Ernest Grodner
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Świerk, Poland

Colectivity, shape coexistence and nuclear chirality in the A=120-130 mass region. The status and plans for 2024

15-149 IJCLab Study of isomeric states in nuclei;
Alpha and cluster emission from exotic isotopes C. PETRACHE J. SREBRNY Nuclear physics

24-158 IJCLab Chirality and lifetimes in lanthanide nuclei
A. ASTIER E. GRODNER Nuclear physics

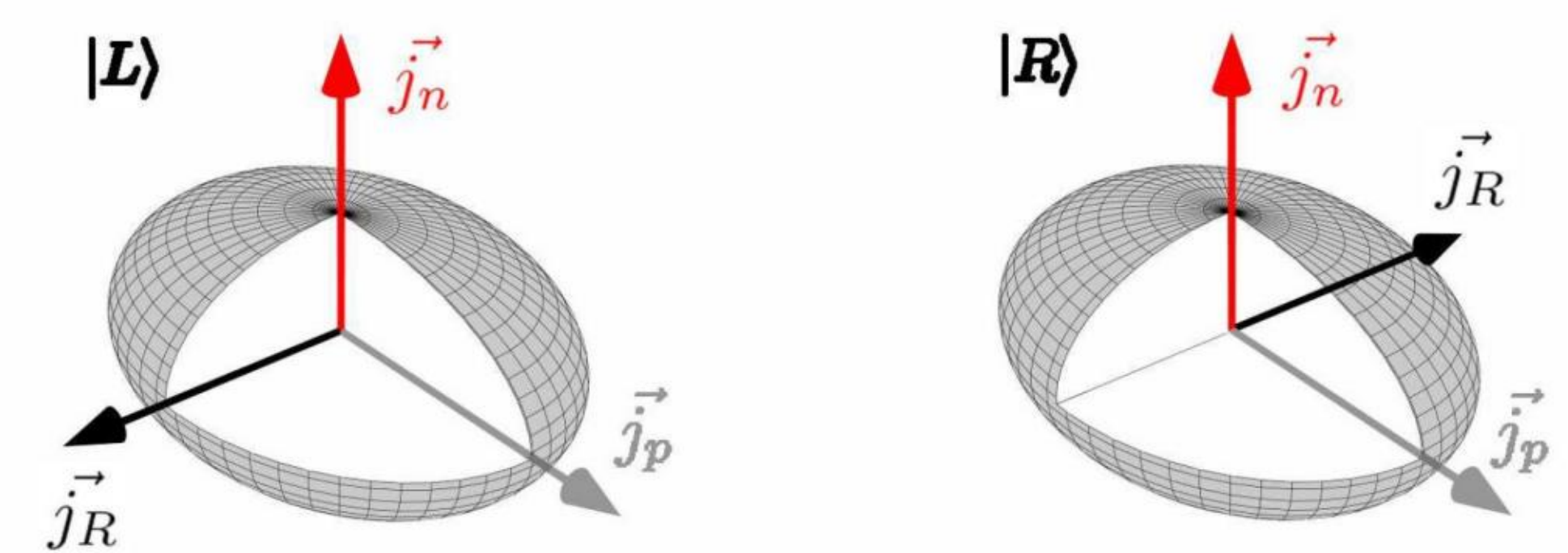
