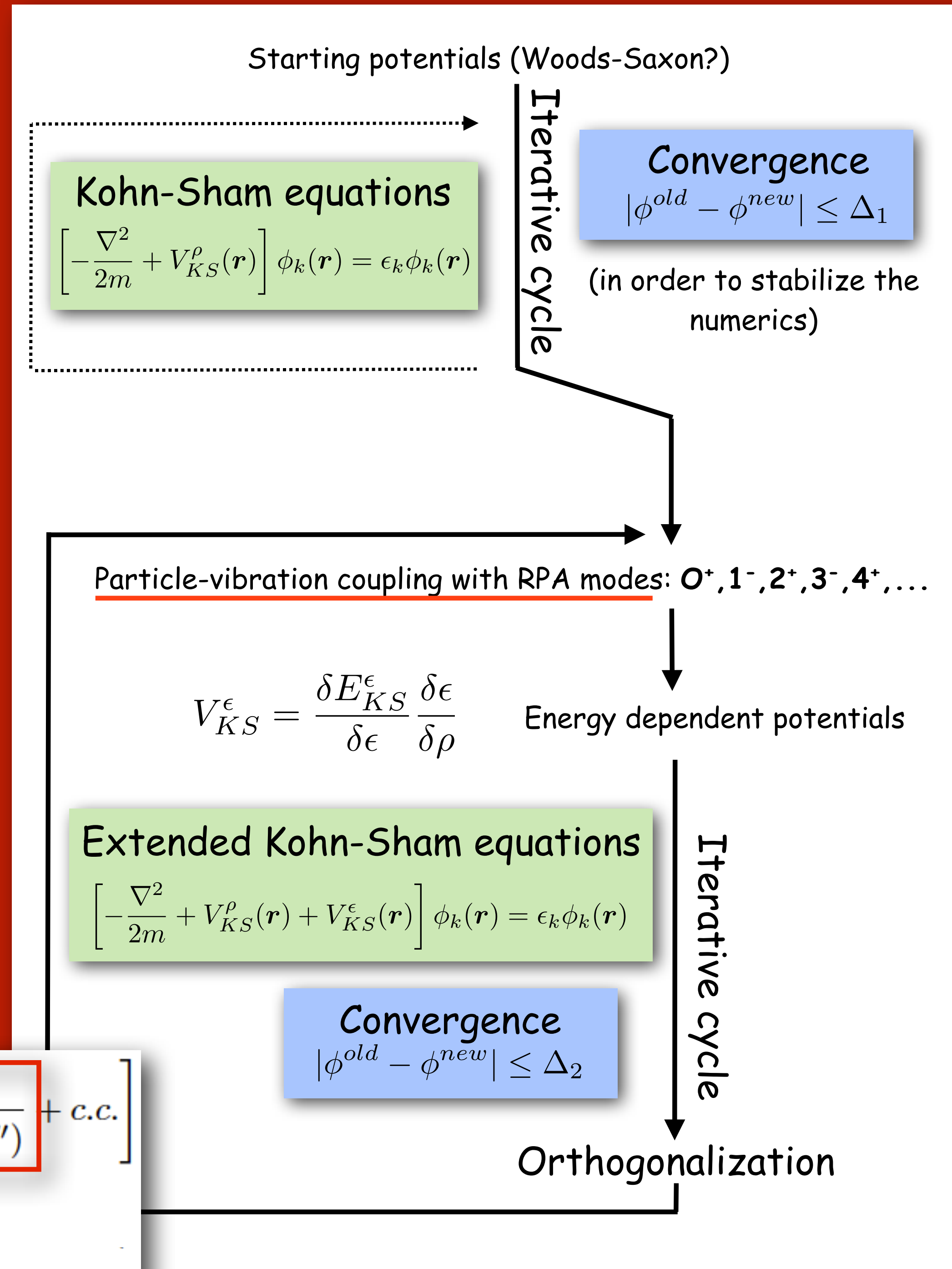
$$E_{\rm tot}[n] = T_{\rm s}[n] + E_{\rm ext}[n] + E_{\rm H}[n] + E_{\rm xc}[n] \; \left(+ E_{\rm ion} \right)$$

