Some aspects of the structure of neutron-rich F isotopes in the Particle-Rotor Model

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NSCL p-KO

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Evolution of shell structure and collectivity in exotic nuclei

A driving question in nuclear physics

Evolution of shell structure and collectivity in exotic nuclei

A driving question in nuclear physics

WIKIPEDIA
The Free Encyclopedia

Island of inversion

1 language

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From Wikipedia, the free encyclopedia

An **island of inversion** is a region of the chart of nuclides where isotopes have enhanced stability in a sea of mostly fleeting and unstable nuclei at the edge of the nuclear map. Each island contains isotopes with a non-standard ordering of single particle levels in the nuclear shell model. Such an area was first described in 1975 by French physicists carrying out spectroscopic mass measurements of exotic isotopes of lithium and sodium.[1] Since then further studies have shown that five such regions exist within the known table of nuclides. These are centered at neutron-rich isotopes of five elements, namely ^{11}Li, ^{20}C, ^{31}Na, ^{42}Si, and ^{64}Cr.[2] Because there are five known islands of inversion, physicists have suggested renaming the phenomenon as an "archipelago of islands of shell breaking".[2] Studies with the purpose of defining the edges of this region are still ongoing.

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

Evolution of shell structure and collectivity in exotic nuclei

A driving question in nuclear physics

Evolution of shell structure in exotic nuclei

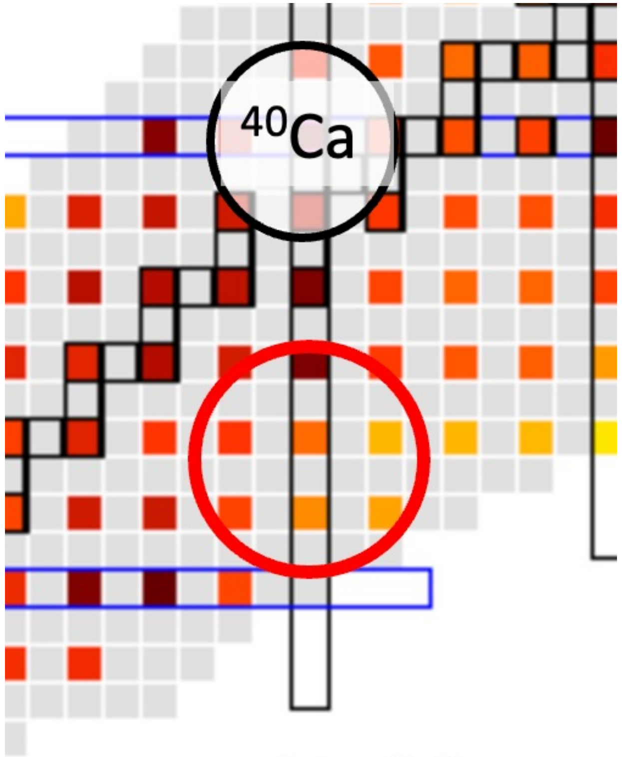
Takaharu Otsuka, Alexandra Gade, Olivier Sorlin, Toshio Suzuki, and Yutaka Utsuno
Rev. Mod. Phys. **92**, 015002 – Published 27 March 2020

Volume 184, number 4 PHYSICS LETTERS B 5 February 1987

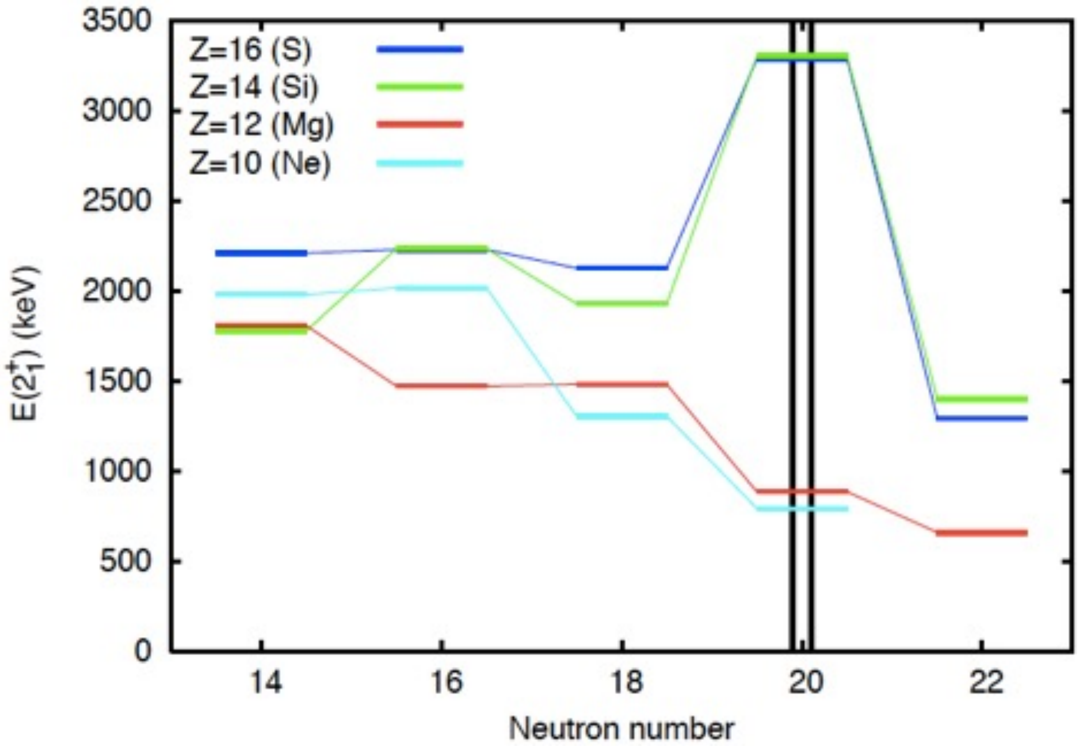
THE ONSET OF DEFORMATION AT THE $N = 20$ NEUTRON SHELL CLOSURE FAR FROM STABILITY

A. POVES [1] and J. RETAMOSA

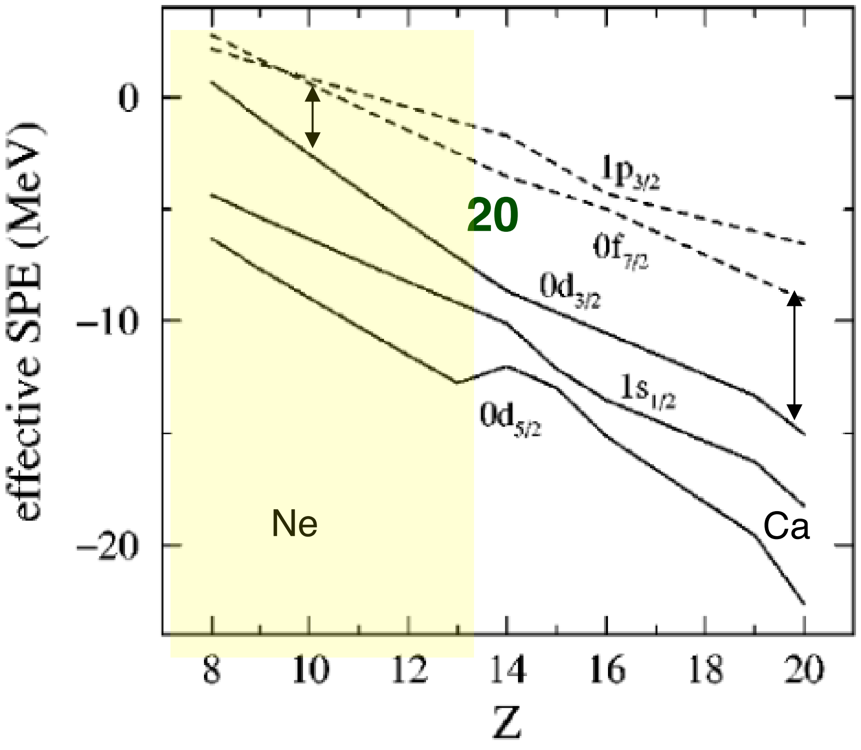
Departamento de Física Teórica, C-XI, Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain



N=20



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



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

N=20 shell gap

$\Delta\ell=\Delta j=2$

→ Quadrupole Correlations

Role of the π $d_{5/2}$- ν $d_{3/2}$ interaction

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

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).

