The Core of ^{25}F in the rotational model

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Outline

Short introduction

Shell Model and residual interactions

Deformation and the Nilsson Model

Particle Rotor Model 101

Application to ^{29}F

The structure of ^{25}F and its core

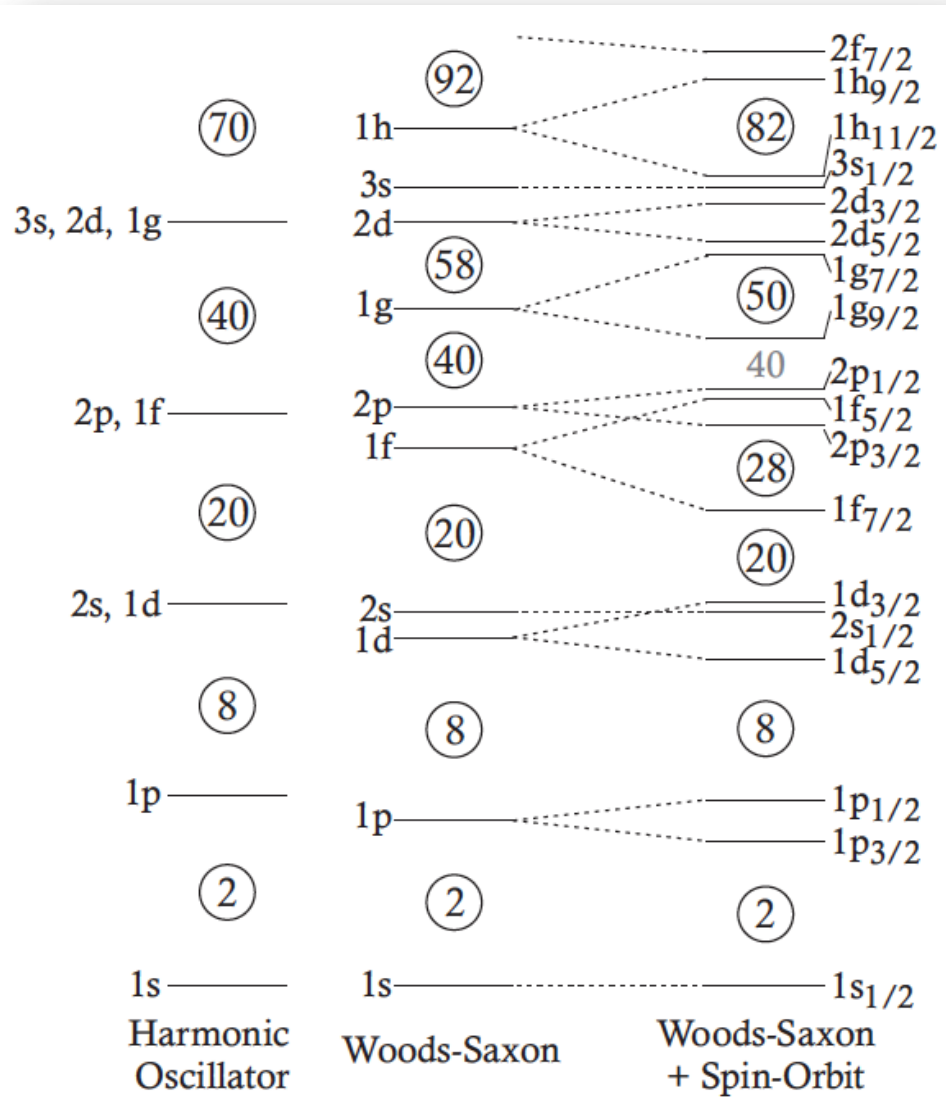
RIBF (p,2p) studies

NSCL p-KO

The PRM view

Summary and Conclusions

Nuclear Shell Model



Maria Goeppert-Mayer & Hans D. Jensen 1963

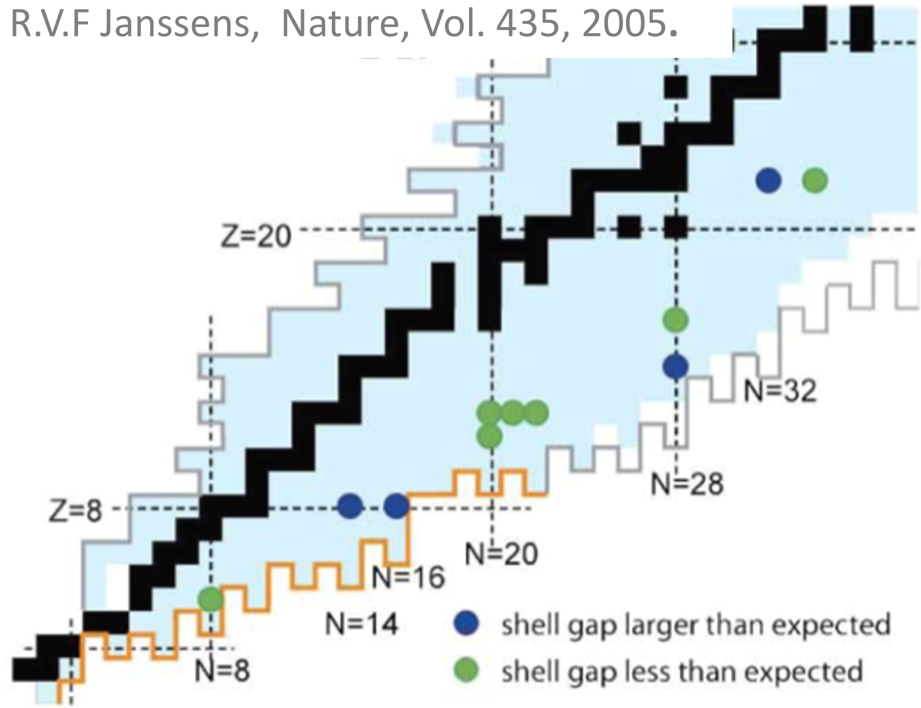
Maria Goeppert-Mayer, Phys. Rev. **75**, 1969 (1949).
O. Haxel, Phys. Rev. **75**, 1766 (1949).

Evolution of Shell Structure and Collectivity

"Classic" magic numbers are generally correct only for stable and near stable isotopes

Experimental studies of new exotic isotopes revealed changes in shell structure and collectivity, and provided insight on the important role played by the central, tensor, (and 3N) forces in these changes

R.V.F Janssens, Nature, Vol. 435, 2005.



A. Poves and J. Retamosa, Phys. Lett. B 184, 311 (1987).

E.K. Warburton, J.A. Becker and B.A. Brown, Phys. Rev. C 41, 1147 (1990).

T. Otsuka *et al.*, Phys. Rev. Lett. **87**, 082502 (2001).

O. Sorlin and M. Porquet, Prog. Part.Nucl. Phys. **61**, 602 (2008).

K. Heyde and J. L. Wood, Rev. Mod. Phys. **83**, 1467 (2011).*

T. Otsuka, A. Gade and O. Sorlin, Rev. Mod. Phys.,92(2020)

Evolution of Shell Structure and Collectivity

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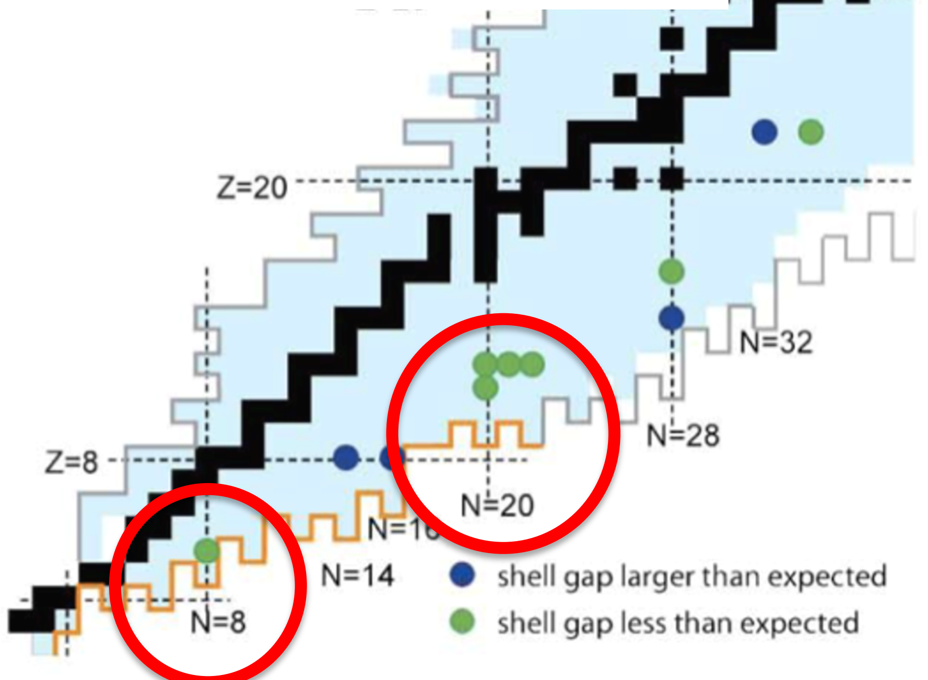

Much evidence has been obtained for the existence of deformed ground states, and a good understanding of the physical mechanism behind the inversion.

Reviews of Modern Physics, Vol. 48, No. 2, Part I, April 1976

The effective interaction between nucleons deduced from nuclear spectra*

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William W. True

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1.B:
1.D.1

Nuclear Physics **A239** (1975) 45–73;

EFFECTIVE TWO-BODY INTERACTION IN SIMPLE NUCLEAR SPECTRA

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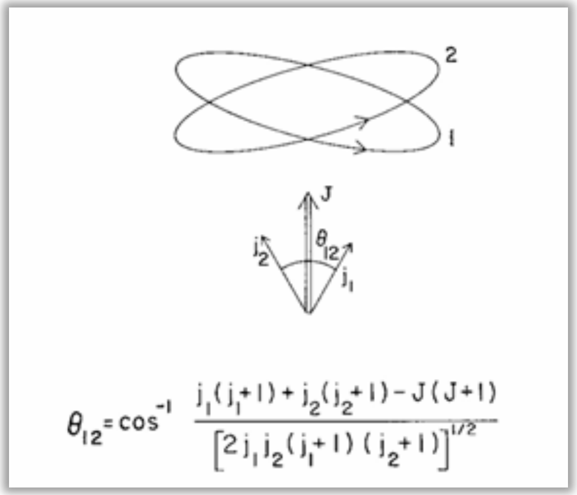
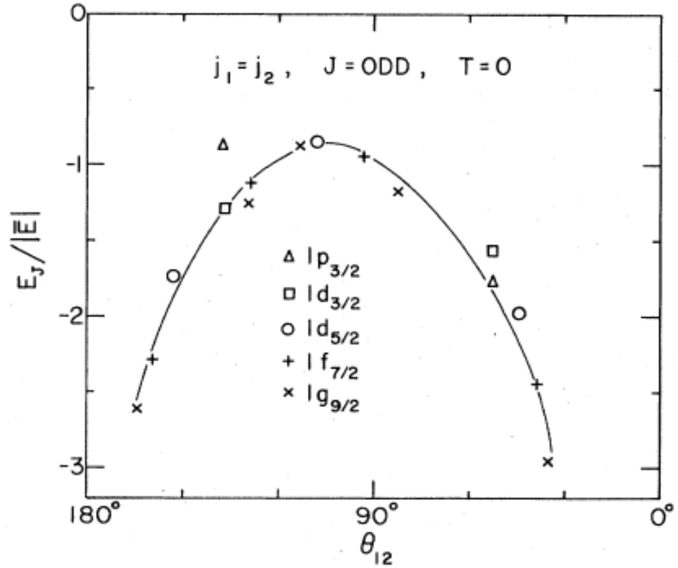
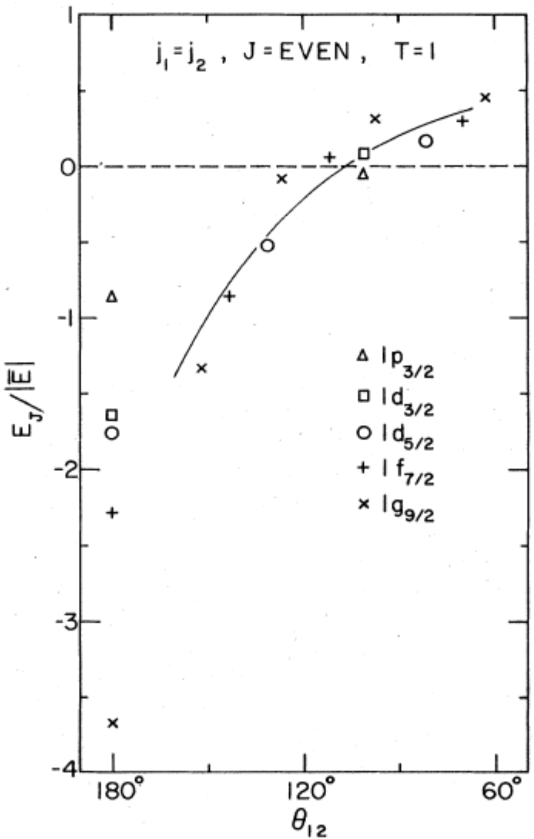
and