Kinetic term

External potential

Hartree potential

Exchange correlation term



Explicit dependence on KS orbitals and energies

$$\frac{\delta E_{\rm xc}[\phi_k, \epsilon_k]}{\delta n(\boldsymbol{r})} = \int {\rm d}^3 r' \, \frac{\delta v_{\rm s}(\boldsymbol{r}')}{\delta n(\boldsymbol{r})} \sum_k \left\{ \int {\rm d}^3 r'' \left[\frac{\delta \phi^{\dagger}_k(\boldsymbol{r}'')}{\delta v_{\rm s}(\boldsymbol{r}')} \boxed{\frac{\delta E_{\rm xc}}{\delta \phi^{\dagger}_k(\boldsymbol{r}'')}} + c.c. \right] + \frac{\delta \epsilon_k}{\delta v_{\rm s}(\boldsymbol{r}')} \boxed{\frac{\partial E_{\rm xc}}{\partial \epsilon_k}} \right\}$$

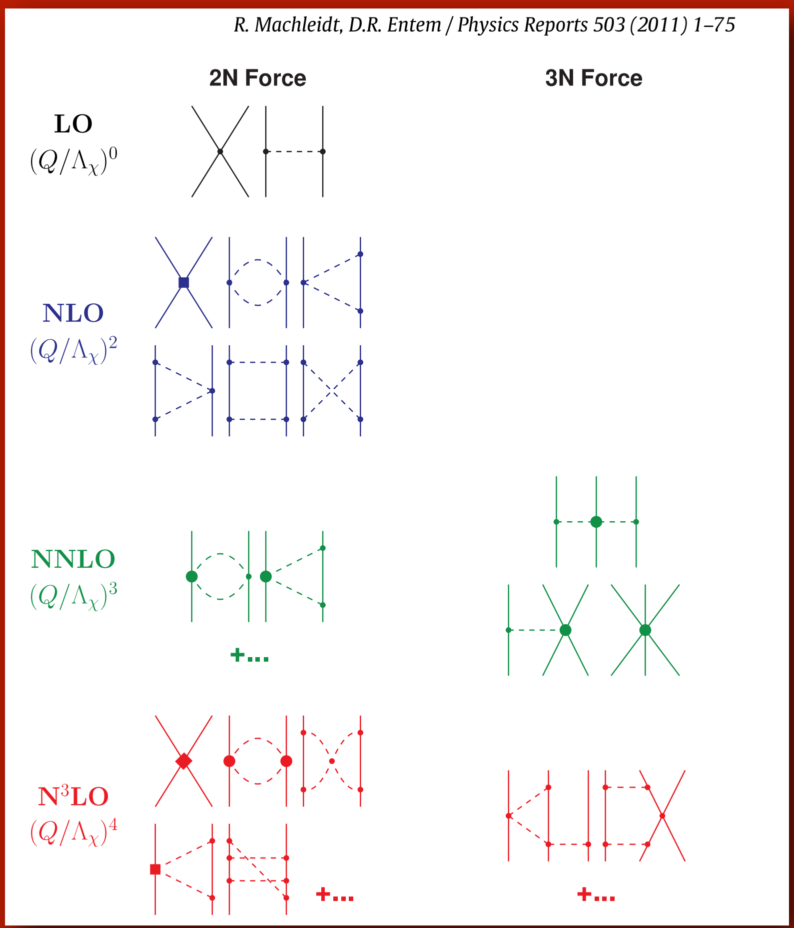
In collaboration with ...