The cases of $^{25,29}F$

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

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

P. Doornenbal,[1,*] H. Scheit,[1,2,†] S. Takeuchi (武内 聡),[1,‡] Y. Utsuno (宇都野 穣),[3] N. Aoi (青井 考),[1,§] K. Li (李 闊昂),[1,2]
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]
[1]*RIKEN Nishina Center, Wako, Saitama 351-0198, Japan*
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[5]*Center for Nuclear Study, University of Tokyo, RIKEN Campus, Wako, Saitama 351-0198, Japan*
[6]*Department of Physics, Tokyo Institute of Technology, Meguro, Tokyo 152-8551, Japan*
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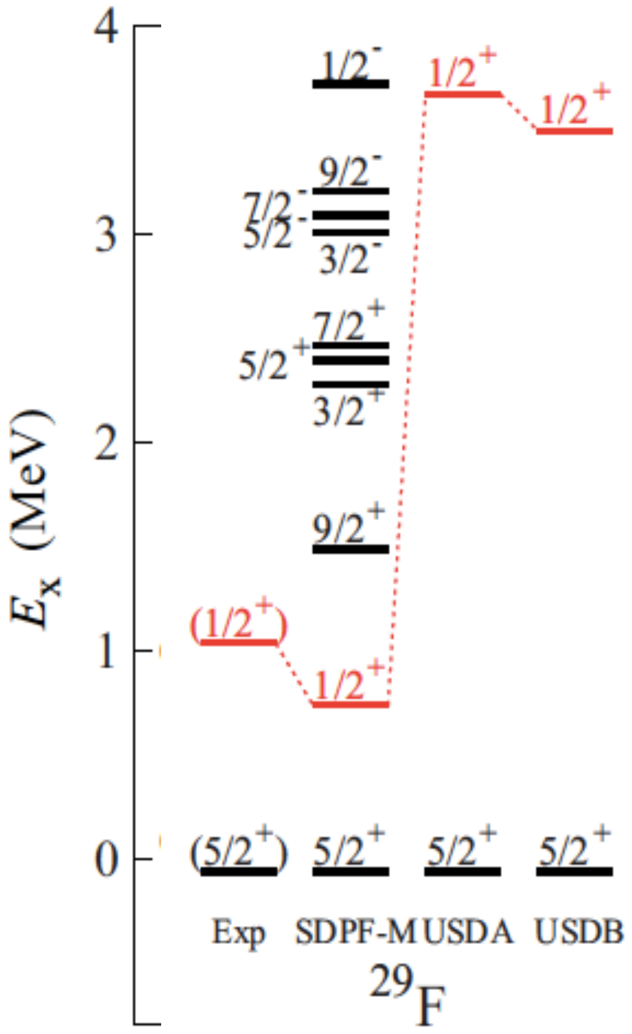
(Received 11 February 2015; revised manuscript received 20 February 2017; published 13 April 2017)

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.



Much evidence has been obtained for the existence of deformed ground states

⇩

How about the deformed shell model ?

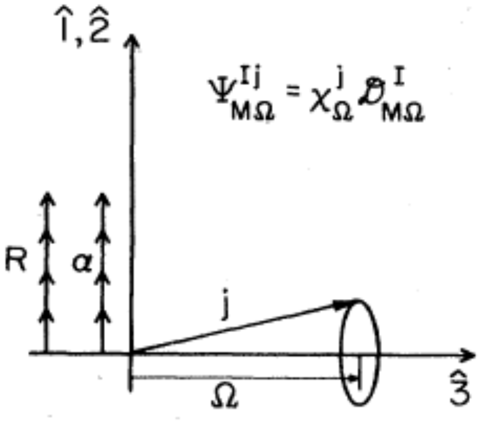
Particle plus Rotor Model 101

PRM Hamiltonian

$$\underbrace{H = E_\Omega}_{\text{Particle}} + \underbrace{\frac{\hbar^2}{2\mathscr{I}} I(I+1)}_{\text{Rotor}} + H_C \longrightarrow \underbrace{H_C = -\frac{\hbar^2}{2\mathscr{I}}(I_+ j_- + I_- j_+)}_{\text{Coriolis coupling}}$$

$H_c/\Delta E_K << 1$

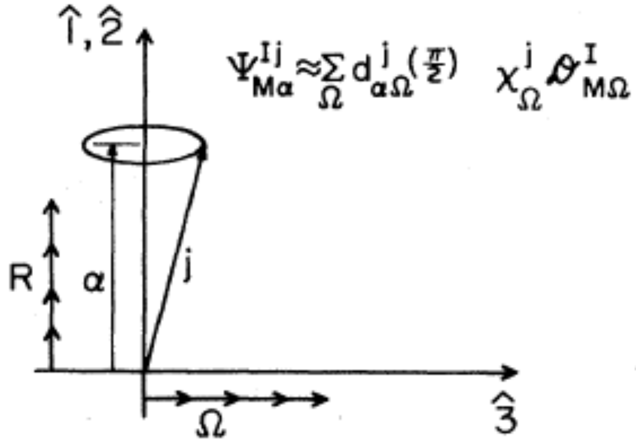
Deformation aligned
Strongly coupled



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

$H_c/\Delta E_K >> 1$

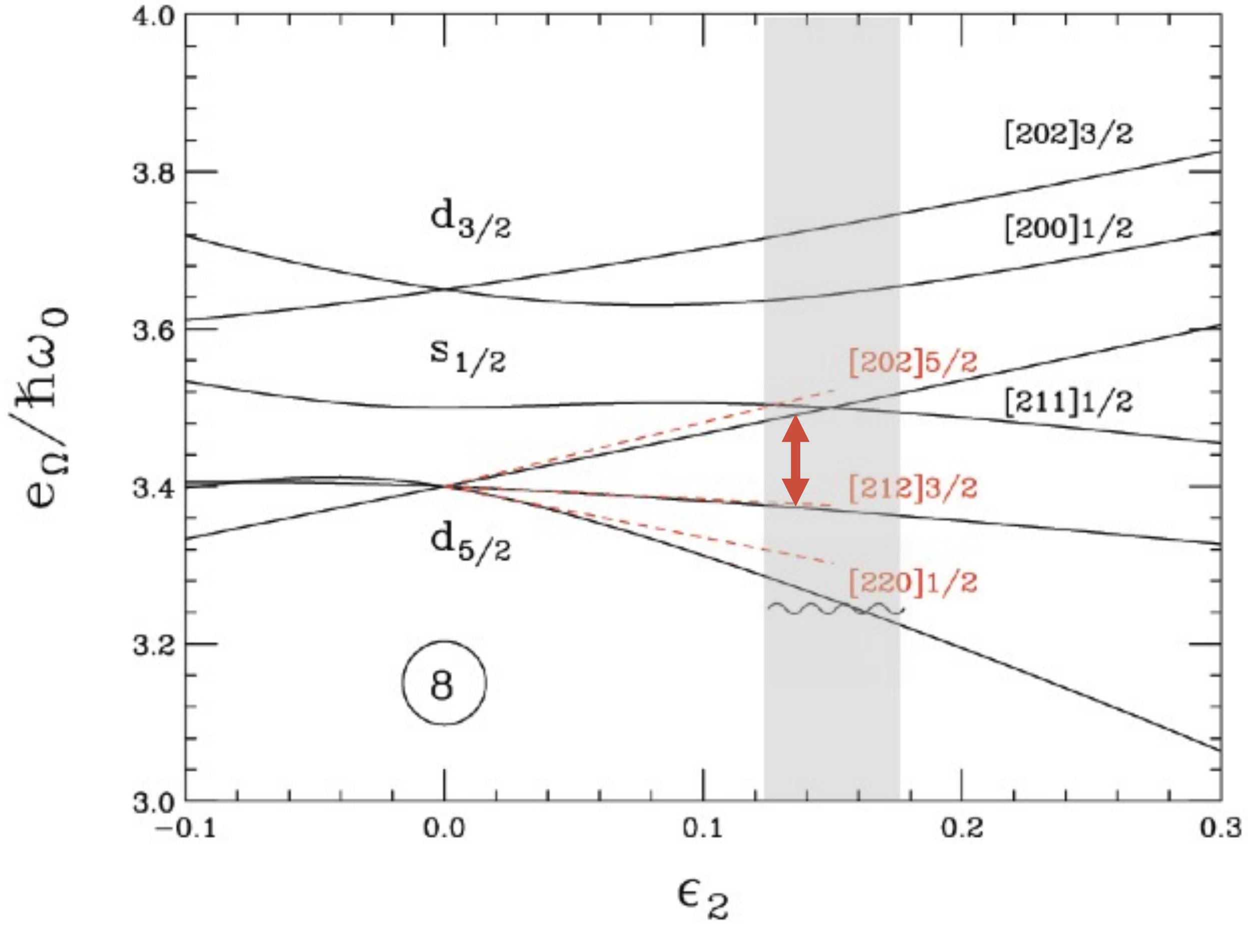
Rotation aligned
Decoupled



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

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

Nilsson levels



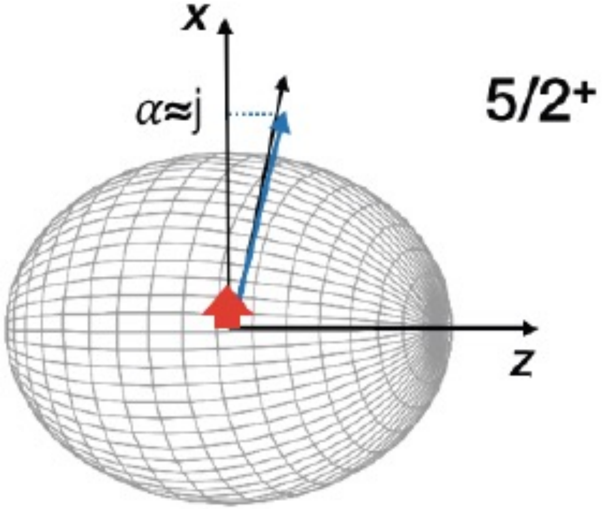
$\Delta E_K \sim \varepsilon_2 h\omega_0 \sim 1$ **MeV**

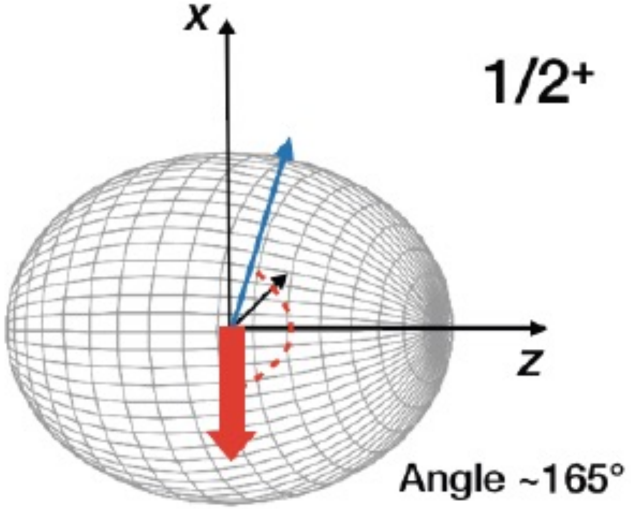
$H_c \sim j.\omega_{rot} \sim 3$ **Mev**

$H_c/\Delta E_K \sim 3 > 1$

Decoupled band?