COPIN-IN2P3 Workshop 2023

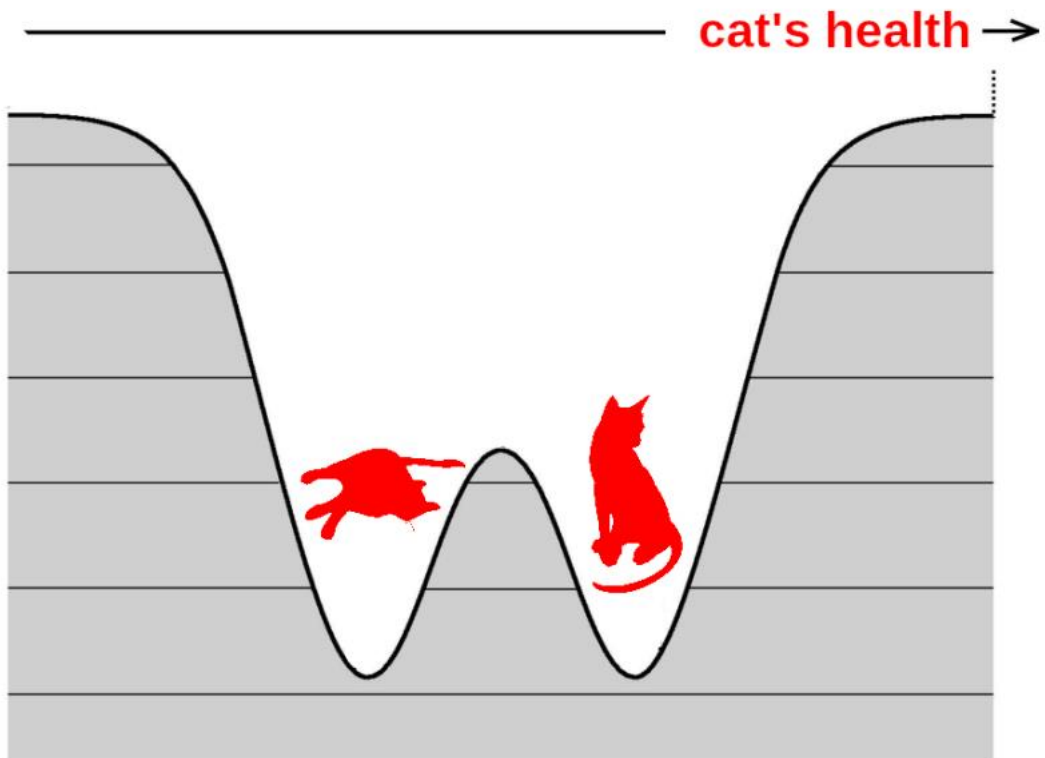
1. Nuclear chirality

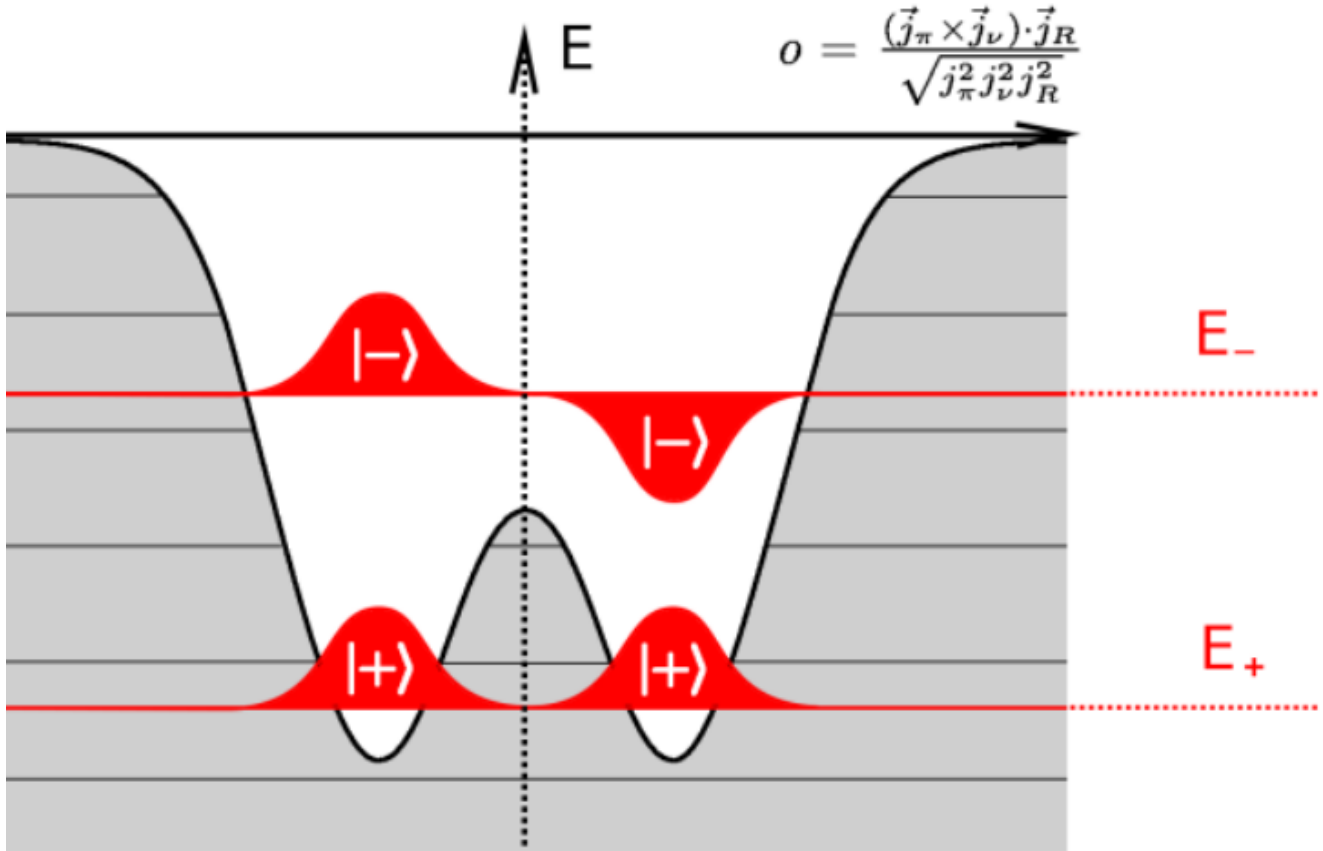
Nuclear chirality

$$R_\pi T|L\rangle = |R\rangle$$

odd-odd nuclei
even-even core (triaxially deformed)
odd proton (particle)
odd neutron (hole)




cat's health

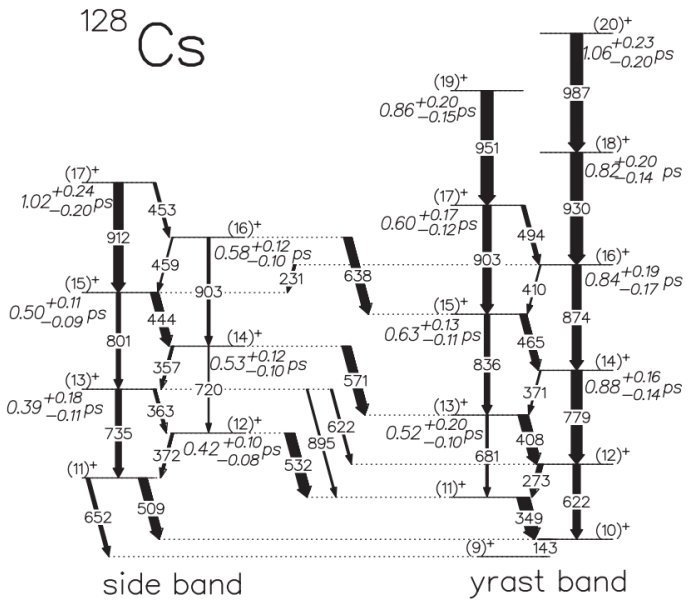

E
$o = \frac{(\vec{j}_\pi \times \vec{j}_\nu)\cdot \vec{j}_R}{\sqrt{j_\pi^2 j_\nu^2 j_R^2}}$
|−⟩
|−⟩
|+⟩
|+⟩
E_
E+