W. M. ALBERICO

Istituto di Fisica Teorica dell'Università di Torino, Torino, Italy







$$V(1,2) \approx G\delta(\theta_{12}) + V_2 P_2(\theta_{12})$$

Short-range (Pairing) + long-range (Quadrupole)

$$G \approx 20 MeV / A \qquad V_2 \approx 50 MeV / A$$

Evolution of Shell Structure and Collectivity

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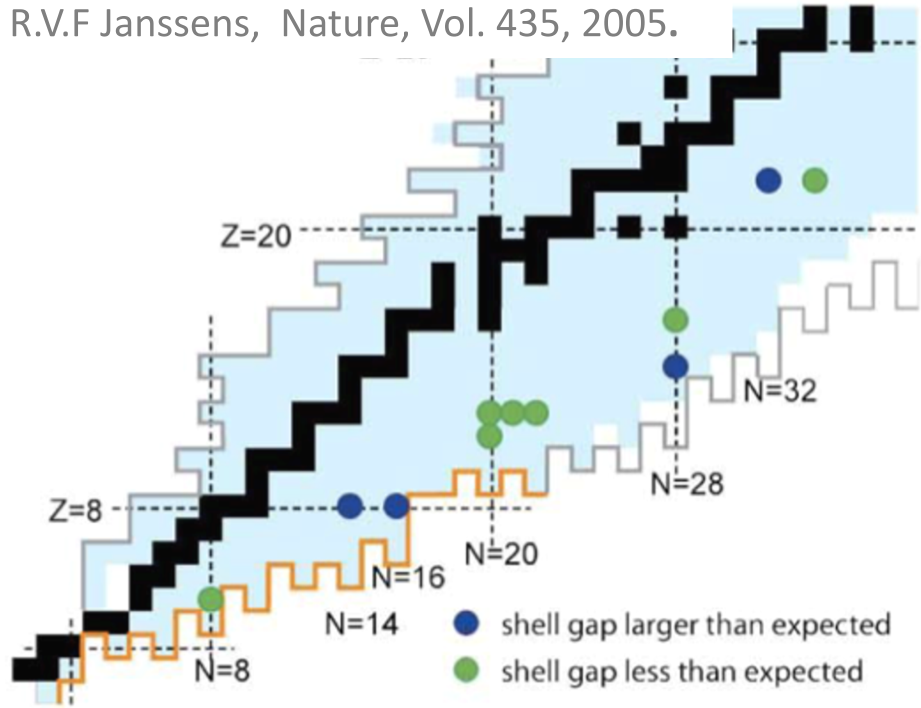
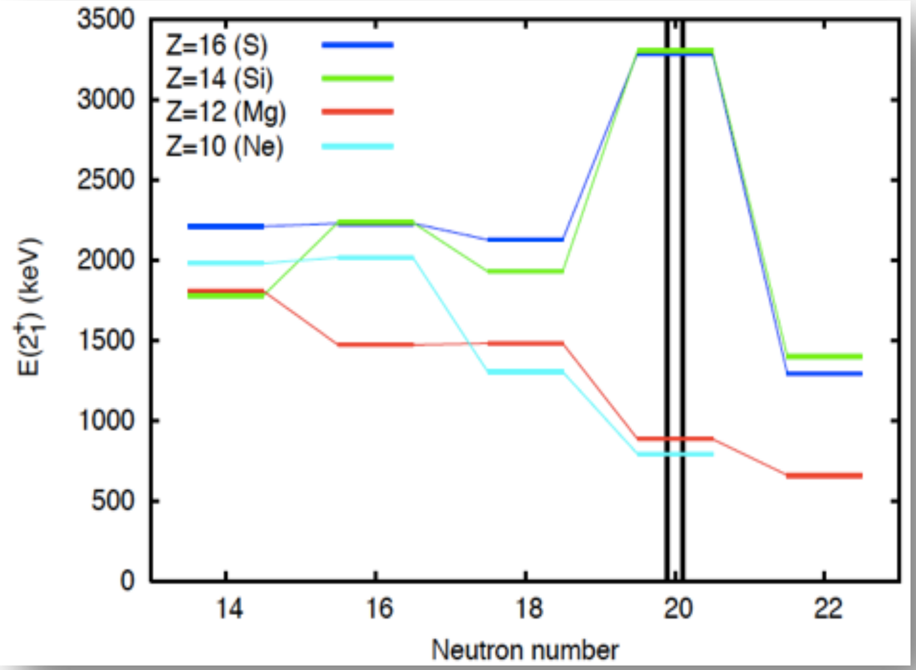


For many body configurations the **single-particle energy scale** plays a major role

A delicate balance between the monopole field and correlations.

$$H = Esp + GP^{+}P + xQ.Q$$

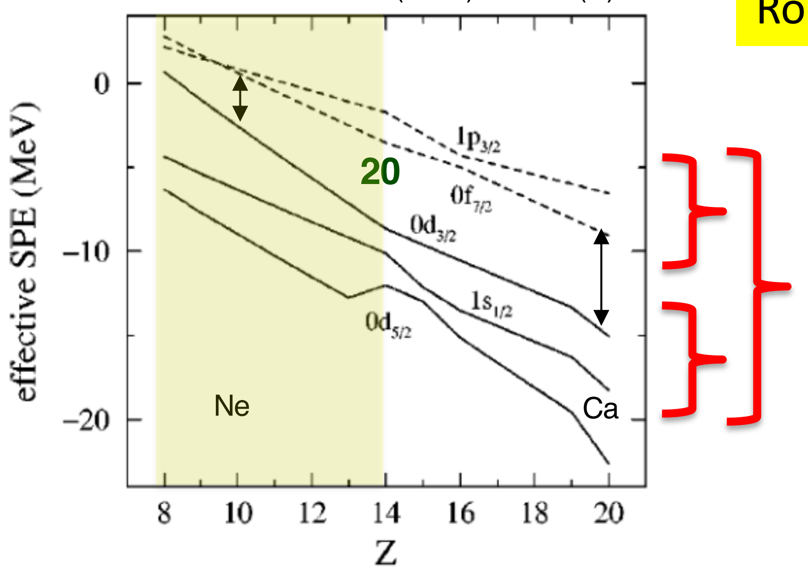
N=20 shell gap



A. Poves and J. Retamosa, Phys. Lett. B **184**, 311 (1987).
E. K. Warburton, J. A. Becker, and B. A. Brown, Phys. Rev. C**41**, 1147 (1990).

N=20 shell gap

Y.Utsuno et al PRC 60 (1999) 011301(R)



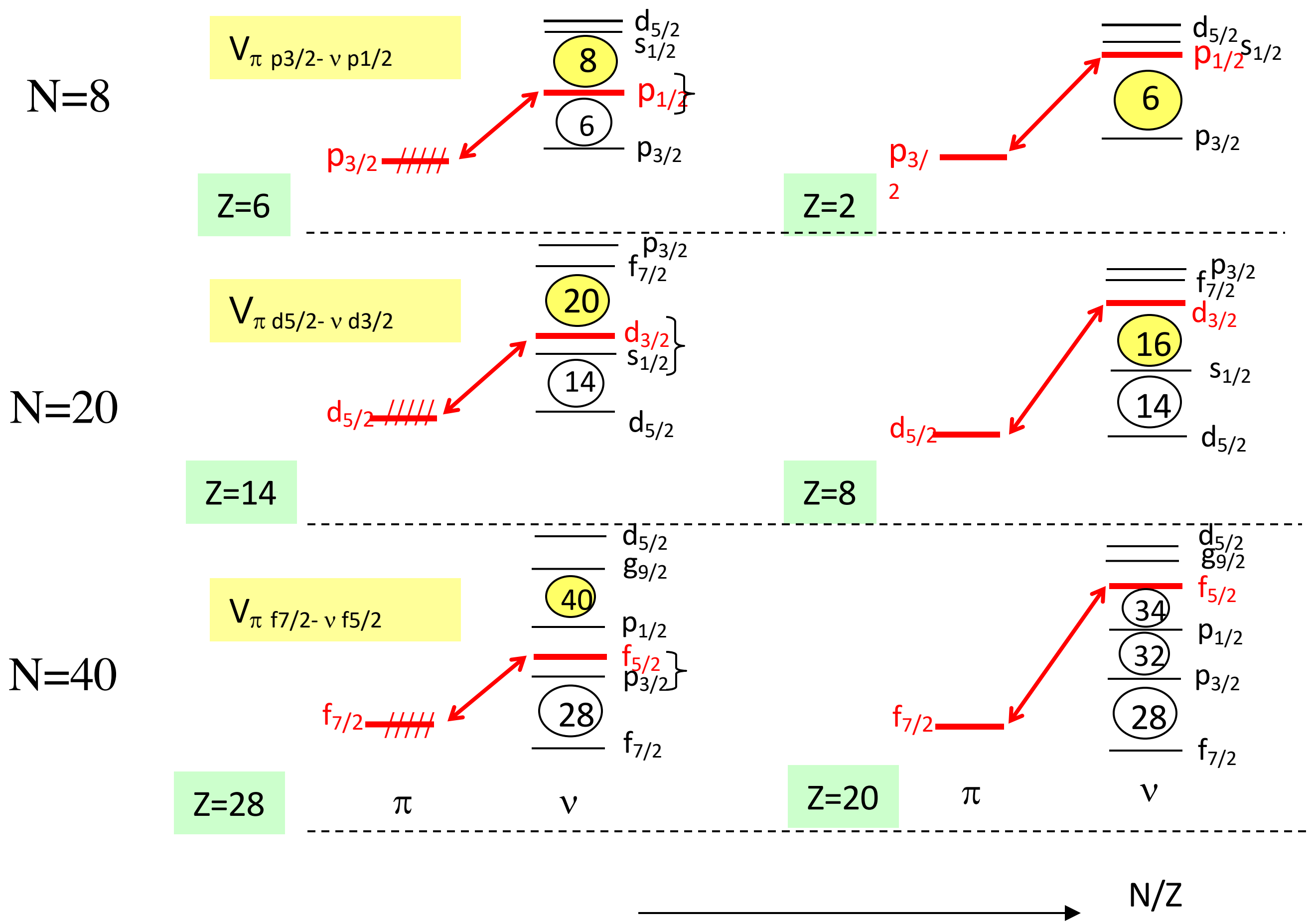
$d_{5/2}$ | $s_{1/2}$ | $d_{3/2}$

Role of the $\pi\ d_{5/2}$- $\nu\ d_{3/2}$ interaction

$\Delta l=\Delta j=2$
→ Quadrupole Correlations

$$H = Esp + GP^{+}P + xQ.Q$$

Harmonic Oscillator Shell Closures



O. Sorlin and M. Porquet, Prog. Part.Nucl. Phys. **61**, 602 (2008).

How about the deformed shell model ?