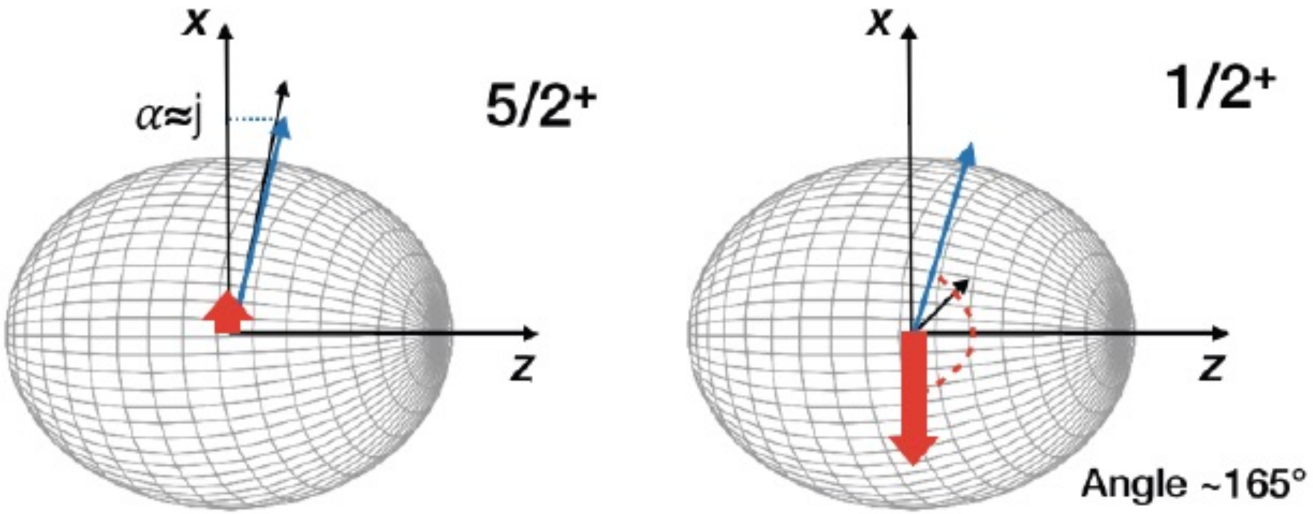
Structure of ^{29}F: Geometry





A.O. Macchiavelli, H. L. Crawford, *et al*. Physics Letters B 775 (2017) 160–162

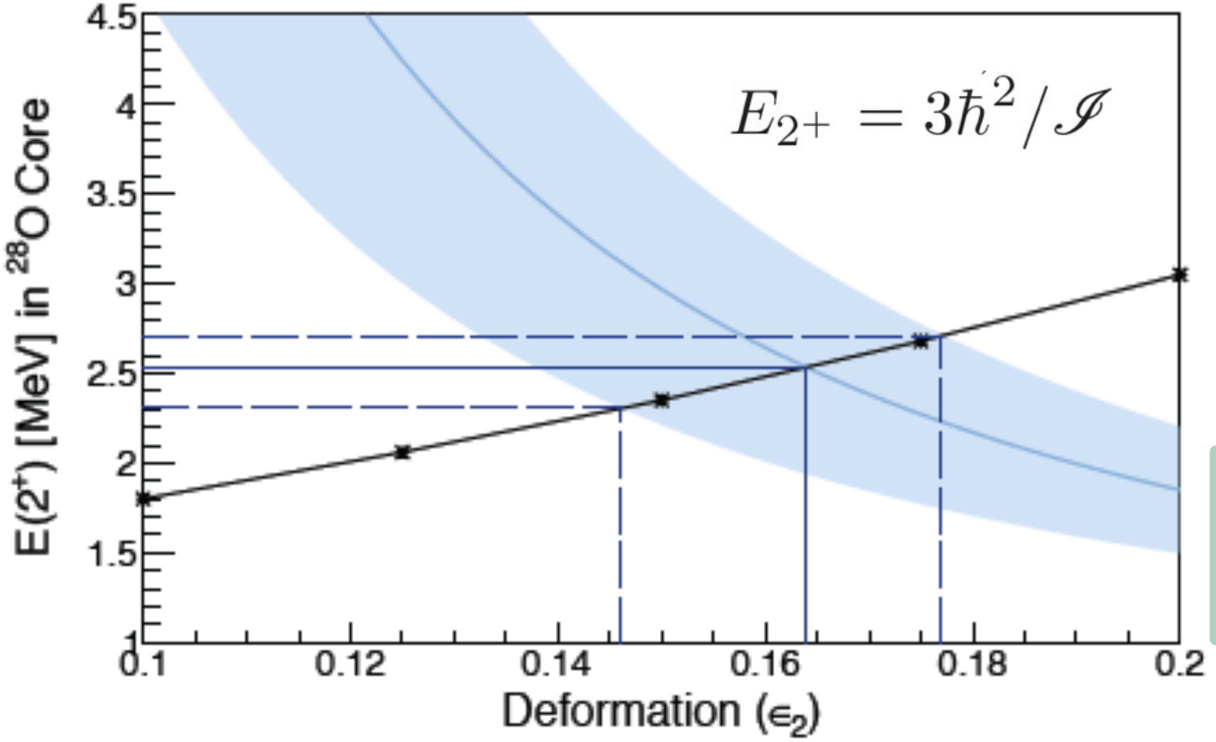
Structure of ^{29}F: Geometry



State	Energy [MeV]	$\langle R \rangle$	E_{rot} [MeV]	$\langle I_z \rangle$	$\langle \vec{I} \cdot \vec{j} \rangle / \lvert I \rvert$	$\langle \vec{R} \cdot \vec{j} \rangle / \lvert R \rvert$
$5/2^+$	0	0.53	0.34	0.11	2.78	−0.30
$1/2^+$	1.08	1.46	2.00	0.5	1.47	−2.14
$3/2^+$	2.2	2.01	2.54	−1.12	1.58	−2.18
$9/2^+$	2.6	2.18	2.91	0.04	2.65	1.76
$7/2^+$	3.2	2.09	2.71	0.60	2.27	0.12

A.O. Macchiavelli, H. L. Crawford, *et al*. Physics Letters B 775 (2017) 160–162

Structure of ^{29}F: PRM Solution

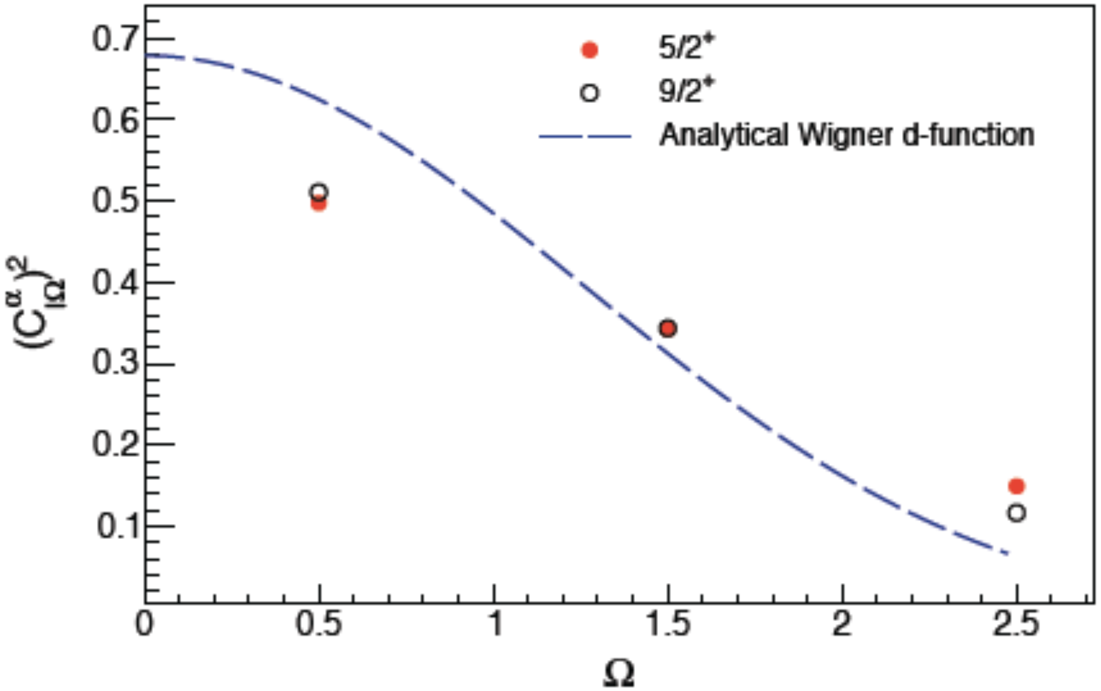


PRM

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

NP1712-RIBF164 (H.Crawford, Coulomb excitation of ^{29}F)

Structure of ^{29}F: Decoupled Band



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

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

Full *sd* PRM calculation

Pure decoupled $d_{5/2}$ band

Structure of ^{25}F and its effective ^{24}O core

PHYSICAL REVIEW LETTERS **124,** 212502 (2020)

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]

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.