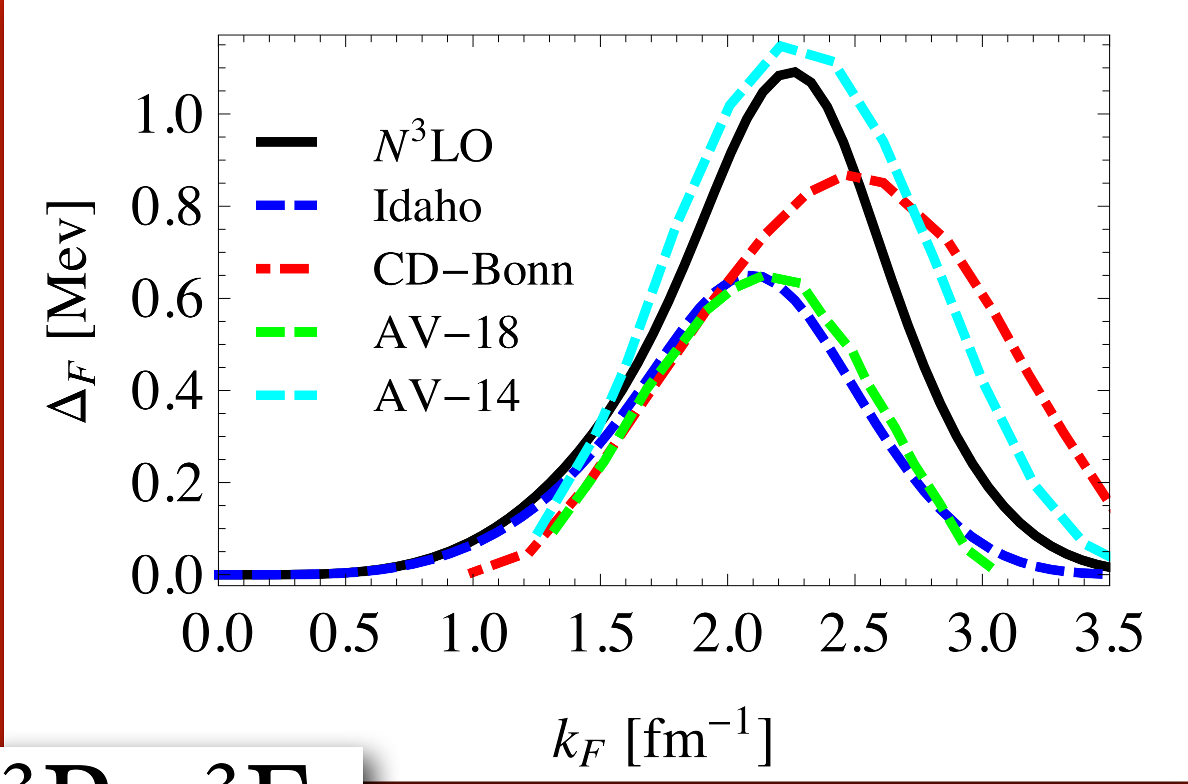
Pairing (from realistic forces)

$$\begin{pmatrix} \Delta_L \\ \Delta_{L'} \end{pmatrix}(k) = -\frac{1}{\pi}\int_0^\infty dk' k'^2 \frac{1}{E(k')} \begin{pmatrix} V_{LL} & -V_{LL'} \\ -V_{L'L} & V_{L'L'} \end{pmatrix}(k,k') \begin{pmatrix} \Delta_L \\ \Delta_{L'} \end{pmatrix}(k')$$