Nilsson Model

- Anisotropic harmonic oscillator potential

$$V(r) = \frac{1}{2} m\left(\omega_1^2 x^2 + \omega_2^2 y^2 + \omega_3^2 z^2\right) - C\mathbf{l}.\mathbf{s} - Dl^2$$

- If axial symmetry is presumed: $\omega_1 = \omega_2 \neq \omega_3$
- An elongation parameter, ε, is introduced such that:

$$\omega_3 = \omega_0\left(1 - \frac{2}{3}\varepsilon\right) \qquad \omega_1 = \omega_2 = \omega_0\left(1 + \frac{1}{3}\varepsilon\right) \qquad \varepsilon = \frac{(\omega_1 - \omega_3)}{\omega_0}$$

- Without spin-orbit and l^2 term the Nilsson energy levels are given by:

$$E = \hbar\omega_1\left(n_1 + \frac{1}{2}\right) + \hbar\omega_2\left(n_2 + \frac{1}{2}\right) + \hbar\omega_3\left(n_3 + \frac{1}{2}\right) = \hbar\omega_0\left[\left(N + \frac{3}{2}\right) - \varepsilon\left(n_3 - \frac{N}{3}\right)\right]$$

- In addition to the principal oscillator number N and its component n_3 the Nilsson quantum numbers are $\Lambda = l_z$, $\Sigma = s_z$, $\Omega = \Lambda + \Sigma = j_z$ and parity $\pi = (-1)^l$.

- Nilsson levels are labeled: $[Nn_3\Lambda]\Omega^\pi$

S. G. Nilsson, Dan. Mat. Fys. Medd 16, 29 (1955).

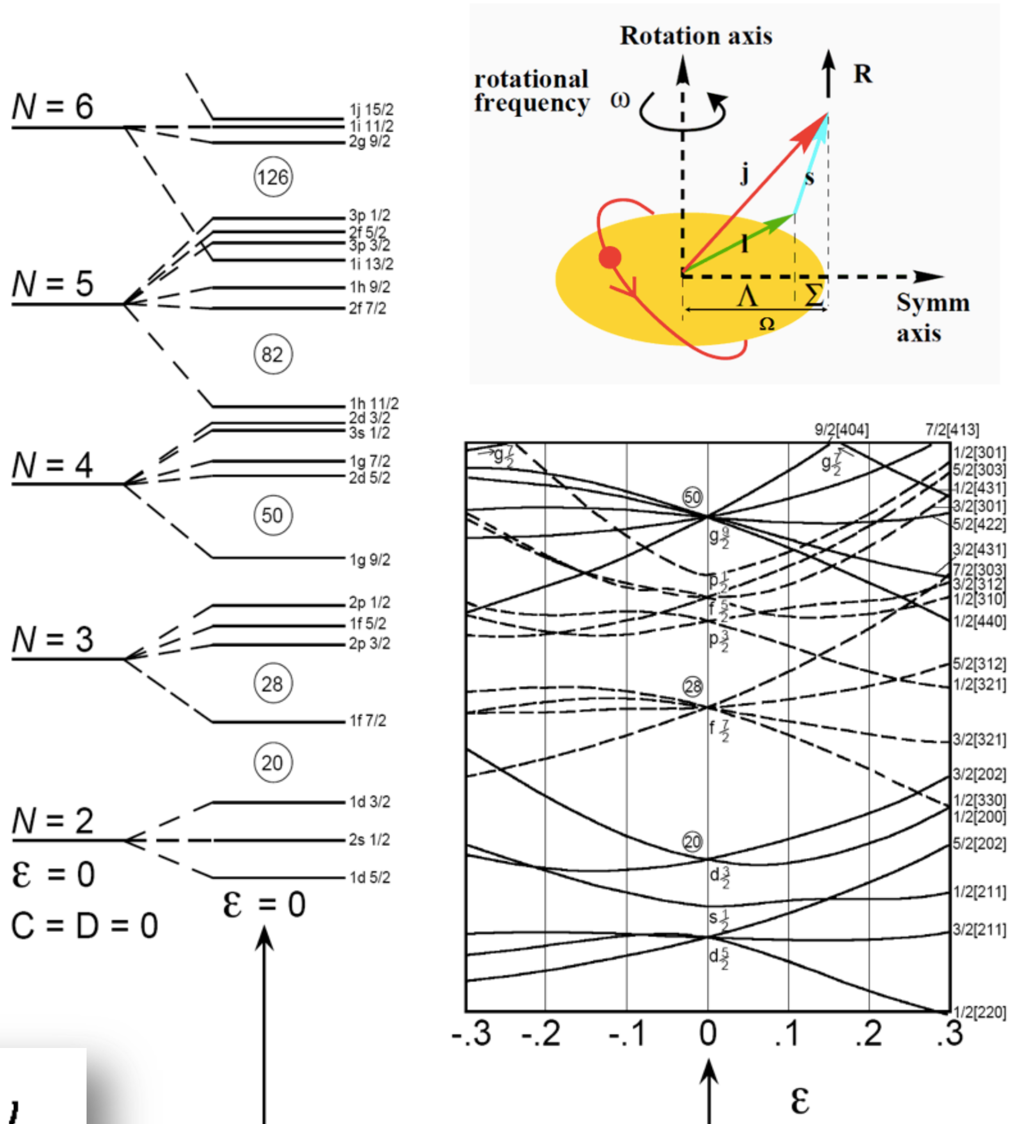
Nilsson Diagram

- The effects of deformation can be seen in the diagram.
- Each spherical level labeled by $N(l_j)$ at $\varepsilon=0$, is split into $(2j+1)/2$ levels with

$$\Omega = \pm\frac{1}{2}, \pm\frac{3}{2}, \ldots, \pm j.$$

- The remaining degeneracy means that each level can accommodate two nucleons.
- Orbits with lower Ω are shifted downwards for $\varepsilon>0$ (prolate) and upwards for $\varepsilon<0$ (oblate).

$$\chi_\nu = \sum_{\alpha j \Omega} c^{(\nu)}_{\alpha j \Omega} \psi^{\alpha j}_{\Omega}, \qquad \alpha = N, l.$$



Deformed Mean Field

Reviews of Modern Physics, Vol. 47, No. 1, January 1975

Coriolis effects and rotation alignment in nuclei*†

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Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

$$E_{\mathrm{Cor}}(\mathrm{max}) \approx 2(\hbar^2/2\mathfrak{J})Ij.$$

The Particle plus Rotor Hamiltonian

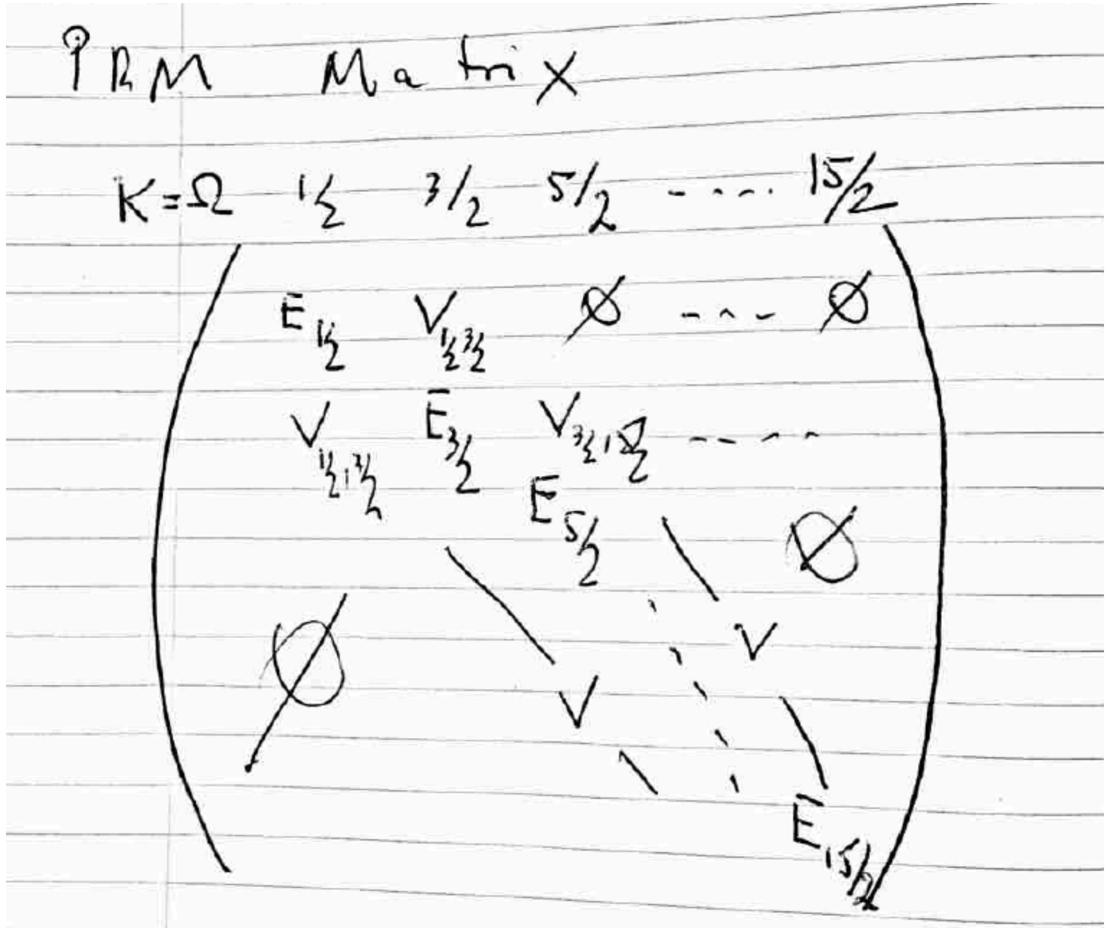
$$H = H_p + H_{\mathrm{rot}} = H_p + (\hbar^2/2\mathfrak{J})\mathbf{R}^2$$
$$= H_p + (\hbar^2/2\mathfrak{J})(R_x{}^2 + R_y{}^2),$$

$$H = H_p + (\hbar^2/2\mathfrak{J})[I(I+1) - K^2] + H_c$$
$$+ (\hbar^2/2\mathfrak{J})[\langle \mathbf{j}^2 \rangle - \Omega^2],$$

$$H_c = -2(\hbar^2/2\mathfrak{J})[I_x j_x + I_y j_y]$$
$$= -(\hbar^2/2\mathfrak{J})[I_+ j_- + I_- j_+].$$