Physics Letters B 672 (2009) 17–21

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

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

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

OAK RIDGE National Laboratory

Structure of ^{25}F and its effective ^{24}O core

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	

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.

PHYSICAL REVIEW C **106**, L061303 (2022)

Letter

Core of ^{25}F studied by the ^{25}F($-p$) proton-removal reaction

H. L. Crawford,[1,*] M. D. Jones,[1,2] A. O. Macchiavelli,[1,3] P. Fallon,[1] D. Bazin,[4] P. C. Bender,[4,†] B. A. Brown,[4,5] C. M. Campbell,[1] R. M. Clark,[1] M. Cromaz,[1] B. Elman,[4,5] A. Gade,[4,5] J. D. Holt,[6] R. V. F. Janssens,[2] I. Y. Lee,[1] B. Longfellow,[4,5,‡] S. Paschalis,[7] M. Petri,[7] A. L. Richard,[4,‡] M. Salathe,[1] J. A. Tostevin,[8] and D. Weisshaar[4]

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[3]*Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*

[4]*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

[5]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA*

[6]*TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia, Canada V6T 2A3*

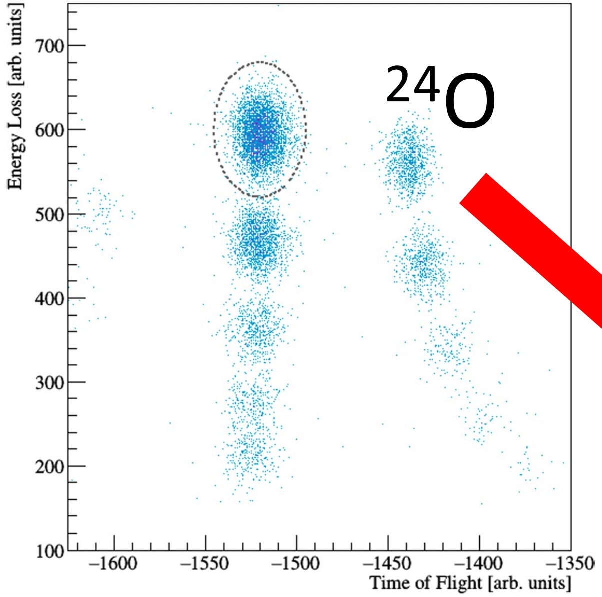
[7]*Department of Physics, University of York, Heslington, York YO10 5DD, United Kingdom*

[8]*Department of Physics, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom*

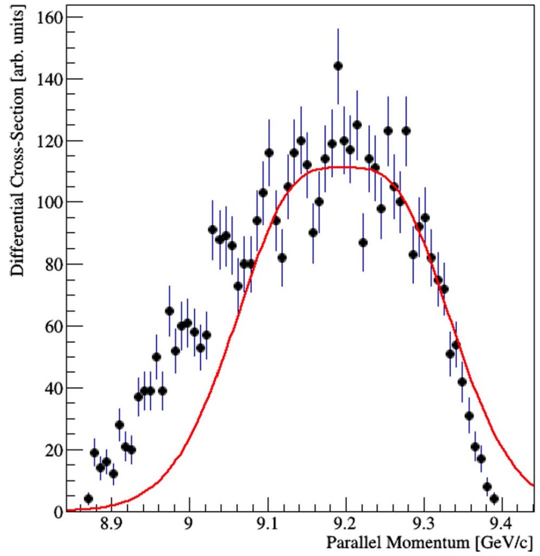
The ^{9}Be(^{25}F$(5/2^+)$, ^{24}O)X proton-removal reaction was studied at the NSCL using the S800 spectrometer. The experimental spectroscopic factor for the ground-state to ground-state transition indicates a substantial depletion of the proton $d_{5/2}$ strength compared to shell-model expectations, similar to the findings of an inverse-kinematics $(p, 2p)$ measurement performed at RIBF. The ^{25}F to ^{24}O ground-states overlap is considerably less than anticipated if the core nucleons behaved as rigid, doubly-magic ^{24}O within ^{25}F. We interpret the new results within the framework of the Particle-Vibration Coupling (PVC) model, of a $d_{5/2}$ proton coupled to a quadrupole phonon of an effective core. This approach provides a good description of the experimental data, requiring an effective ^{24}O* core with a phonon energy of $\hbar\omega_2 = 3.2$ MeV and a $B(E2) \approx 2.7$ W.u. – softer and more collective than a bare ^{24}O. Both the Nilsson deformed mean field and the PVC models appear to capture the properties of the effective core of ^{25}F, suggesting that the additional proton polarizes ^{24}O in such a way that it becomes either slightly deformed or a quadrupole vibrator.

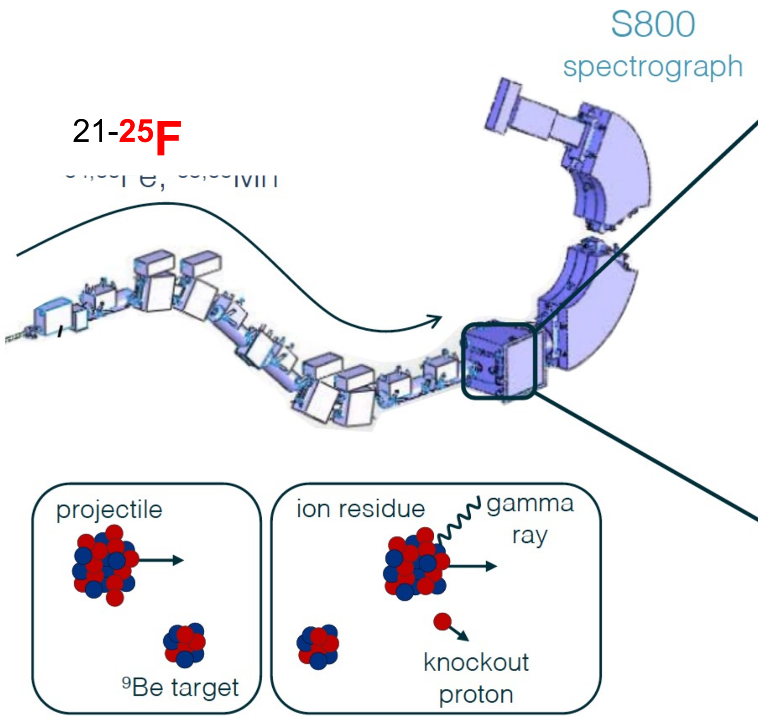
Proton Knockout at NSCL

^{20}Ne	^{21}Ne	^{22}Ne	^{23}Ne	^{24}Ne	^{25}Ne	^{26}Ne	^{27}Ne
^{19}F	^{20}F	^{21}F	^{22}F	^{23}F	^{24}F	^{25}F	^{26}F
^{18}O	^{19}O	^{20}O	^{21}O	^{22}O	^{23}O	^{24}O	^{25}O
^{17}N	^{18}N	^{19}N	^{20}N	^{21}N	^{22}N	^{23}N	^{24}N



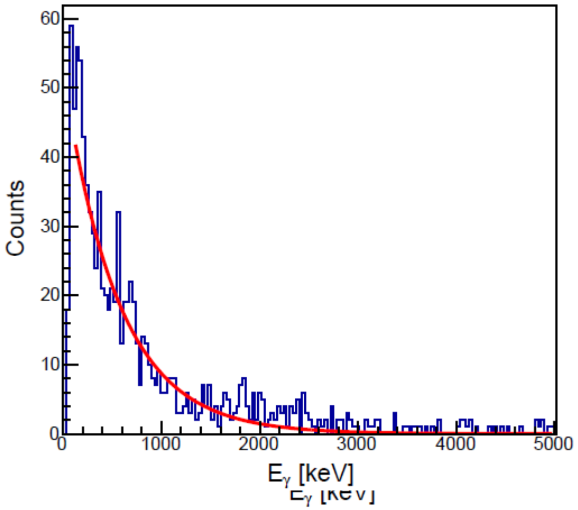
$\ell=2 \rightarrow d_{5/2}$





4 quads at 58°, 8 quads at 90°

https://people.nscl.msu.edu/~noji/gret_12det



- Paschalis *et al.*, NIM A 709 (2013) 44–55
- Bazin *et al.*, NIM B 204 (2003) 629–633

$\sigma = 4.3(6)\ mb$ $\quad$ $\sigma_{sp} = 15.7\ mb$ $\quad$ $S_{exp} = 0.27\ (4)$ $\quad$ $\mathbf{0.56(15)corrected}$