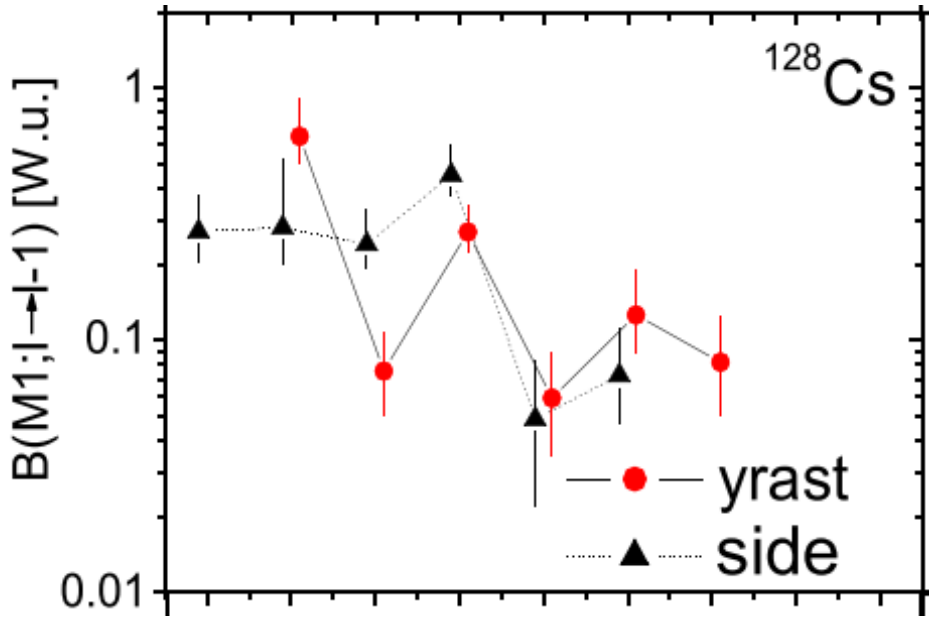
128Cs first experimental confirmation of chirality 2003-2005

PRL 97, 172501 (2006) PHYSICAL REVIEW LETTERS week ending 27 OCTOBER 2006

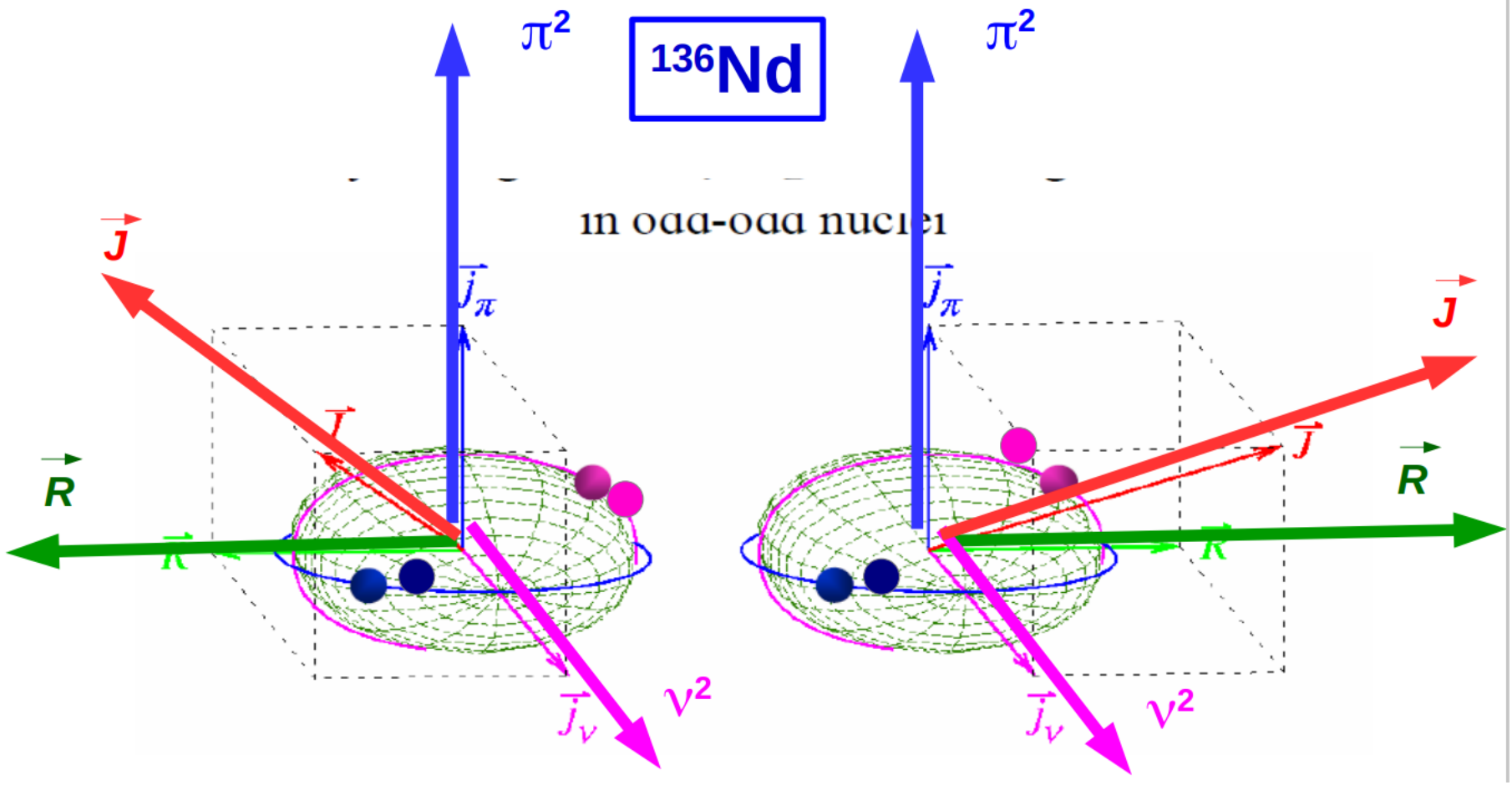
^{128}Cs as the Best Example Revealing Chiral Symmetry Breaking