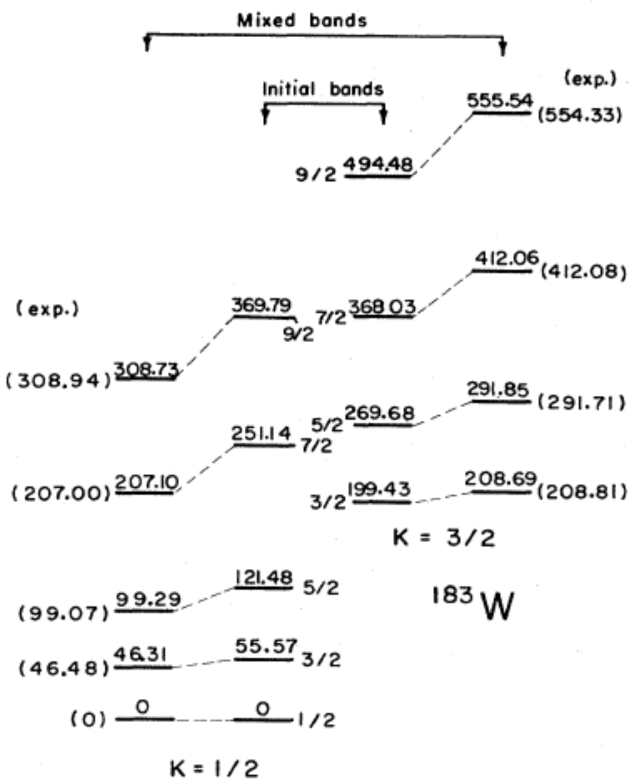
$$\langle I, \Omega \pm I \mid H_c \mid I, \Omega \rangle$$
$$= -(\hbar^2/2\mathfrak{J})[(I \mp K)(I \pm K + 1)]^{1/2} \langle \Omega \pm 1 \mid j_\pm \mid \Omega \rangle;$$

$$\langle j, \Omega \pm 1 \mid j_\pm \mid j, \Omega \rangle = [(j \mp \Omega)(j \pm \Omega + 1)]^{1/2}.$$



$$\psi_I = \sum_K \mathcal{A}_K | IK \rangle .$$

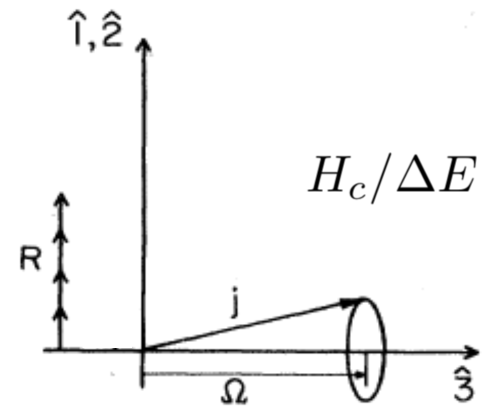
The first study



Kerman, A. K., 1956, Dan. Mat. Fys. Medd. 30, No. 15.

Coupling Limits

Deformation aligned
Strongly coupled

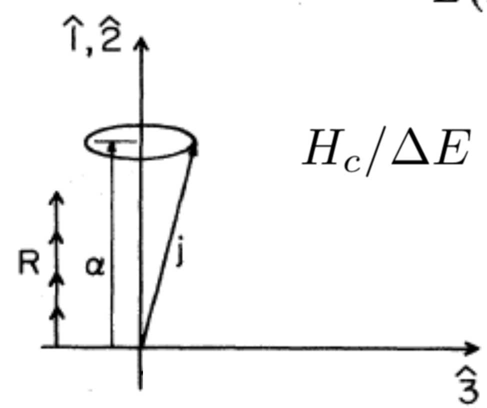


$$H_c/\Delta E \ll 1$$

$$I = K,\ K+1,\ \ldots$$

$$E(K,I) = E_K + AI(I+1) + BI^2(I+1)^2 + \cdots$$

Rotation aligned
Decoupled



$$H_c/\Delta E \gg 1$$

$$I = j,\ \ j+2,\ \ j+4, \ldots$$

$$E(I+2) - E(I) \approx E(R+2) - E(R).$$

Structure of ^{29}F

PHYSICAL REVIEW C **95**, 041301(R) (2017)

Low-Z shore of the "island of inversion" and the reduced neutron magicity toward ^{28}O

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M. Matsushita (松下 昌史),[1,4,‖] D. Steppenbeck,[1] H. Wang (王 赫),[1,2] H. Baba (馬場 秀忠),[1] E. Ideguchi (井手口 栄治),[5,§]
N. Kobayashi (小林 信之),[6,§] Y. Kondo (近藤 洋介),[6] J. Lee (李曉菁),[1,¶] S. Michimasa (道正 新一郎),[5]
T. Motobayashi (本林 透),[1] T. Otsuka (大塚 孝治),[5,7] H. Sakurai (櫻井 博儀),[1] M. Takechi (武智 麻耶),[1,#]
Y. Togano (栂野 泰宏),[1,‡] and K. Yoneda (米田健一郎)[1]
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[2]Peking University, Beijing 100871, People's Republic of China
[3]Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, Ibaraki 319-1195, Japan
[4]Department of Physics, Rikkyo University, Toshima, Tokyo 172-8501, Japan
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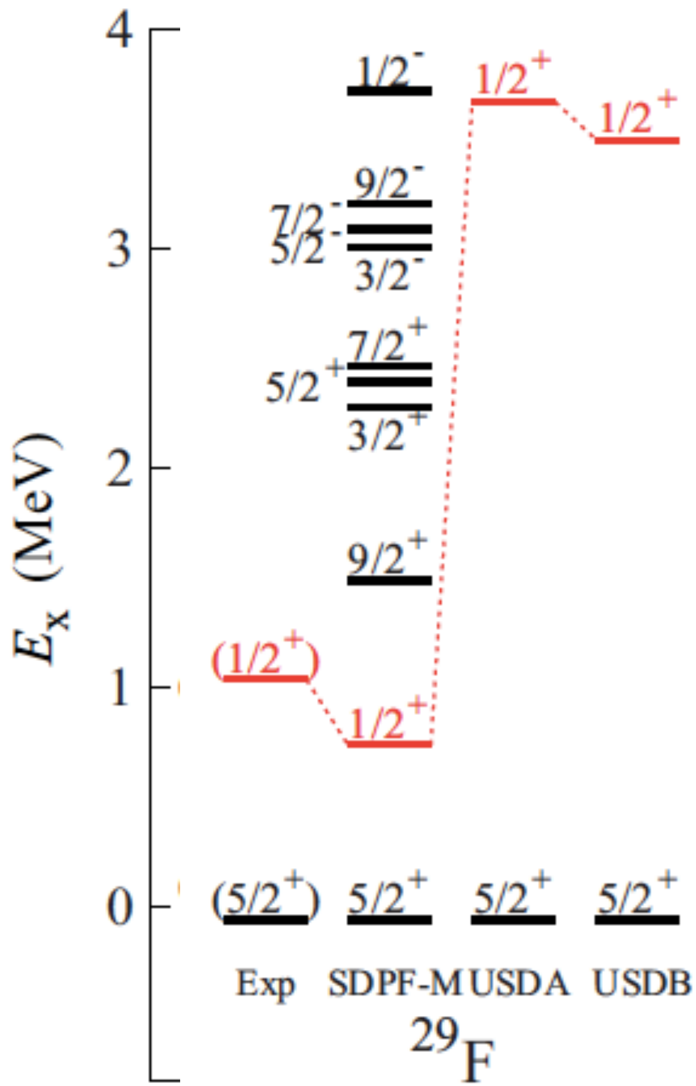
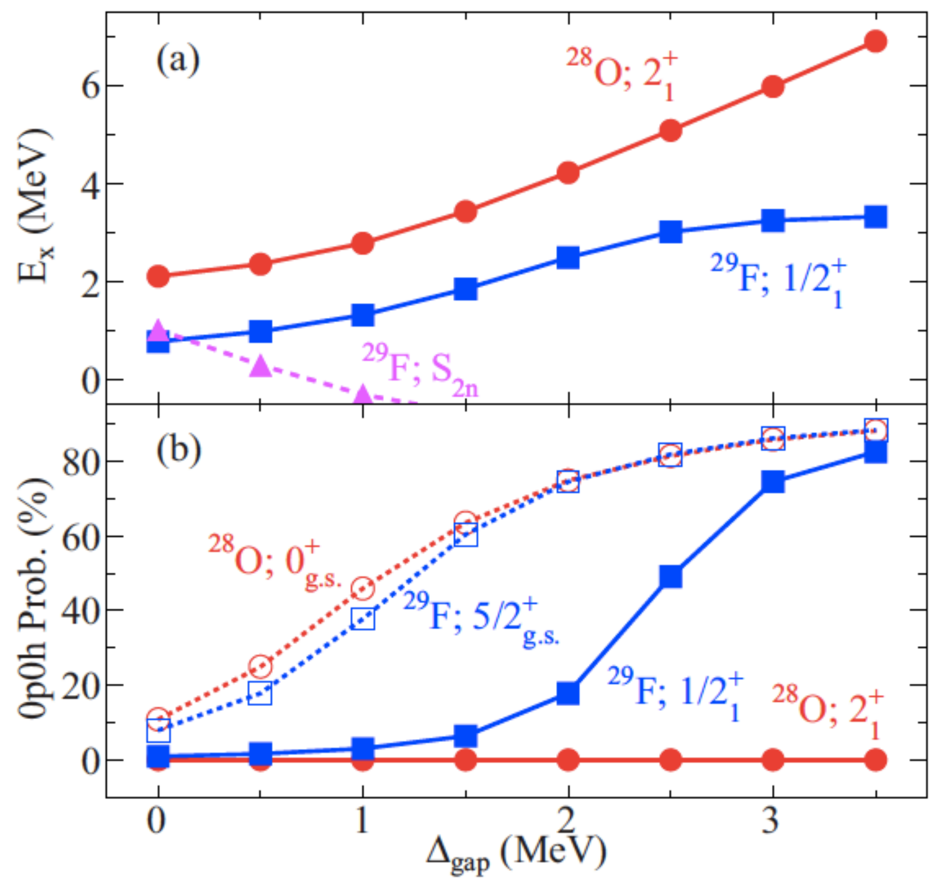
(Received 11 February 2015; revised manuscript received 20 February 2017; published 13 April 2017)