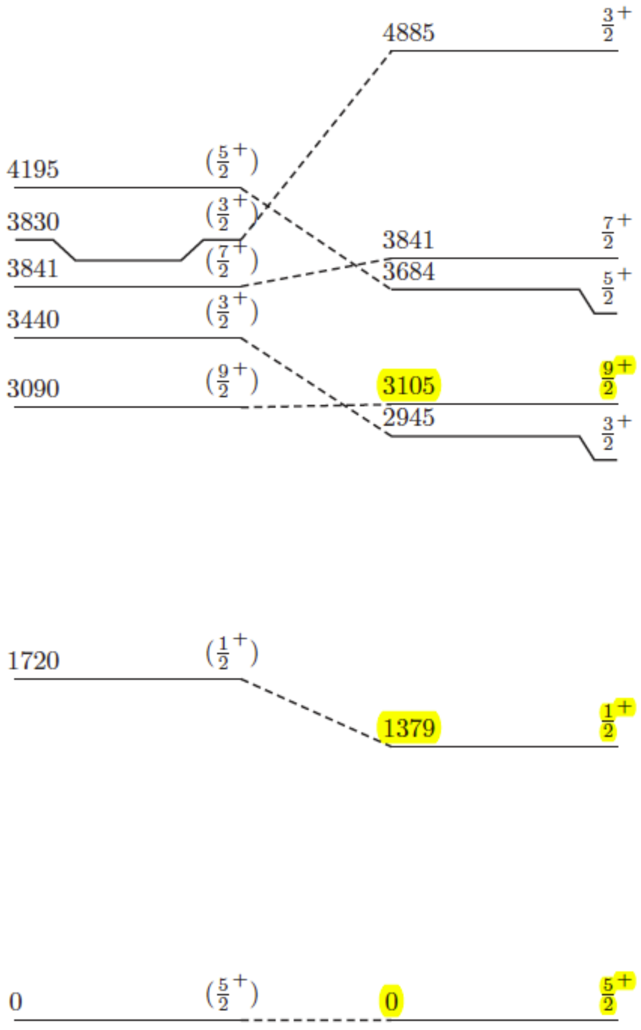
PHYSICAL REVIEW C **102**, 041301(R) (2020)

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
Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

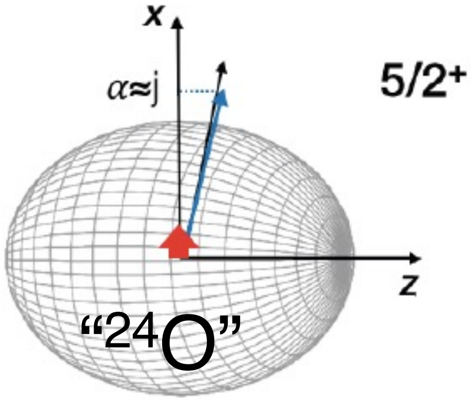
^{25}F in the PRM



Experiment
Theory

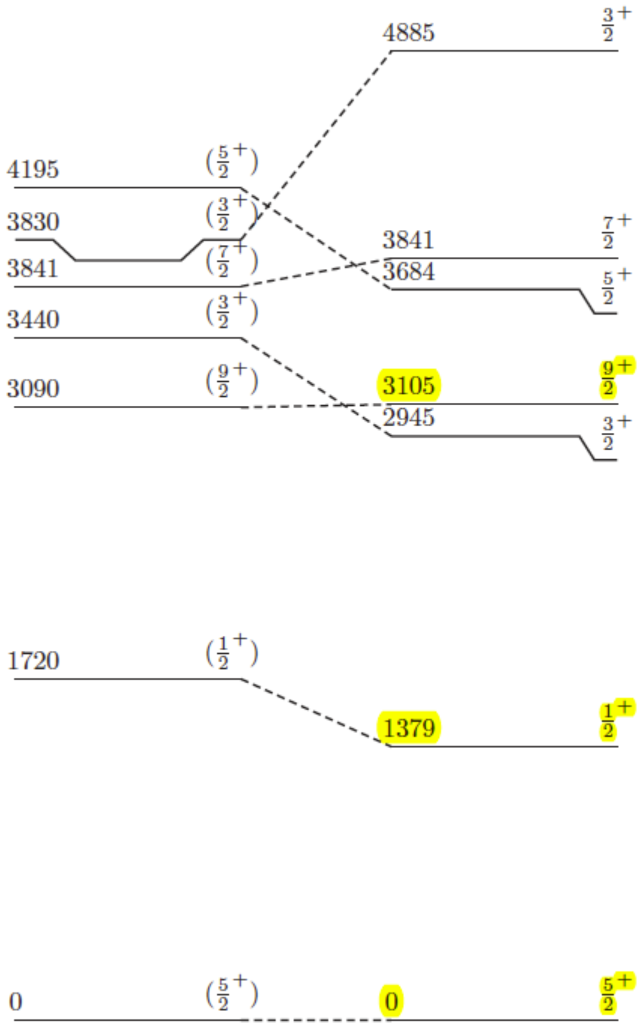
The effective ^{24}O core in ^{25}F can be interpreted as a slightly deformed rotor with:

$E_{2^+}(\text{core}) \approx 3.2$ MeV and $\varepsilon_2 \approx 0.15$,



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

^{25}F in the PRM



Experiment

Theory

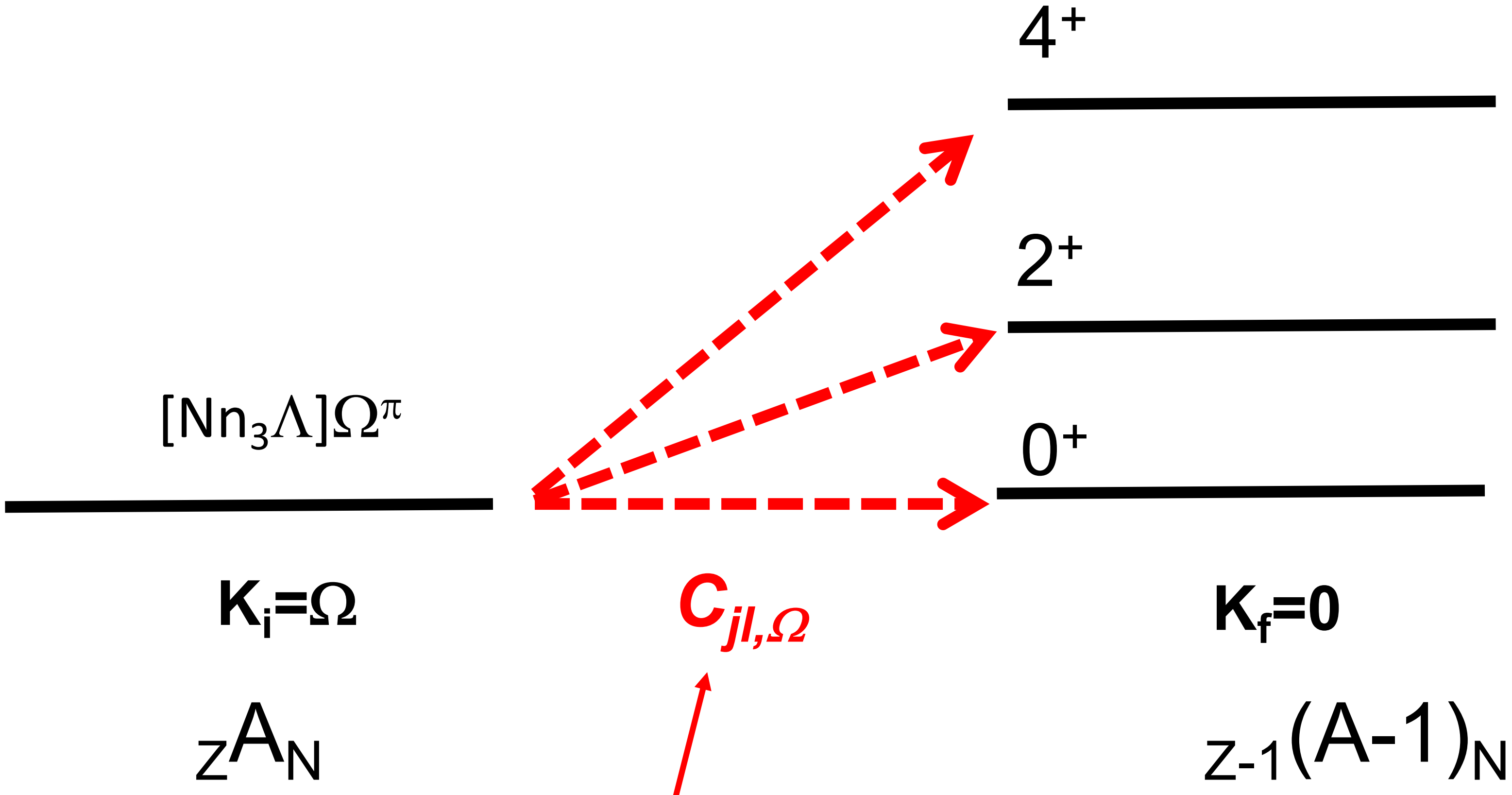
Furthermore, in ^{26}F * the 1^+ ground and 4^+ isomeric states can be associated with the antiparallel and parallel couplings of the odd neutron in the $d_{3/2}$ Nilsson multiplet to the structure of ^{25}F.