E. Grodner,[1] J. Srebrny,[1,2] A. A. Pasternak,[1,2,3] I. Zalewska,[1] T. Morek,[1] Ch. Droste,[1] J. Mierzejewski,[2] M. Kowalczyk,[1,2] J. Kownacki,[2] M. Kisieliński,[2,4] S. G. Rohoziński,[5] T. Koike,[6] K. Starosta,[7] A. Kordyasz,[2] P. J. Napiorkowski,[2] M. Wolińska-Cichocka,[2] E. Ruchowska,[4] W. Płóciennik,[4,*] and J. Perkowski[8]





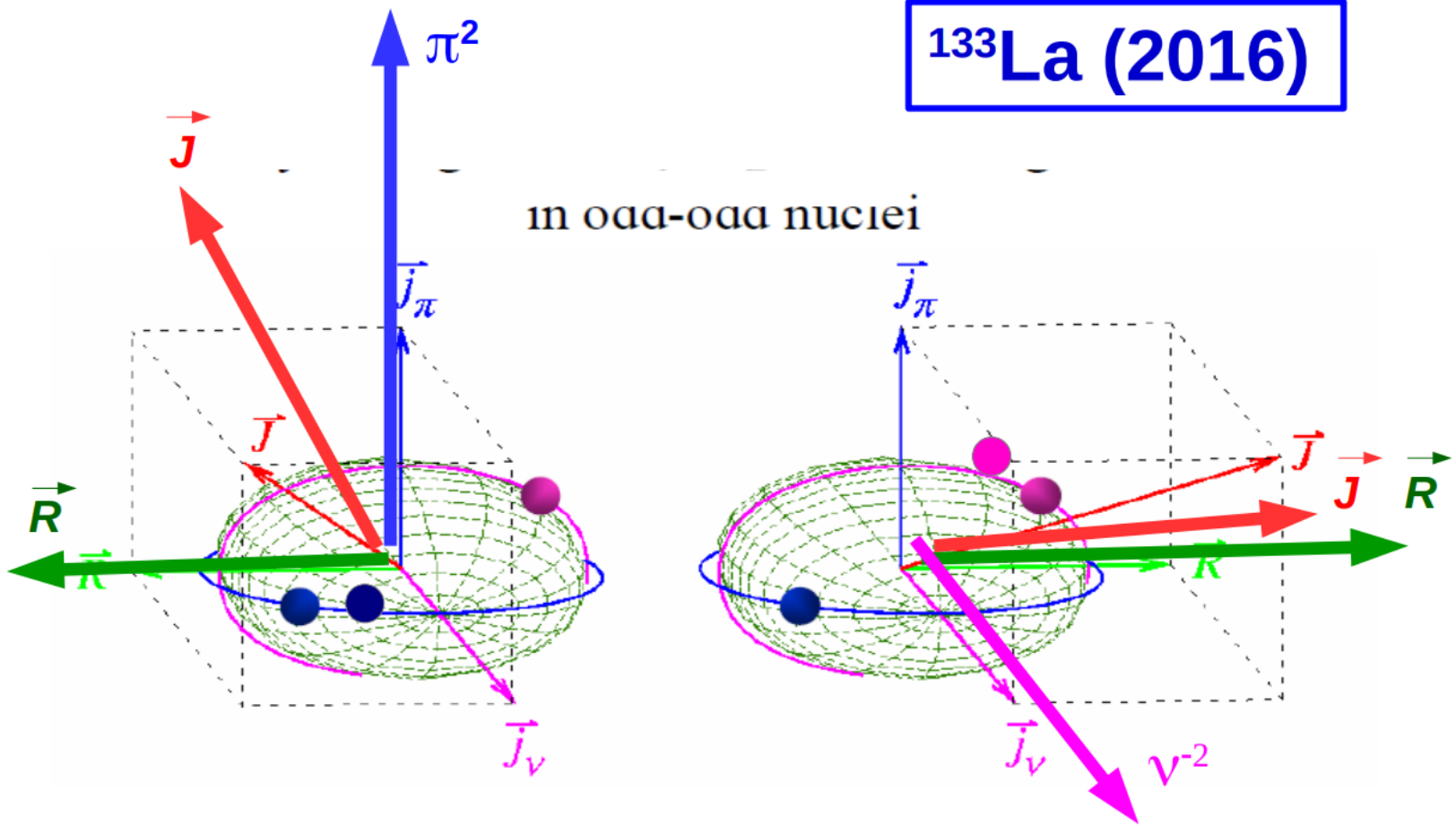
Chirality in even-even nuclei: 4-qp configurations