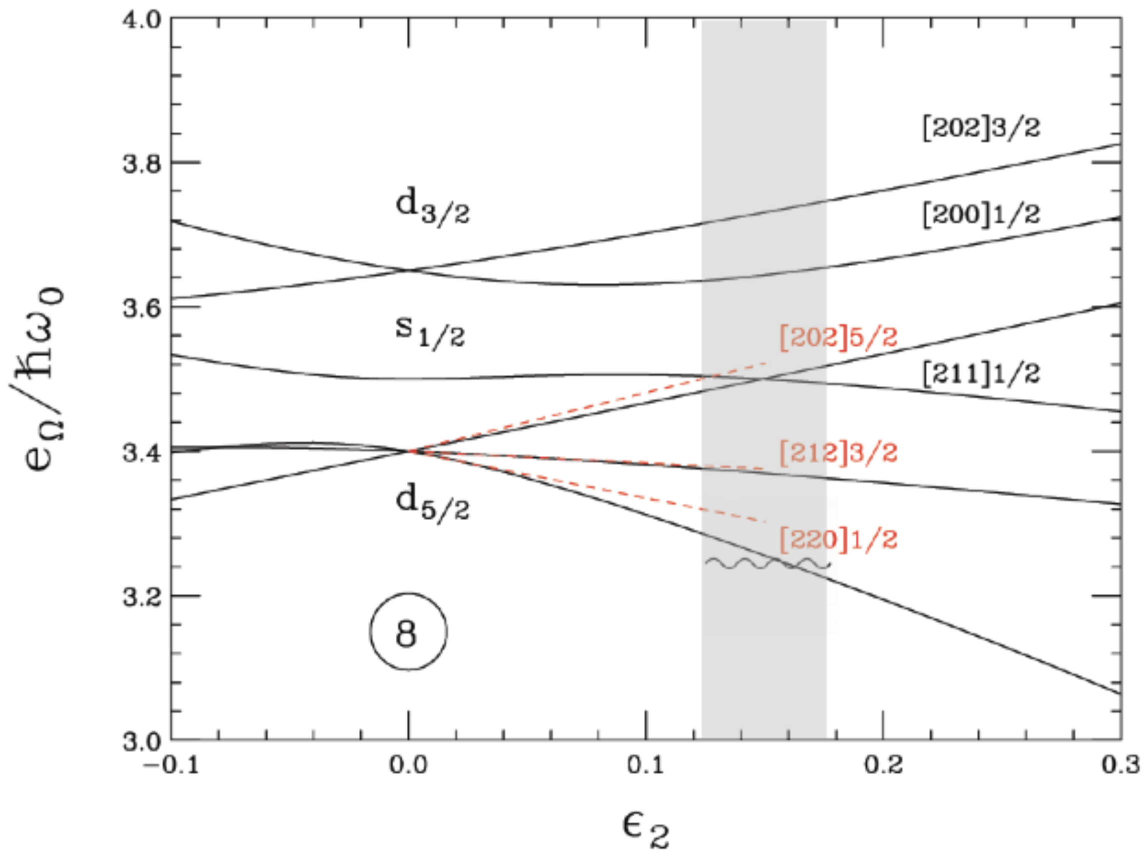
The two odd-even fluorine isotopes ^{27,29}F were studied via in-beam γ-ray spectroscopy at the RIKEN Radioactive Isotope Beam Factory. A secondary beam of ^{30}Ne was used to induce one-proton and one-proton–two-neutron removal reactions on carbon and polyethylene targets at midtarget energies of 228 MeV/u. Excited states were observed at 915(12) keV for ^{27}F and at 1080(18) keV for ^{29}F. Both were assigned a $1/2_1^+$ spin and parity. The low transition energy for ^{29}F largely disagrees with shell model predictions restricted to the sd model space. Calculations using effective interactions that include the neutron pf shell indicate that the $N = 20$ gap is quenched for ^{29}F, thus extending the "island of inversion" to isotopes with proton number $Z = 9$. Variations of the $N = 20$ gap further reveal a strong correlation to the $1/2_1^+$ level energy in ^{29}F and suggest a persistent reduced neutron gap for ^{28}O.

Structure of ^{29}F

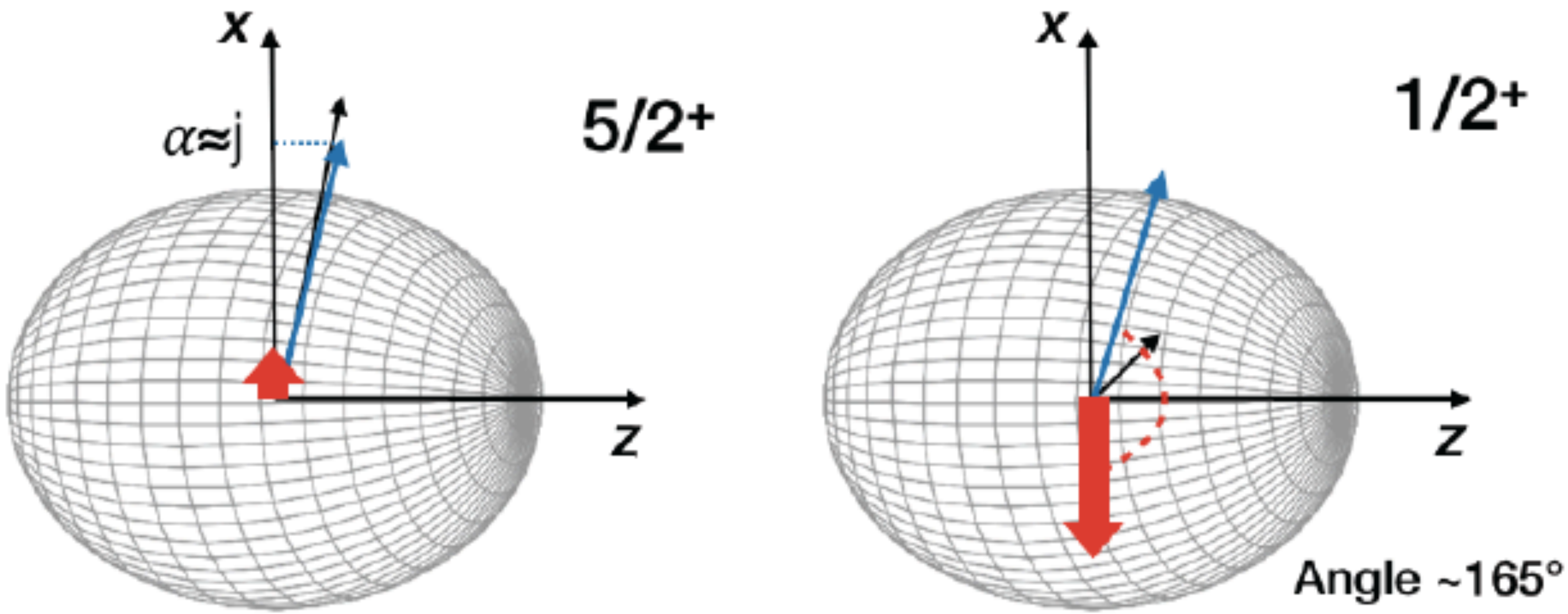




The Nilsson view

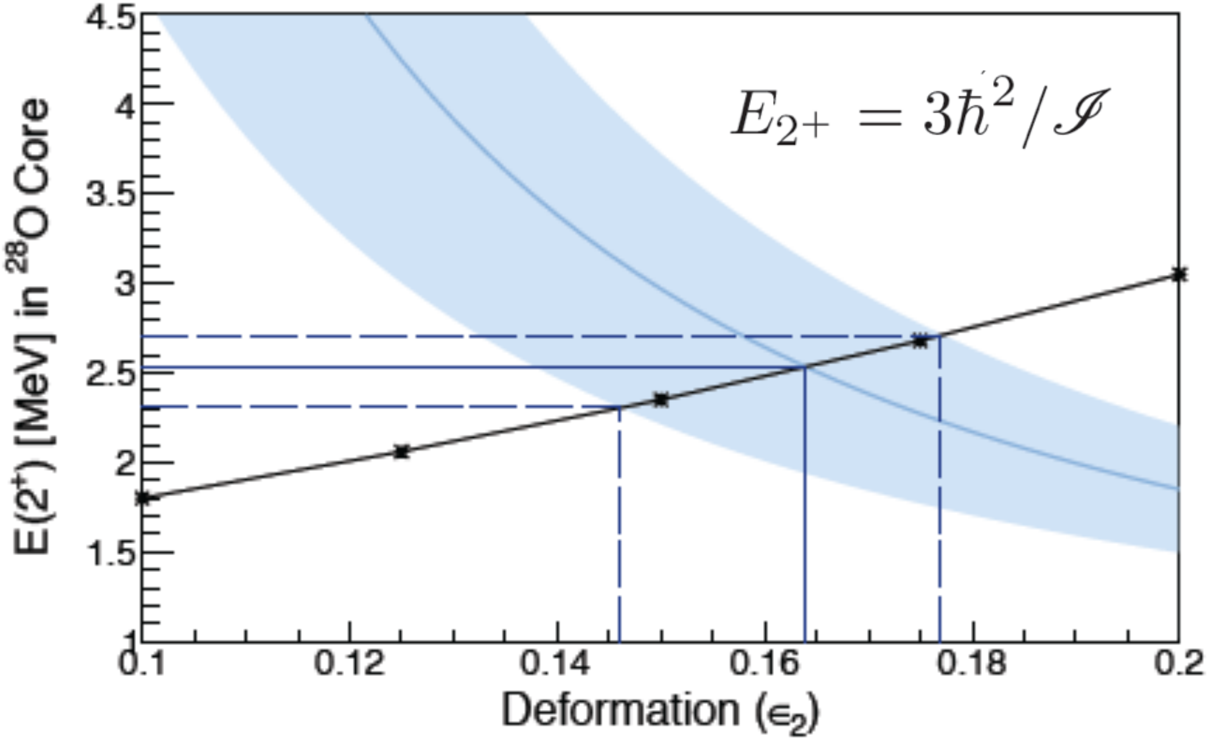


Structure of ^{29}F: Geometry



AOM *et al*. Physics Letters B 775 (2017) 160–162

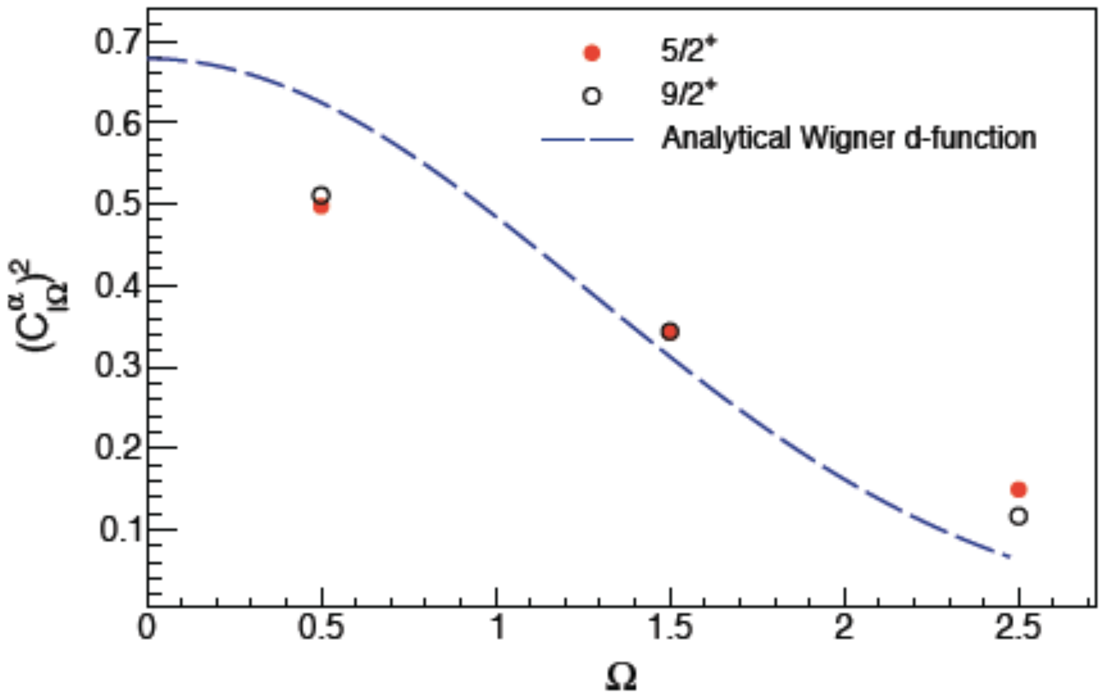
Structure of ^{29}F: PRM Solution



PRM

$$\mathscr{I} = \frac{\mathscr{I}_{rigid}}{(1 + (\frac{2\Delta}{\hbar\omega_0\epsilon_2})^2)^{3/2}}$$