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)

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

(-1p) à la Nilsson



$$|[Nn_3\Lambda]\Omega^\pi\rangle = \sum_{\alpha j \Omega} c^{(\nu)}_{\alpha j \Omega} \psi^{\alpha j}_{\Omega}, \qquad \alpha = N, l.$$

Nilsson Spectroscopic Factors

Single nucleon knockout

$$
\begin{aligned}
S_{i,f}(j\ell, K) &= (g\langle I_i j \Omega_\nu K_i | I_f K_f \rangle C_{j,\ell} V_\nu \langle \phi_f | \phi_i \rangle)^2 \\
&= \theta_{i,f}(j\ell, K)^2
\end{aligned}
$$

Nilsson amplitudes

BCS occupations

Core overlap

$$
\boxed{\frac{d\sigma}{d\Omega} = \sum_{j,\ell} S_{j,\ell} \times \sigma_\ell^{sp}}
$$

B. Elbek and P. Tjom,
Advances in Nucl. Phys. Vol 3, 259 (1969)

Spectroscopic factors

PRM $\Rightarrow$ $\psi_I = \sum_K \mathcal{A}_K |IK\rangle.$ $\Rightarrow$ $S_{i,f}(j\ell) = \left(\sum_K \mathcal{A}_K \theta_{i,f}(j\ell, K)\right)^2,$

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

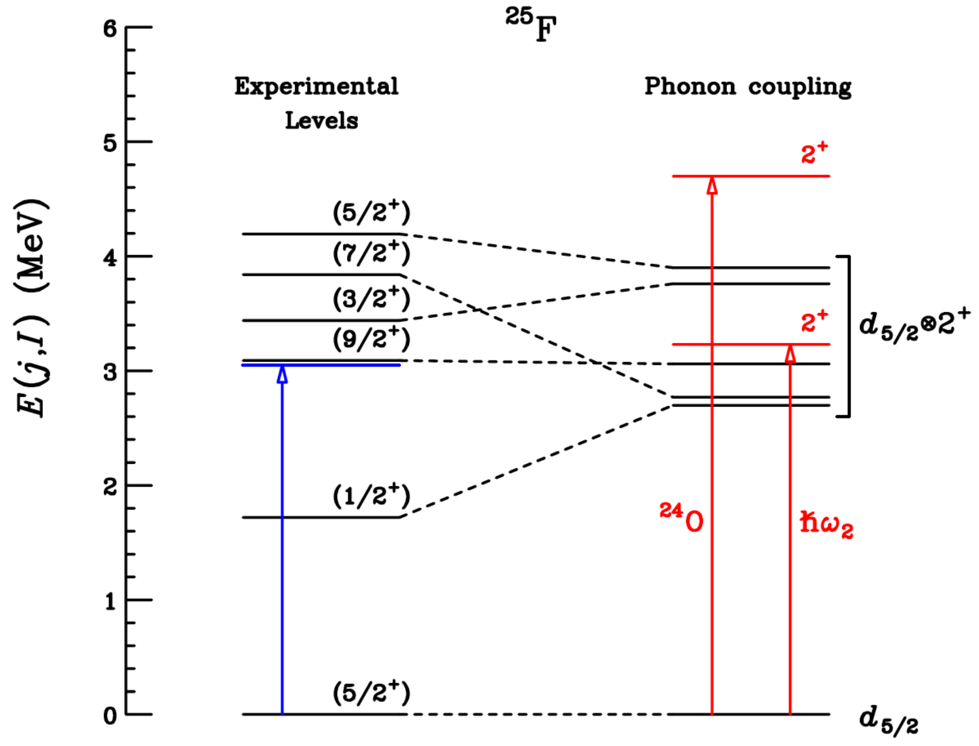
No Quenching

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

Following: T. Takemasa, M. Sakagami, and M. Sano, Phys. Rev. Lett. **29**, 133 (1979).

T. Takemasa, Comput. Phys. Commun. **36**, 79 (1985).

A Particle vibration coupling view



$$\Delta E(j,I) = \frac{h^2(j,j,2)}{\hbar\omega_2}\Big(\delta_{jI} + (2j+1)\Big)\begin{Bmatrix} 2 & j & j \\ 2 & j & I \end{Bmatrix}$$

$$h(j,j,2) = \left(\frac{5}{4\pi}\right)^{1/2}\langle j\tfrac{1}{2}20|j\tfrac{1}{2}\rangle\left(\frac{\hbar\omega_2}{2C_2}\right)^{1/2}\langle j|\kappa_2(r)|j\rangle$$

$$B(E2, n=0\to n=1) = 5\left(\frac{3}{4\pi}ZeR^2\right)^2\left(\frac{\hbar\omega_2}{2C_2}\right)$$

$$\widehat{|j\rangle} \approx a|j,n=0\rangle + b|j,n=1\rangle \qquad b = \frac{h(j,j,2)}{\hbar\omega_2}$$

$$C^2S_{PVC} = a^2\langle^{24}\mathrm{O}|^{24}\mathrm{O}*\rangle^2 \quad = 0.6$$

Parameter	^{24}O	^{24}O*	^{28}O*
$\hbar\omega_2$	4.7	3.2	2.0
$h(j,j,2)$	0.73	1.58	1.75
C_2	204	140	97
$B(E2)$	0.0012	0.0055	0.0082

A first look at ^{28,30}F

PHYSICAL REVIEW LETTERS **124,** 152502 (2020)

Extending the Southern Shore of the Island of Inversion to ^{28}F

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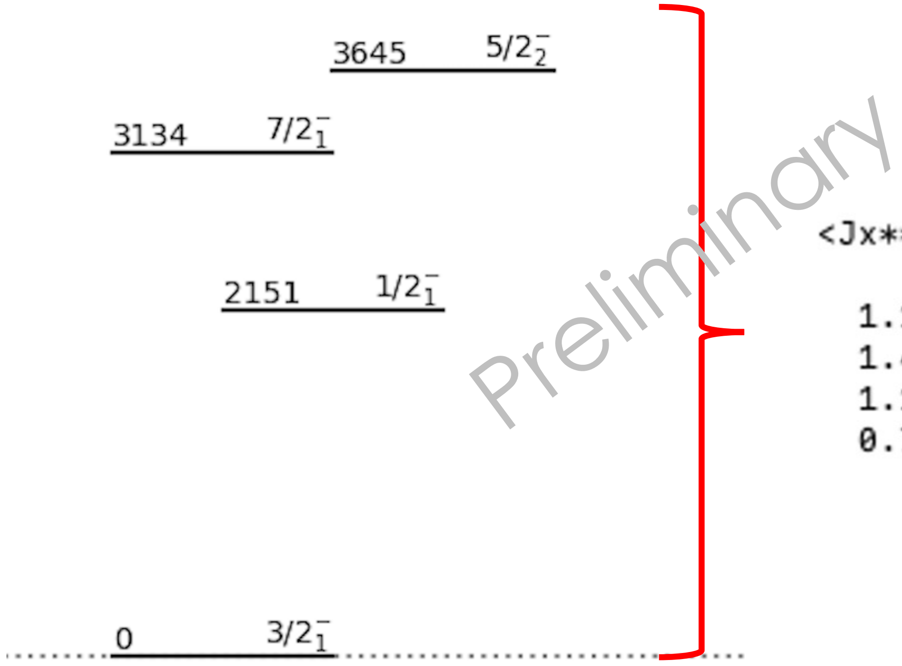
(SAMURAI21 collaboration)

Detailed spectroscopy of the neutron-unbound nucleus ^{28}F has been performed for the first time following proton/neutron removal from ^{29}Ne/^{29}F beams at energies around 230 MeV/nucleon. The invariant-mass spectra were reconstructed for both the $^{27}\mathrm{F}^{(*)}+n$ and $^{26}\mathrm{F}^{(*)}+2n$ coincidences and revealed a series of well-defined resonances. A near-threshold state was observed in both reactions and is identified as the ^{28}F ground state, with $S_n(^{28}\mathrm{F}) = -199(6)$ keV, while analysis of the $2n$ decay channel allowed a considerably improved $S_n(^{27}\mathrm{F}) = 1620(60)$ keV to be deduced. Comparison with shell-model predictions and eikonal-model reaction calculations have allowed spin-parity assignments to be proposed for some of the lower-lying levels of ^{28}F. Importantly, in the case of the ground state, the reconstructed $^{27}\mathrm{F}+n$ momentum distribution following neutron removal from ^{29}F indicates that it arises mainly from the $1p_{3/2}$ neutron intruder configuration. This demonstrates that the island of inversion around $N = 20$ includes ^{28}F, and most probably ^{29}F, and suggests that ^{28}O is not doubly magic.