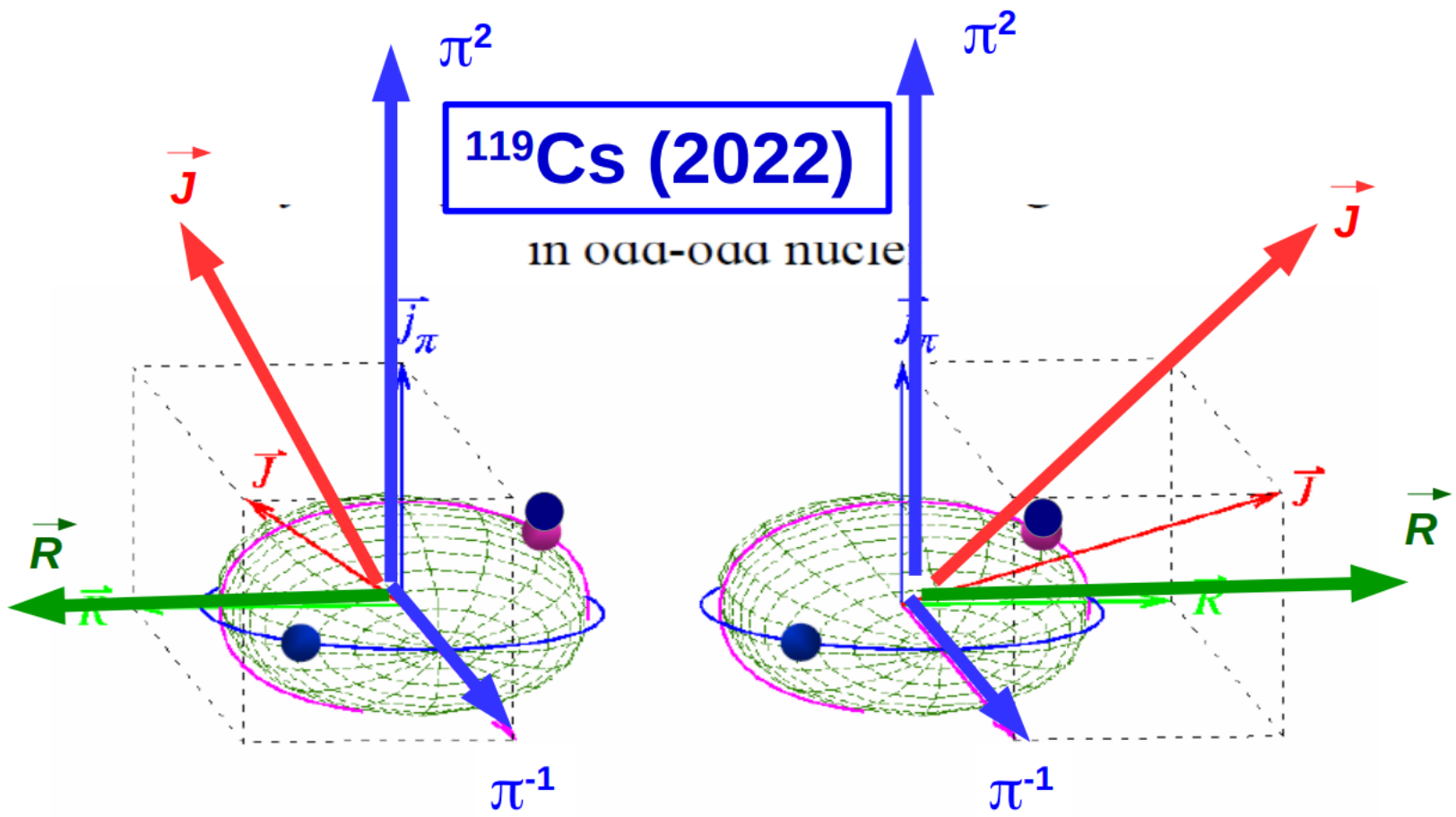
Chirality in odd-even nuclei: 3-qp ($\pi^2\&\nu^{-1}$ or $\pi^1\&\nu^{-2}$) configurations

^{135,137}Nd (2019),^{131}Ba (2020)

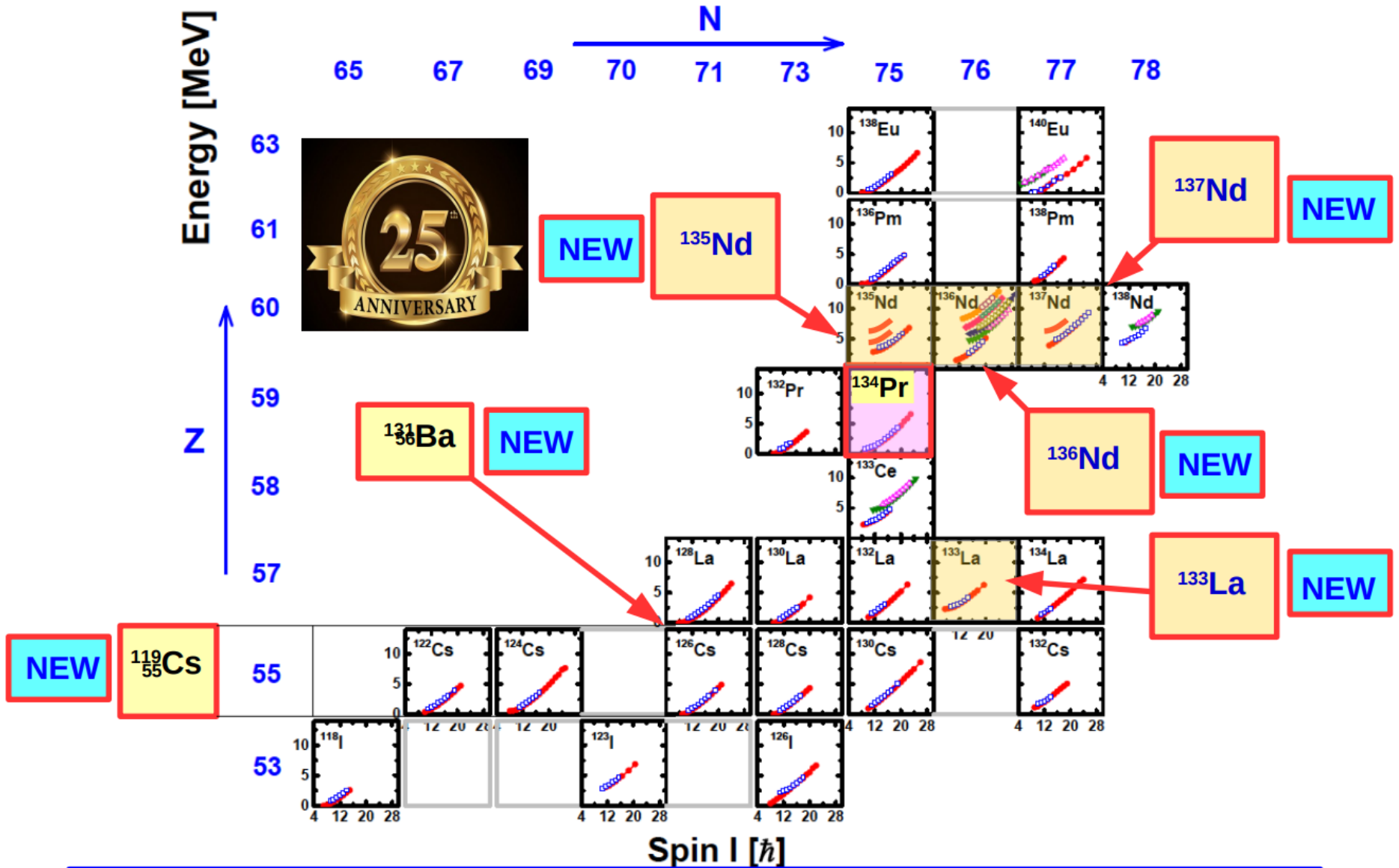
^{133}La (2016)