$$E(k)^2 = [\epsilon(k) - \epsilon(k_F)]^2 + D(k)^2$$

$$D(k)^2 = \Delta_L(k)^2 + \Delta_{L'}(k)^2$$





$^3P_2$-$^3F_2$

In collaboration with S. Maurizio

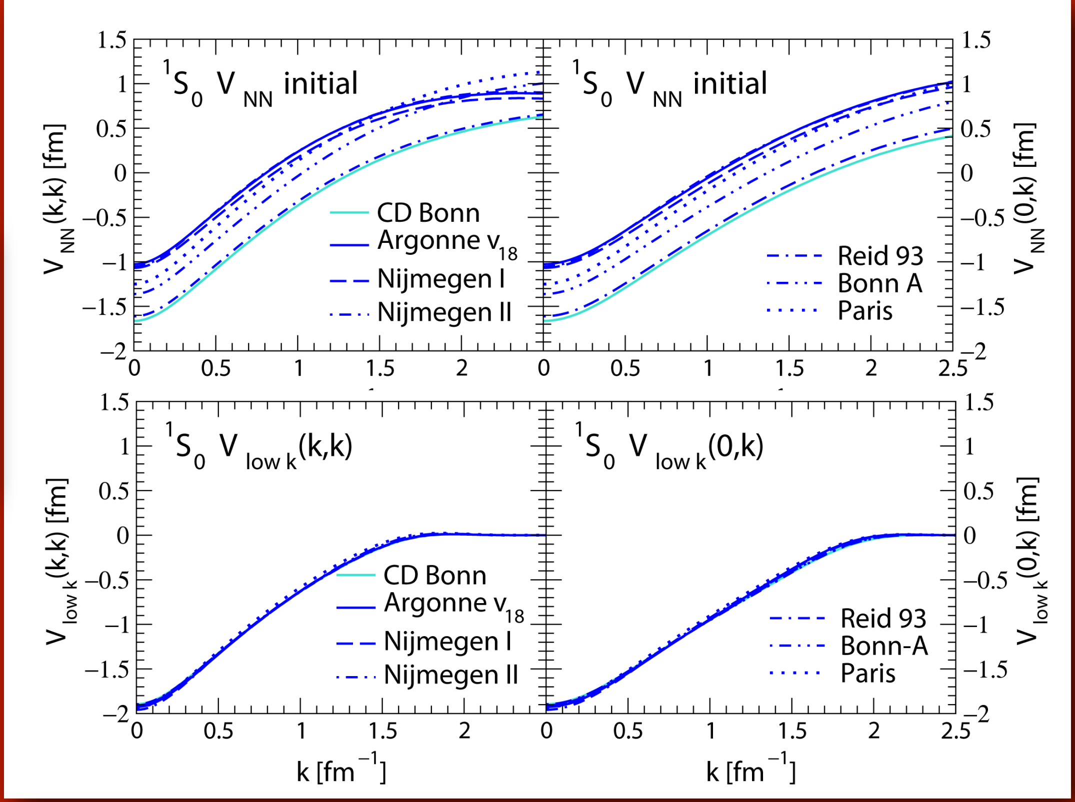
Optical Potentials with V_{lowk}

$$T_\Lambda(p,q;q^2) = V_\Lambda(p,q) + \frac{2}{\pi}\int dk k^2 V_\Lambda(p,k) f_\Lambda^2(k) \frac{1}{q^2-k^2} T_\Lambda(k,q;q^2)$$

$$\frac{d}{d\Lambda} T_\Lambda(p,q;q^2) = 0$$

$$\frac{d}{d\Lambda} V_\Lambda(p,q) = \frac{2}{\pi}\int dk k^2 V_\Lambda(p,k) T(k,q;q^2) \frac{d}{d\Lambda}\left[f^2(k)\right] \frac{1}{k^2-q^2}$$

$$V_{Low\ k}(p,q) = f_\Lambda(p) V_\Lambda(p,q) f_\Lambda(q)$$



Optical Potentials with V_{lowk}

~~NN potential → G-matrix~~

~~Phenomenological densities~~

V_{lowk}

ρ_{mf}

$$U(E,r) = \lambda_R V(E,r) + i\lambda_I W(E,r) + \lambda^R_{SO} V_{SO}(E,r) + i\lambda^I_{SO} W_{SO}(E,r).$$

In collaboration with ...