Structure of ^{29}F: Decoupled Band



$$|I,\alpha\rangle = \sum_{\Omega_p=1/2}^{5/2} C^{\alpha}_{I\Omega_p} |I,\Omega_p\rangle$$

$$C^{\alpha}_{I\Omega} \approx d^{j}_{\alpha,\Omega}(\pi/2)$$

Direct reactions

$$d\sigma^{(-1)}(j; I_1 \to I_2) = (2I_1+1)^{-1} \sum_{M_1 M_2 m} d\sigma^{(-1)}(jm; I_1 M_1 \to I_2 M_2)$$

$$= (2j+1)^{-1}(2I_1+1)^{-1}\langle I_1 \| a^\dagger(j) \| I_2 \rangle^2 \, d\sigma_{sp}^{(-1)}(j)$$

$$d\sigma_{sp}^{(-1)}(j) = \sum_m d\sigma_{sp}^{(-1)}(jm)$$

Structure

$$\mathscr{S} = (2I_2+1)^{-1}\langle I_2 \| a^\dagger(j) \| I_1 \rangle^2$$

Reaction
DWBA
Eikonal
DWIA

Macfarlane, M. H., and French, J. B. (1960), ***Rev. Mod. Phys.* 32,** 567.

Direct reactions

Sum rules

$$\sum_{\alpha I_2} \langle I_1 \| a^\dagger(j) \| \alpha I_2 \rangle^2 = (2I_1 + 1)\langle I_1 M_1 | \sum_m a^\dagger(jm) a(jm) | I_1 M_1 \rangle$$
$$= (2I_1 + 1) n(j)$$

$$\sum_{\alpha I_2} \langle \alpha I_2 \| a^\dagger(j) \| I_1 \rangle^2 = (2I_1 + 1)\langle I_1 M_1 | \sum_m a(jm) a^\dagger(jm) | I_1 M_1 \rangle$$
$$= (2I_1 + 1)(2j + 1 - n(j))$$

Macfarlane, M. H., and French, J. B. (1960), ***Rev. Mod. Phys.*** **32,** 567.

How Different is the Core of ^{25}F from ^{24}O$_{g.s.}$?

T. L. Tang,[1,2,*] T. Uesaka,[2] S. Kawase,[1,†] D. Beaumel,[3] M. Dozono,[2] T. Fujii,[1] N. Fukuda,[2] T. Fukunaga,[4] A. Galindo-Uribarri,[5] S. H. Hwang,[6,‡] N. Inabe,[2] D. Kameda,[2] T. Kawahara,[7] W. Kim,[6] K. Kisamori,[1] M. Kobayashi,[1] T. Kubo,[2] Y. Kubota,[1,§] K. Kusaka,[2] C. S. Lee,[1] Y. Maeda,[8] H. Matsubara,[2,∥] S. Michimasa,[1] H. Miya,[1] T. Noro,[4] A. Obertelli,[2,9,§] K. Ogata,[10,11] S. Ota,[1] E. Padilla-Rodal,[12] S. Sakaguchi,[4] H. Sakai,[2] M. Sasano,[2] S. Shimoura,[1] S. Stepanyan,[6] H. Suzuki,[2] M. Takaki,[1] H. Takeda,[2] H. Tokieda,[1] T. Wakasa,[4] T. Wakui,[13,¶] K. Yako,[1] Y. Yanagisawa,[2] J. Yasuda,[4] R. Yokoyama,[1] K. Yoshida,[2] K. Yoshida,[10,**] and J. Zenihiro[2]

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Physics Letters B 672 (2009) 17–21

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Physics Letters B

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Evidence for a doubly magic ^{24}O

C.R. Hoffman [a,*], T. Baumann [b], D. Bazin [b], J. Brown [c], G. Christian [b,d], D.H. Denby [e], P.A. DeYoung [e], J.E. Finck [f], N. Frank [b,d,1], J. Hinnefeld [g], S. Mosby [h], W.A. Peters [b,d,2], W.F. Rogers [h], A. Schiller [b,3], A. Spyrou [b], M.J. Scott [f], S.L. Tabor [a], M. Thoennessen [b,d], P. Voss [f]

NSCL
MoNA

^{26}F 85 MeV/A

PRL **102,** 152501 (2009) PHYSICAL REVIEW LETTERS week ending 17 APRIL 2009

One-Neutron Removal Measurement Reveals ^{24}O as a New Doubly Magic Nucleus

R. Kanungo,[1,*] C. Nociforo,[2] A. Prochazka,[2,3] T. Aumann,[2] D. Boutin,[3] D. Cortina-Gil,[4] B. Davids,[5] M. Diakaki,[6] F. Farinon,[2,3] H. Geissel,[2] R. Gernhäuser,[7] J. Gerl,[2] R. Janik,[8] B. Jonson,[9] B. Kindler,[2] R. Knöbel,[2,3] R. Krücken,[7] M. Lantz,[9] H. Lenske,[3] Y. Litvinov,[2] B. Lommel,[2] K. Mahata,[2] P. Maierbeck,[7] A. Musumarra,[10,11] T. Nilsson,[9] T. Otsuka,[12] C. Perro,[1] C. Scheidenberger,[2] B. Sitar,[8] P. Strmen,[8] B. Sun,[2] I. Szarka,[8] I. Tanihata,[13] Y. Utsuno,[14] H. Weick,[2] and M. Winkler[2]

GSI FRS

^{24}O at 920 MeV/A

PRL **109,** 022501 (2012) PHYSICAL REVIEW LETTERS week ending 13 JULY 2012

$N = 16$ Spherical Shell Closure in ^{24}O

K. Tshoo,[1,*] Y. Satou,[1] H. Bhang,[1] S. Choi,[1] T. Nakamura,[2] Y. Kondo,[2] S. Deguchi,[2] Y. Kawada,[2] N. Kobayashi,[2] Y. Nakayama,[2] K. N. Tanaka,[2] N. Tanaka,[2] N. Aoi,[3] M. Ishihara,[3] T. Motobayashi,[3] H. Otsu,[3] H. Sakurai,[3] S. Takeuchi,[3] Y. Togano,[3] K. Yoneda,[3] Z. H. Li,[3] F. Delaunay,[4] J. Gibelin,[4] F. M. Marqués,[4] N. A. Orr,[4] T. Honda,[5] M. Matsushita,[5] T. Kobayashi,[6] Y. Miyashita,[7] T. Sumikama,[7] K. Yoshinaga,[7] S. Shimoura,[8] D. Sohler,[9] T. Zheng,[10] and Z. X. Cao[10]

RIKEN

$^{24}O(p,p')$

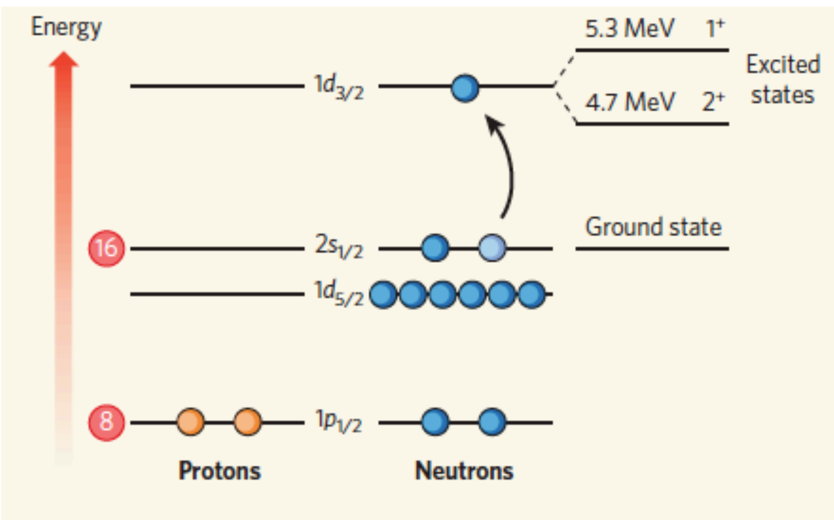
NUCLEAR PHYSICS

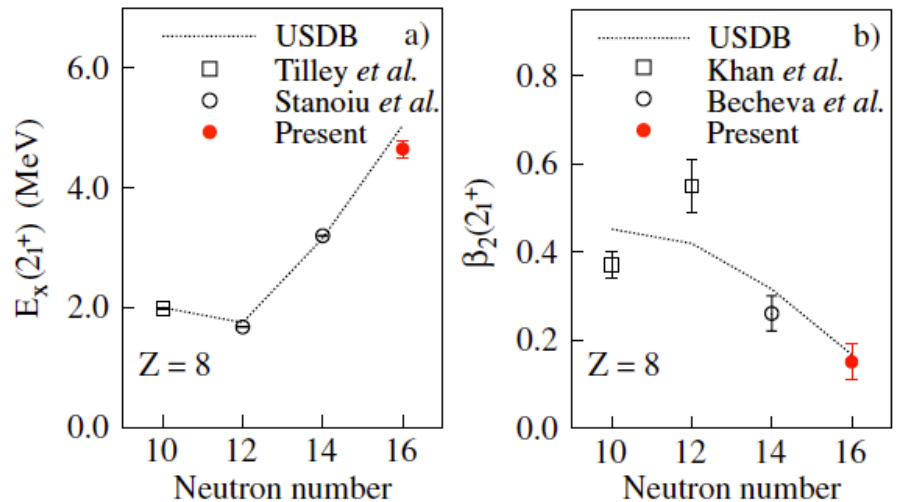
Unexpected doubly magic nucleus

^{24}O

Robert V. F. Janssens

NATURE -- Vol 459 -- 25 June 2009





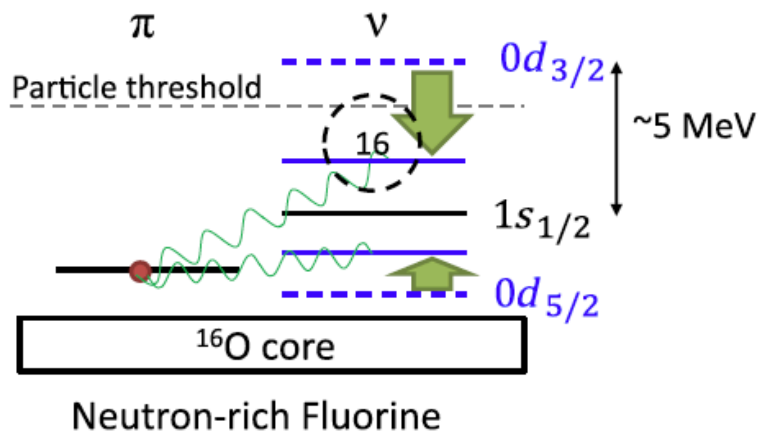
PRL 109, 022501 (2012)