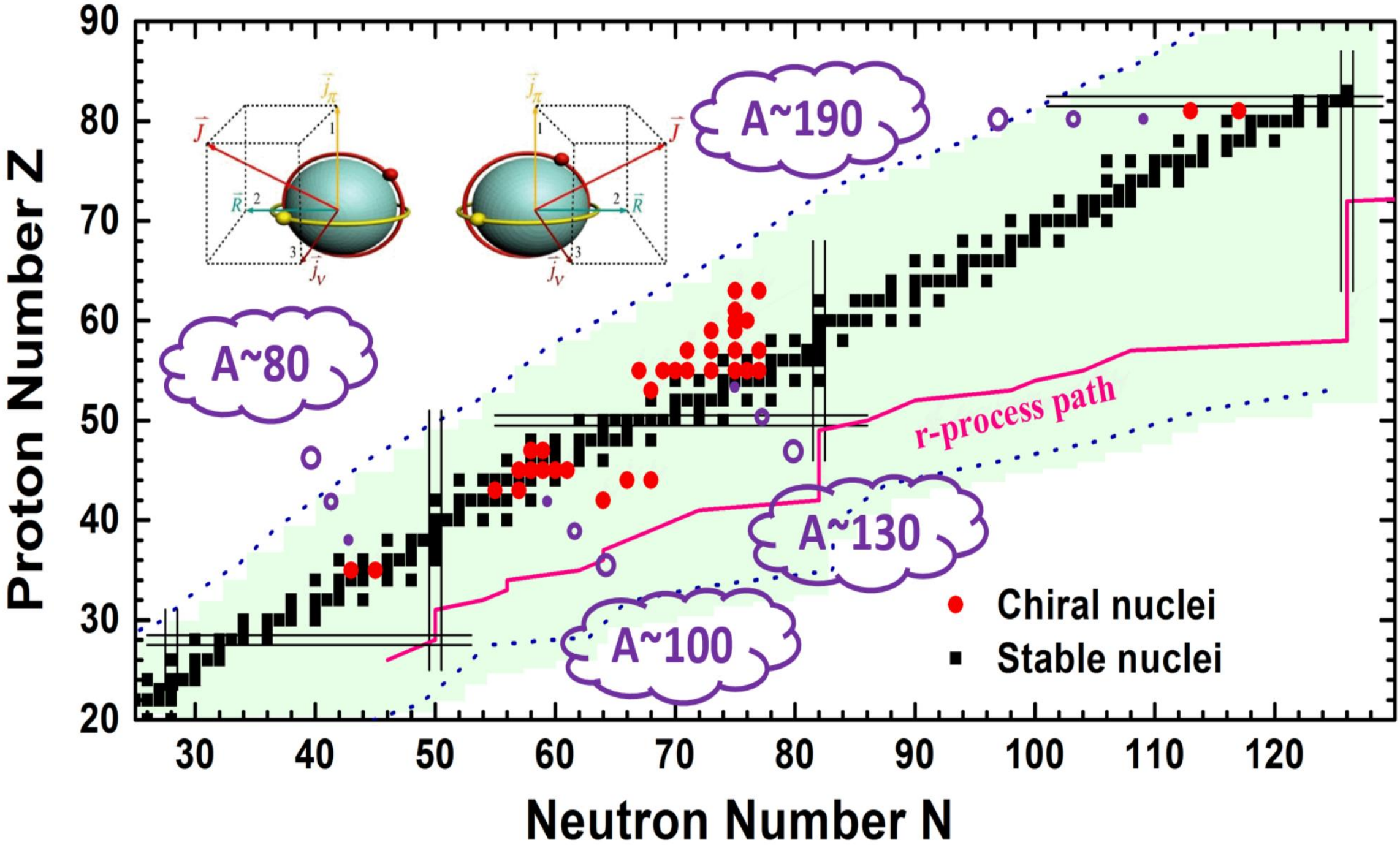
Chirality with identical particles: 3-protons (π^2 & π^{-1})