Hypernuclei

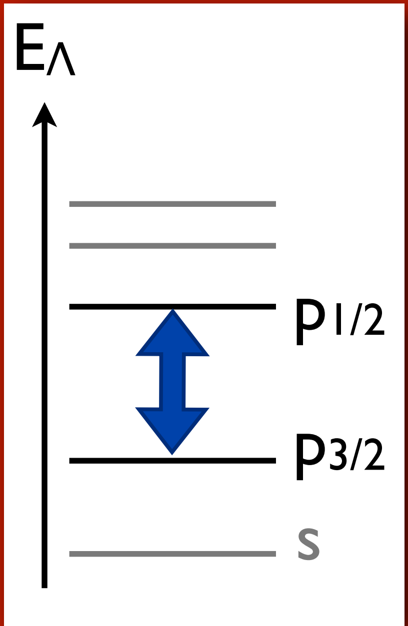
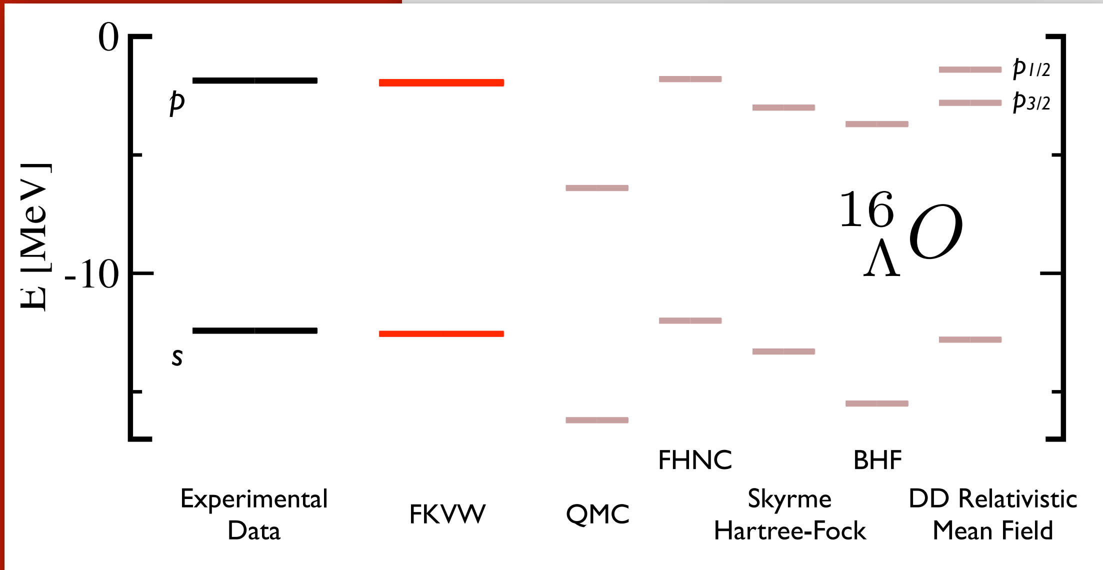


Table 4

P-shell spin–orbit splittings $\Delta \equiv \Delta\epsilon^{\Lambda}(p)$ for six hypernuclei ($^{13}_{\Lambda}$C, $^{16}_{\Lambda}$O, $^{40}_{\Lambda}$Ca, $^{89}_{\Lambda}$Y, $^{139}_{\Lambda}$La, $^{208}_{\Lambda}$Pb). Experimental values [44], or empirical estimates [1,47,48], are shown in comparison with our theoretical predictions (FKVW), using a broad range of ζ parameters (see Eq. (12)), and other relativistic calculations with (RMFI [11]) or without (RMFII [14]) tensor coupling. All energies are given in keV. The asterisk means that a local fit has been necessary.

Nucleus	Exp. Δ [keV]	FKVW ($0.4 \leqslant \zeta \leqslant 0.66$)	RMFI [11]	RMFII [14]
$^{13}_{\Lambda}$C	$152 \pm 54 \pm 36$ [44]	$-160 \leqslant \Delta \leqslant 510$	310	$\sim 1100^*$
$^{16}_{\Lambda}$O	$300 \leqslant \Delta \leqslant 600$ [47] $-800 \leqslant \Delta \leqslant 200$ [1]	$-210 \leqslant \Delta \leqslant 490$	270	~ 1400
$^{40}_{\Lambda}$Ca	–	$-140 \leqslant \Delta \leqslant 420$	210	~ 1400
$^{89}_{\Lambda}$Y	90 [48]	$-40 \leqslant \Delta \leqslant 180$	110	~ 700
$^{139}_{\Lambda}$La	–	$-20 \leqslant \Delta \leqslant 80$	50	~ 300
$^{208}_{\Lambda}$Pb	–	$-20 \leqslant \Delta \leqslant 70$	50	~ 300