OAK RIDGE
National Laboratory

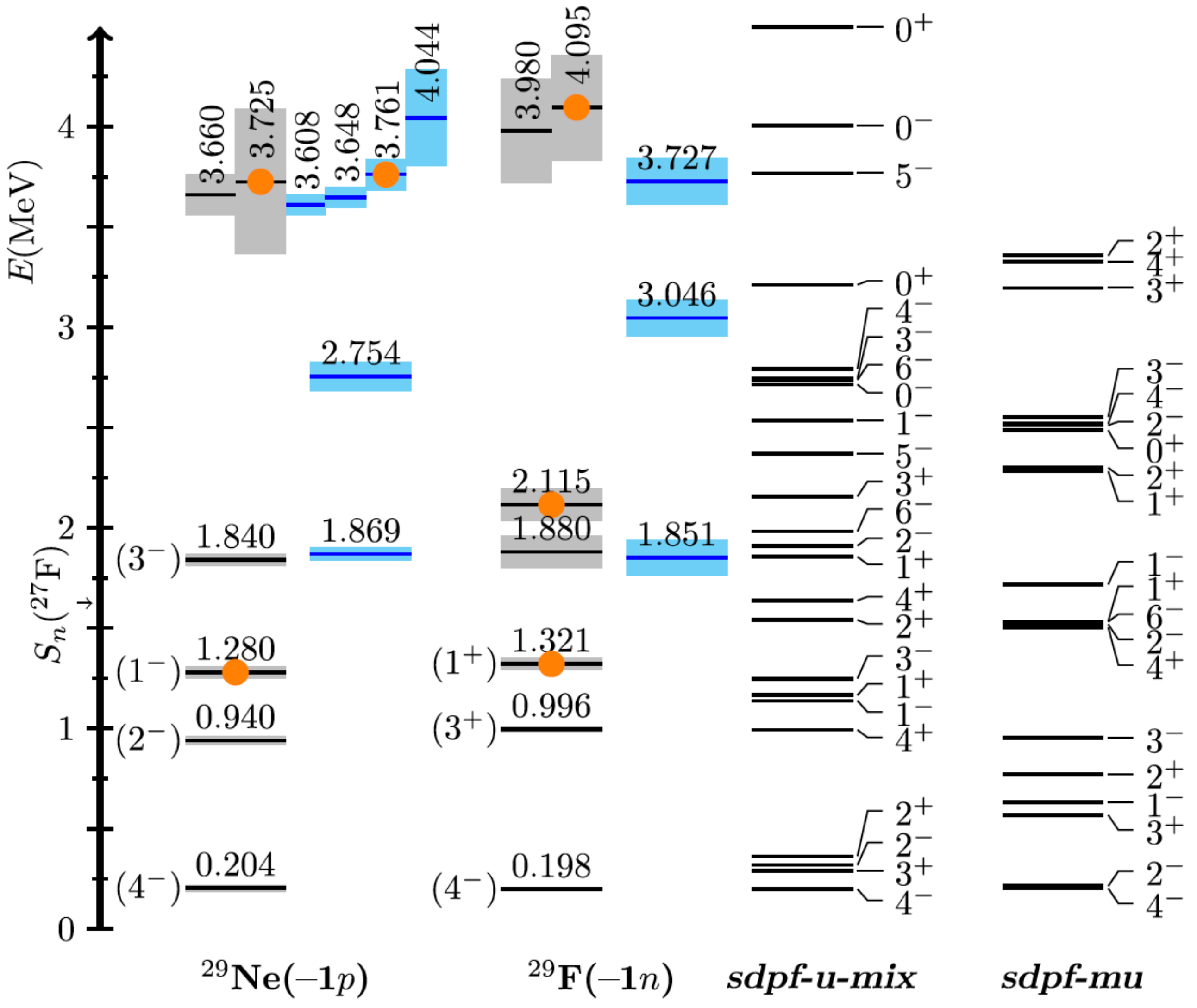
A first look at $^{28,30}F$



Neutron plus $^{28}O^*$

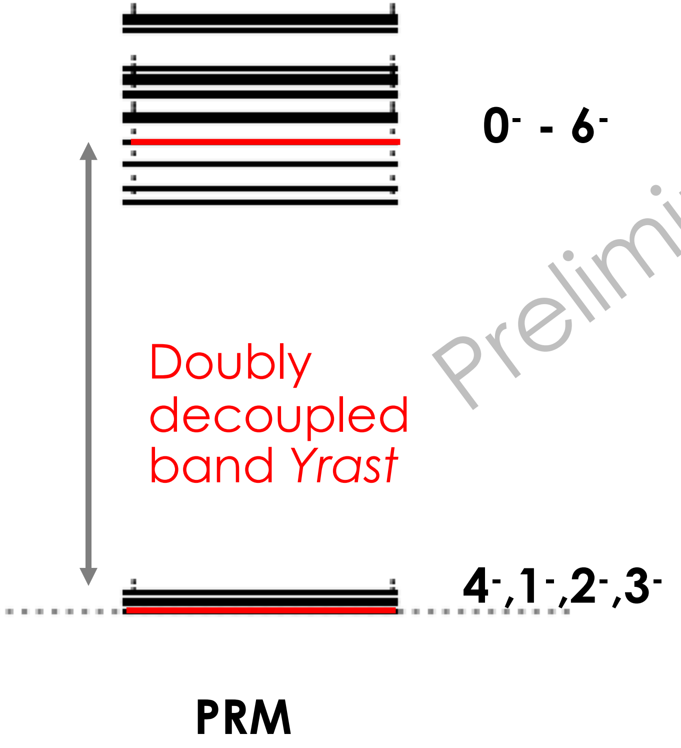
<table>
<tr><th><Jx**2></th><th><Jy**2></th><th><Jz**2></th><th><I.j>/|I|</th><th><Rx**2></th><th><Ry**2></th><th><Rz**2></th><th><R.j>/|R|</th></tr>
<tr><td>1.18</td><td>1.18</td><td>0.78</td><td>1.74</td><td>0.08</td><td>0.08</td><td>0.00</td><td>0.59</td></tr>
<tr><td>1.42</td><td>1.42</td><td>0.25</td><td>-0.80</td><td>2.61</td><td>2.61</td><td>0.00</td><td>-1.65</td></tr>
<tr><td>1.18</td><td>1.18</td><td>0.77</td><td>1.57</td><td>3.21</td><td>3.21</td><td>0.00</td><td>1.22</td></tr>
<tr><td>0.71</td><td>0.71</td><td>1.84</td><td>1.03</td><td>2.94</td><td>2.94</td><td>0.00</td><td>-0.08</td></tr>
</table>