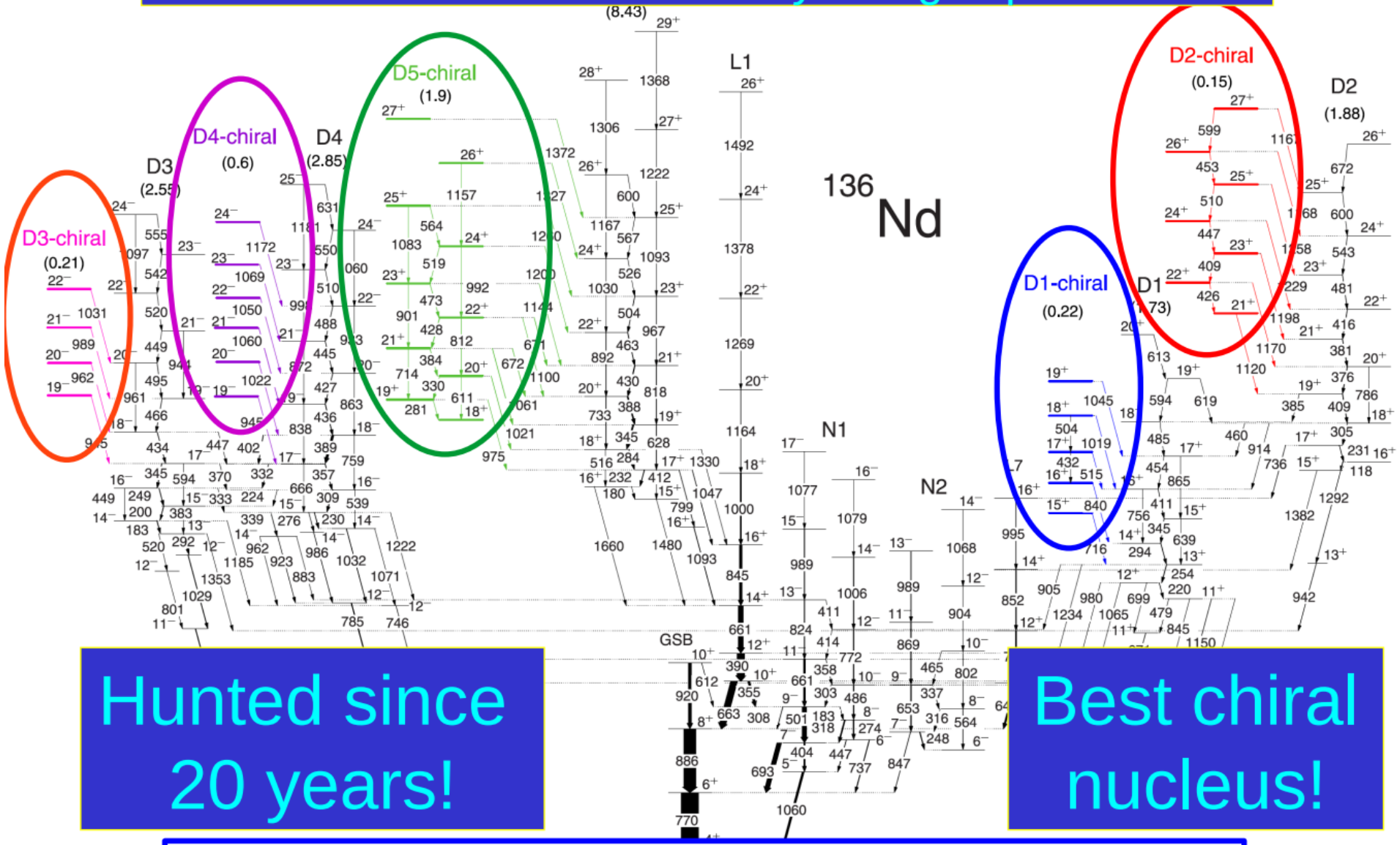
25 Anniversary of chiral bands (1997-2022)



B.W. Xiong, Y.Y. Wang, ADNDT 125 (2018) 193: Nuclear chiral bands data tables


Proton Number Z
Neutron Number N
A~190
A~80
A~130
A~100
r-process path
Chiral nuclei
Stable nuclei

Ultimate chirality under best conditions:
stable maximal triaxiality at high spins



Hunted since 20 years!

Best chiral nucleus!

CP, B.F. Lv et al, PRC 97 (2018) 041304 (R)

CWAN'23

International Conference on Chirality and Wobbling in Atomic Nuclei

Huizhou (China); July 10 - 14, 2023

Theme of the Conference

Dynamics and statics of nuclear triaxiality

Topics:

Chirality and Wobbling:
Theoretical approaches
Experimental evidence

Collective modes:
Nature of triaxiality
Large scale diagonalization
Very neutron rich nuclei

Organizing Committee

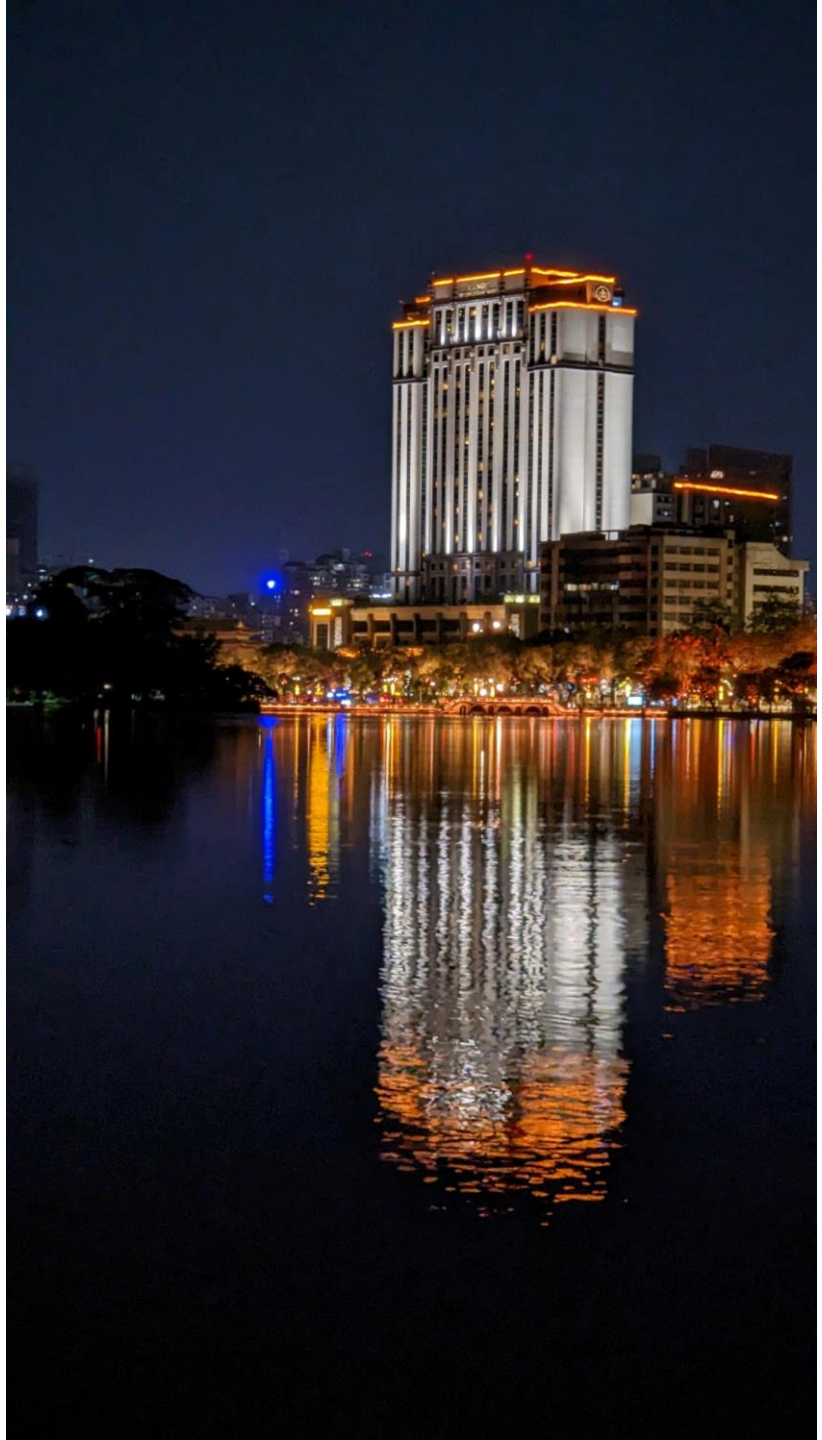
C. M. Petrache (Chair, IJCLab)
France: A. Astier, I. Deloncle
China: S. Guo, P. W. Zhao,Y. X. Liu, X. T. He, B. F. Lv, K. K. Zheng