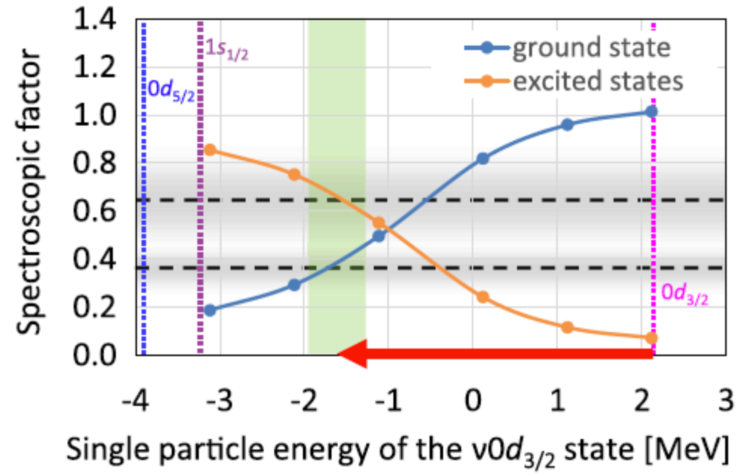
The structure of a neutron-rich ^{25}F nucleus is investigated by a quasifree $(p, 2p)$ knockout reaction at 270*A* MeV in inverse kinematics. The sum of spectroscopic factors of $\pi 0d_{5/2}$ orbital is found to be 1.0 ± 0.3. However, the spectroscopic factor with residual ^{24}O nucleus being in the ground state is found to be only 0.36 ± 0.13, while those in the excited state is 0.65 ± 0.25. The result shows that the ^{24}O core of ^{25}F nucleus significantly differs from a free ^{24}O nucleus, and the core consists of ~35% $^{24}O_{g.s.}$. and ~65% excited ^{24}O. The result may infer that the addition of the $0d_{5/2}$ proton considerably changes neutron structure in ^{25}F from that in ^{24}O, which could be a possible mechanism responsible for the oxygen dripline anomaly.

TABLE I. Experimental results, integrated cross-sections, and spectroscopic factors. S_{exp} extracted from experimental cross section and theoretical single-particle cross sections. J^{π}_{th} is the spin-parity used for theoretical calculations.

Channel	Mean [MeV]	Width [MeV]	σ_{exp} [μb]	σ_{th} [μb]	J^{π}_{th}	S_{exp}	S_{th}(USDB)	S_{th}(SFO)	S_{th}(SPDF-MU)
(^{25}F, ^{24}O)	−0.5(1.1)	4.8(1.3)	53(18)	149(24)	$5/2^+$	0.36(13)	1.01	0.90	0.95
(^{25}F, ^{23}O)	6.5(1.4)	6.3(9)	81(26)	125(26)	$5/2^+$	0.65(25)	0.01	0.07	0.05
(^{25}F, ^{22}O)	12.7(6)	7.6(6)	274(71)	80(24)	$1/2^-$	3.43(1.4)		2.19	
(^{23}F, ^{22}O)	1.0(8)	6.0(6)	61(14)	166(28)	$5/2^+$	0.37(10)	1.08	0.92	1.00
(^{23}F, ^{21}O)	9.5(4)	7.9(4)	456(67)	93(25)	$1/2^-, 3/2^-$	4.9(1.5)		5.21	
(^{23}F, ^{20}O)	18.0(5)	9.7(5)							

PRL 124, 212502 (2020)



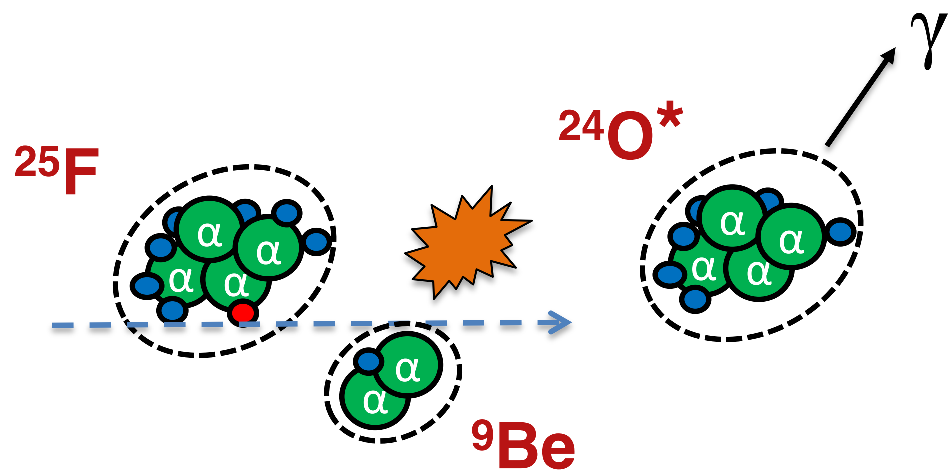


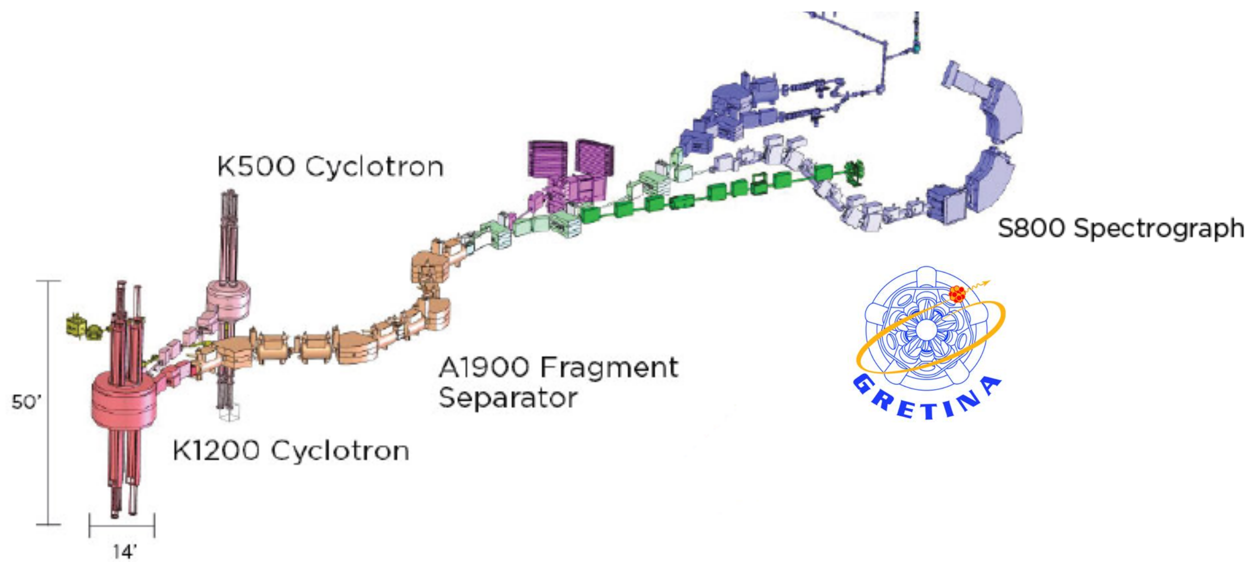
The $0d_{5/2}$ proton knockout from ^{25}F populates the ^{24}O ground state with a smaller probability than the ^{24}O excited states. This result indicates that the oxygen core of ^{25}F is considerably different from $^{24}O_{gs}$ and has a larger overlap with the excited states of ^{24}O. The change in the neutron-shell structure due to the $0d_{5/2}$ proton may be responsible for the small overlap between ^{25}F and $^{24}O_{gs}$

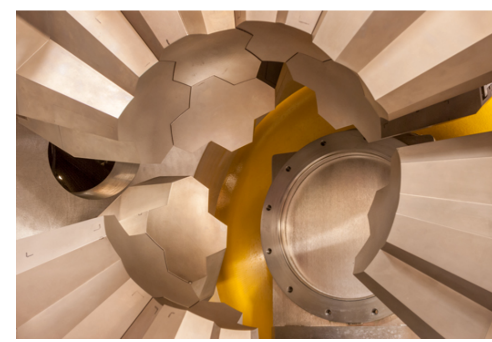
A comparison with the shell model calculations indicates that the USDB, SFO, and SFPD-MU interactions are insufficient to reproduce the present results. A stronger tensor force or other mechanism such as the 3N force effects, or both, might be needed to explain the experimental results. More experimental and theoretical studies are necessary to clarify the mechanism for the change in the core of neutron-rich fluorine from the ground state of oxygen isotopes.

Proton Knockout at NSCL

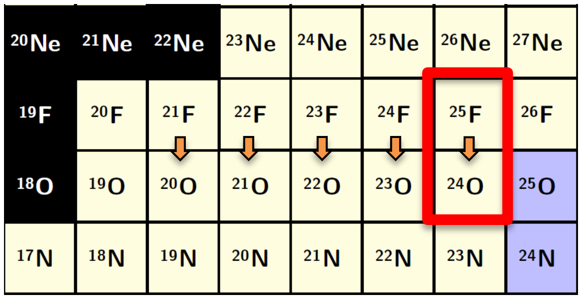
E16022: M.D. Jones, H. L. Crawford, *et al.*