Hypernuclei

KEK_J-PARC-PAC2012-XV

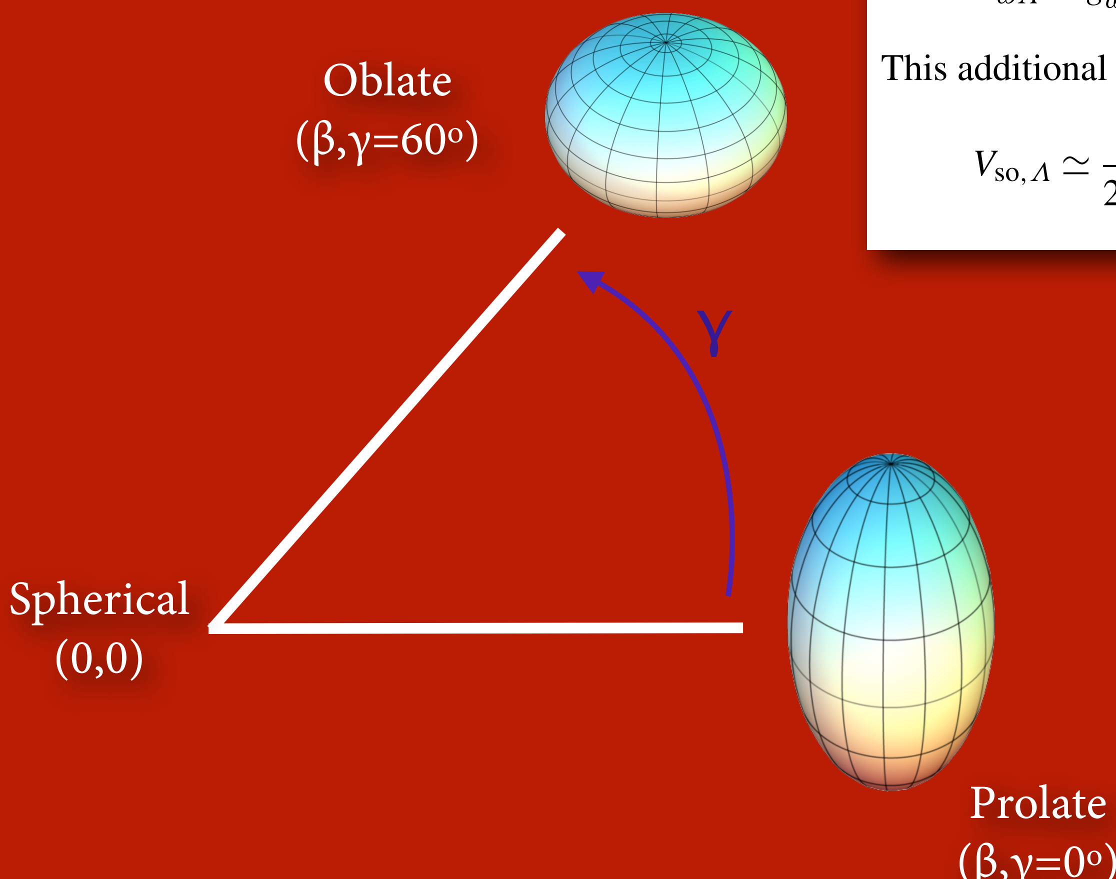
Letter of Intent for J-PARC 50 GeV Proton Synchrotron

γ-ray spectroscopy of a well deformed *sd*-shell nucleus: $^{25}_{\Lambda}$Mg

$$\mathcal{L}_{\omega\Lambda} = g_{\omega}^{\Lambda}\bar{\psi}_{\Lambda}\gamma^{\mu}\psi_{\Lambda}\omega_{\mu} + \frac{f_{\omega}^{\Lambda}}{2M_{\Lambda}}\bar{\psi}_{\Lambda}\sigma^{\mu\nu}\psi_{\Lambda}\partial_{\nu}\omega_{\mu}.$$

This additional term modifies the effective Λ spin–orbit potential as follows:

$$V_{\mathrm{so},\Lambda} \simeq \frac{1}{2M_{\Lambda}^{*2}}\left[\frac{1}{r}\frac{\partial}{\partial r}\left(\left(2\frac{f_{\omega}^{\Lambda}}{g_{\omega}^{\Lambda}}+1\right)\Sigma_{V}^{\Lambda} - \Sigma_{S}^{\Lambda}\right)\right]\boldsymbol{l}\cdot\boldsymbol{s}.$$



Because of tensor forces, a Λ hyperon in a *p* state could induce different deformations

In collaboration with ...