$\rightarrow$ $p_{3/2}$ decoupled band



^{28}F

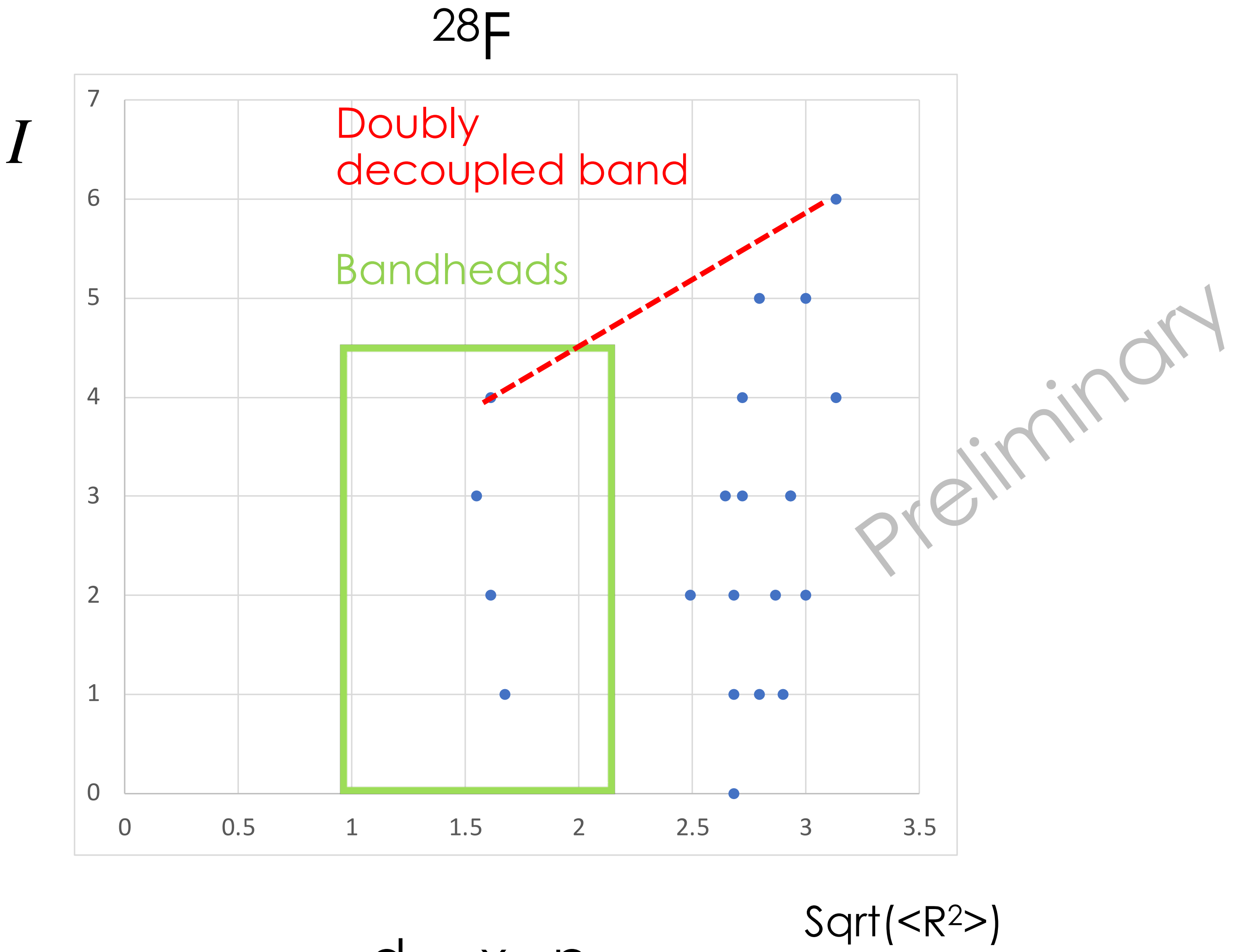
No residual V_{pn}



$\pi d_{5/2} \times \nu p_{3/2}$

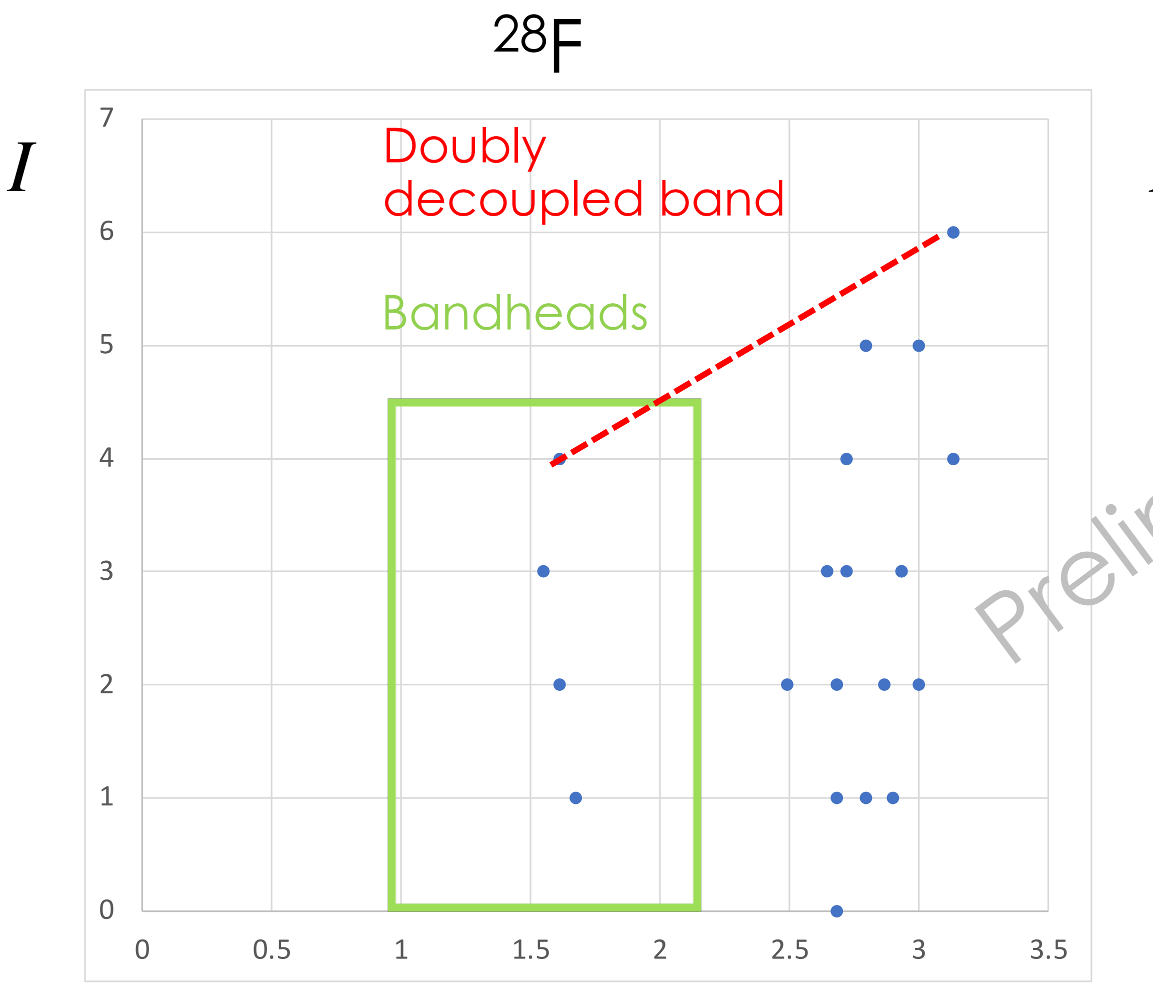
Preliminary

Angular momentum structure

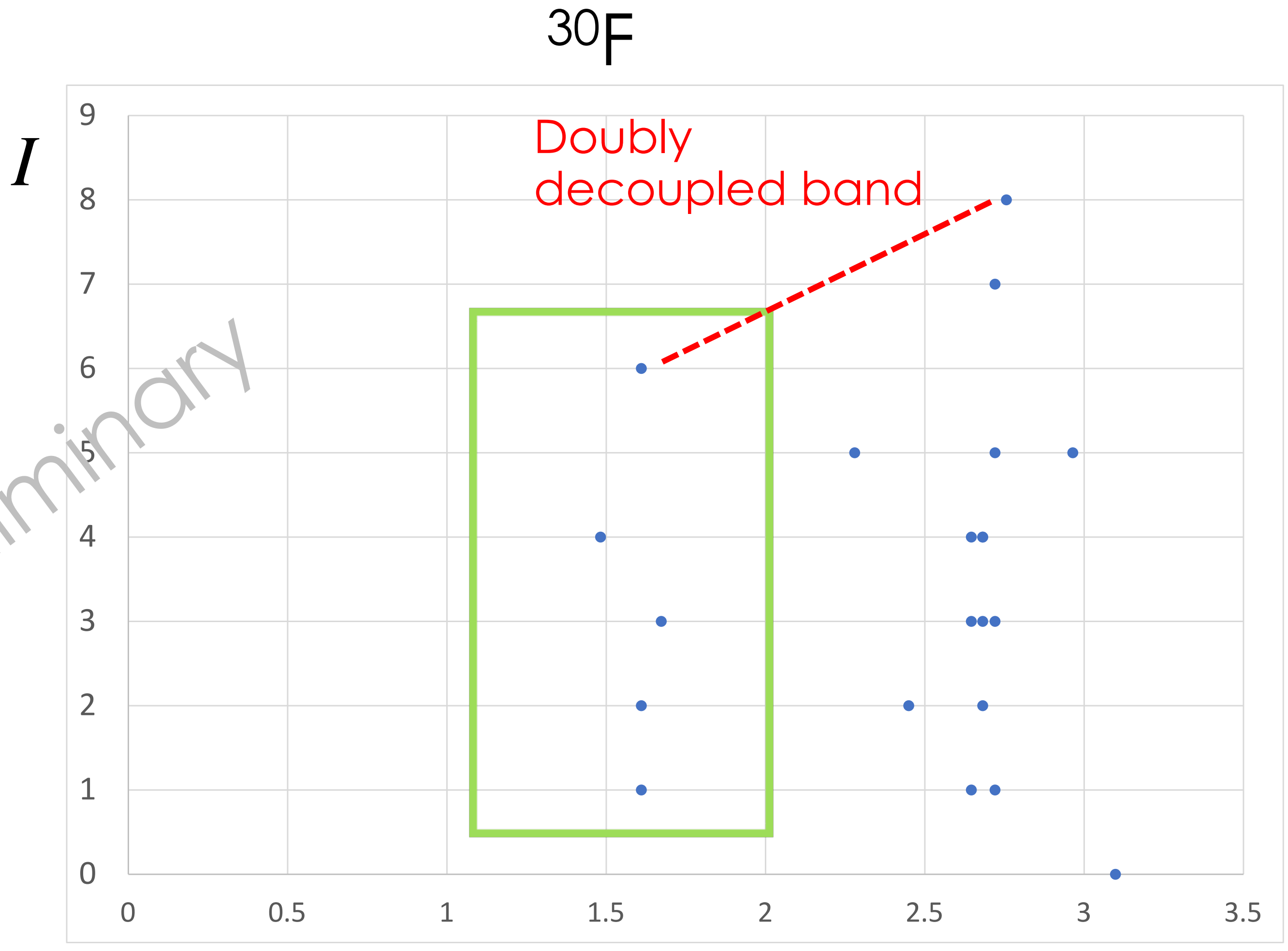


$\pi d_{5/2} \times \nu p_{3/2}$

Angular momentum structure



$\pi d_{5/2} \times \nu p_{3/2}$



$\pi d_{5/2} \times \nu f_{7/2}$

Summary

The low-lying structure of $^{25,29}F$ 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 $^{24,28}O$ and stabilizes its dynamic deformation. Thus, the effective core in ^{25}F (^{29}F) can be interpreted as a slightly deformed rotor with $E2+$ (core) ≈ 3.2 MeV (2.5MeV) and $\varepsilon_2 \approx 0.15$, compared to the real doubly magic ^{24}O (^{28}O) with $E2+ \approx 4.7$ MeV (??) and weak vibrational quadrupole collectivity.

Electromagnetic observables for the three lowest experimental levels, obtained in the PRM, suggest that Coulomb excitation experiments will shed further light on the validity of our interpretation.

Two-qp plus rotor model calculations of $^{28,30}F$ are in progress. Inclusion of residual V_{pn} next

Merci !