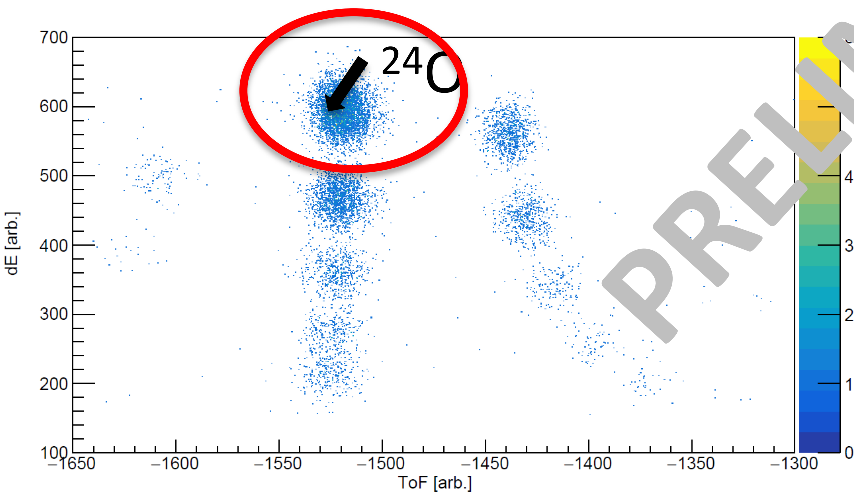


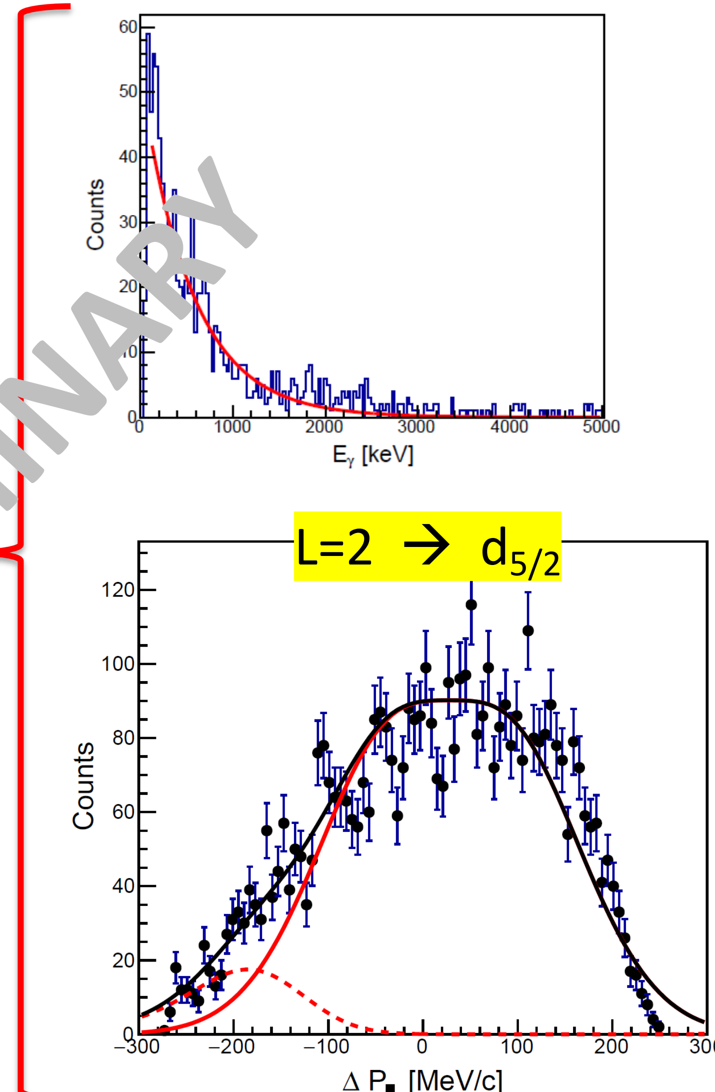




Proton Knockout at NSCL







$\sigma = 5.14\ mb$

$\sigma_{sp} = 17\ mb$

$S = 0.30\ (5)$

PHYSICAL REVIEW C **102**, 041301(R) (2020)

Rapid Communications

Core of ^{25}F in the rotational model

A. O. Macchiavelli, R. M. Clark, H. L. Crawford, P. Fallon, I. Y. Lee, C. Morse, C. M. Campbell, M. Cromaz, and C. Santamaria

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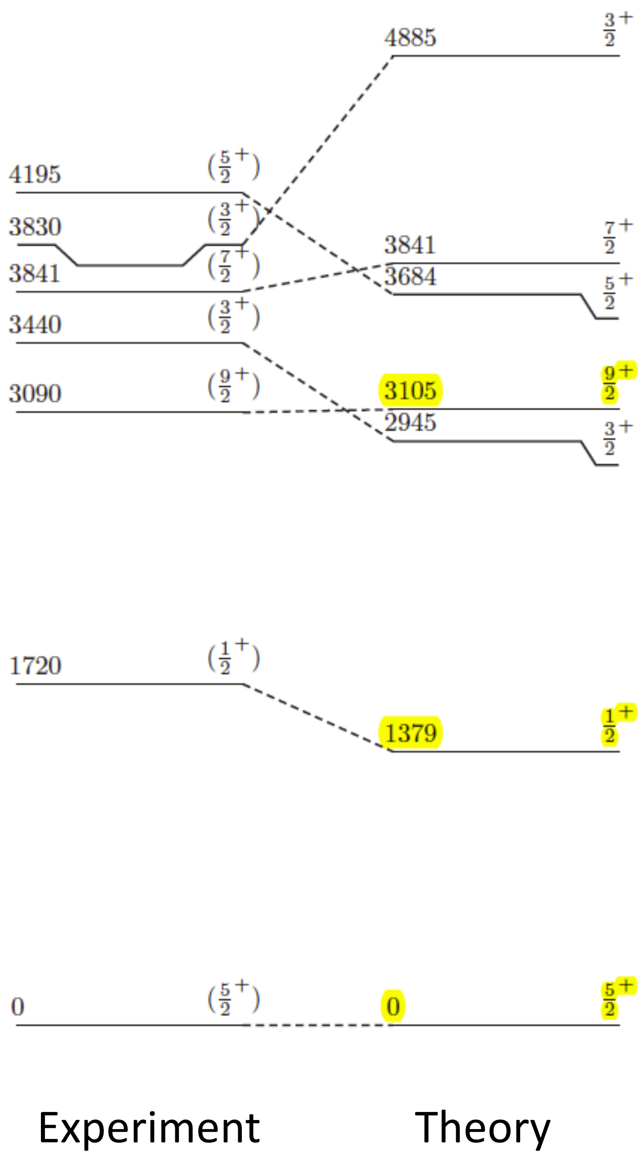
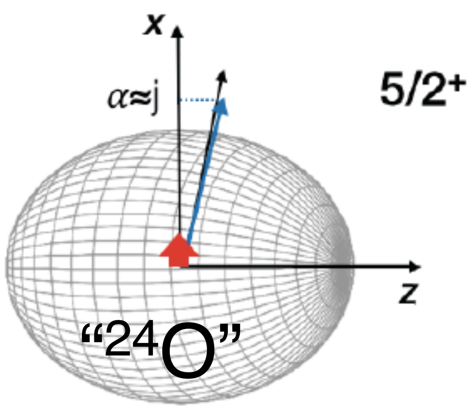
^{25}F in the PRM



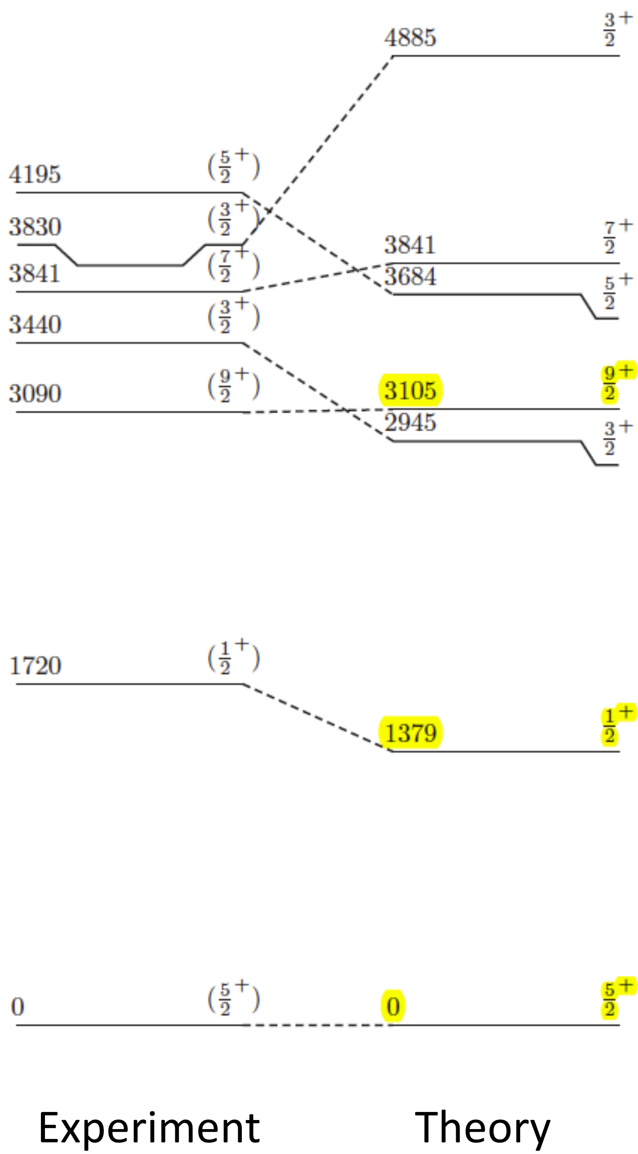
The effective ^{24}O core in ^{25}F can be interpreted as a slightly deformed rotor with:

$E_2^+(\text{core}) \approx 3.2$ MeV and $\varepsilon_2 \approx 0.15$,



Zs. Vajta *et al*., Phys. Rev. C **89**, 054323 (2014).

^{25}F in the PRM



Zs. Vajta *et al.*, Phys. Rev. C **89**, 054323 (2014).

Furthermore, in ^{26}F * the 1^+ ground and 4^+ isomeric states can be associated with the antiparallel and parallel couplings of the odd neutron in the $d_{3/2}$ Nilsson multiplet to the structure of ^{25}F.

The former, favored by the Gallagher-Moszkowski rule gives 1^+ as the lowest state and the latter a 4^+ as the bandhead of a doubly decoupled band.

* A. Lepailleur *et al.*, Phys. Rev. Lett. **110**, 082502 (2013)

Spectroscopic factors

PRM

$$\psi_I = \sum_K \mathcal{A}_K | IK\rangle.$$

$$S_{i,f}(j\ell) = \left(\sum_K \mathcal{A}_K \theta_{i,f}(j\ell, K) \right)^2,$$

$$\theta_{i,f}(j\ell, K) = \sqrt{2}\langle I_i j K \Omega_\pi | I_f 0\rangle C_{j,\ell} \langle \phi_f | \phi_i \rangle$$

Nilsson amplitudes

Core overlap

Spectroscopic factors

Final state in ^{24}O	S_{exp} ** Ref. [7]	S_{th} PRM1	PRM2	SDPF-MU
Ground	0.36(13)	0.85	0.56	0.95
Excited	0.65(25)	0.15	0.44	0.05

$\langle \phi_f | \phi_i \rangle \approx 0.81$ *

Following: T. Takemasa, M. Sakagami, and M. Sano, Phys. Rev. Lett. **29**, 133 (1979).
T. Takemasa, Comput. Phys. Commun. **36**, 79 (1985).

**Not Quenching ??

* A simple volume overlap gives $\langle \phi_f | \phi_i \rangle \approx \frac{1}{1+\epsilon_2+\frac{2}{3}\epsilon_2^2+\cdots} \approx 0.85.$

Further studies ?

TABLE II. Electromagnetic properties of the low-lying levels of ^{25}F in the PRM. Magnetic moments have been calculated using $g_R = Z/A$ and $g_s = 0.7(g_s)_{\mathrm{free}}$.

I^π	E_x (MeV)	μ (μ_N)	Q ($e$fm^2)	$B(E2; I \to \frac{5}{2}^+)$ (WU)
$\frac{5}{2}^+$	0	3.9	−4.5	
$\frac{1}{2}^+$	1.4	1.9	0	3.9
$\frac{9}{2}^+$	3.1	4.6	−7.8	1.9

Summary and conclusions

The low-lying structure of ^{25}F can be understood in terms of the rotation-aligned coupling limit of the PRM.

Coriolis coupling on the $d_{5/2}$ proton Nilsson multiplet gives rise to a decoupled band with a $5/2^+$ bandhead.

Calculated proton spectroscopic factors for the $^{25}F(5/2^+)(-1p)$ ^{24}O reaction are in agreement with the experimental data. The observed fragmentation of the $d_{5/2}$ strength is due to both deformation and a core overlap.

The Nilsson plus PRM picture suggests that the extra proton with a dominant component in the down-sloping [220] ½ level polarizes ^{24}O and stabilizes its dynamic deformation. Thus, the effective core in ^{25}F can be interpreted as a slightly deformed rotor with $E2+$ (core) ≈ 3.2 MeV and $\varepsilon_2 \approx 0.15$, compared to the real doubly magic 24O with $E2+$ ≈ 4.7 MeV and weak vibrational quadrupole collectivity.

Electromagnetic observables for the three lowest experimental levels, obtained in the PRM, suggest that measurements of the magnetic and quadrupole moments of the $5/2^+$ state as well as Coulomb excitation will shed further light on the validity of our interpretation.

Thank You !