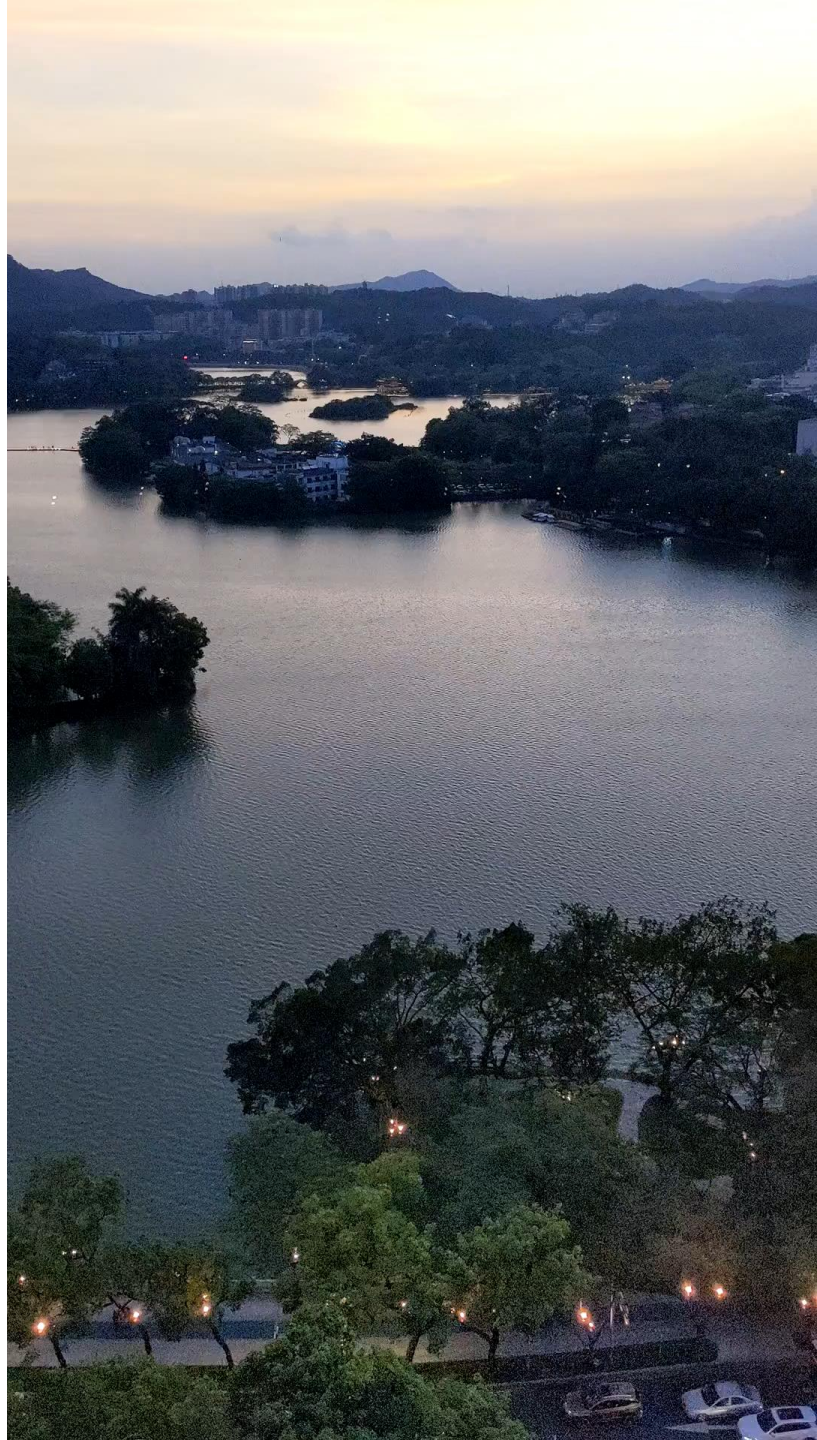
Advisory Committee

R. Bark, R. Clark, G. Colò, J. Dobaczewski, J. Dudek, S. Frauendorf, R. Jolos, R. Julin, T. Koike, E. Lawrie, Z. P. Li, J. Meng, N. Minkov, T. Nakatsukasa, M. Oi, C. Qi, A. A. Raduta, P. Ring, W. Satuła, J. Sheikh, J. Srebrny, J. Timár, D. Vretenar, P. Walker, J.Wood, R. Wyss, Y. Sun,Y. M. Zhao, X. H. Zhou, F. R. Xu

https://indico.in2p3.fr/event/28956/
https://indico.impcas.ac.cn/event/32/

J. Deloncle (IJCLab), Earth photo NASA





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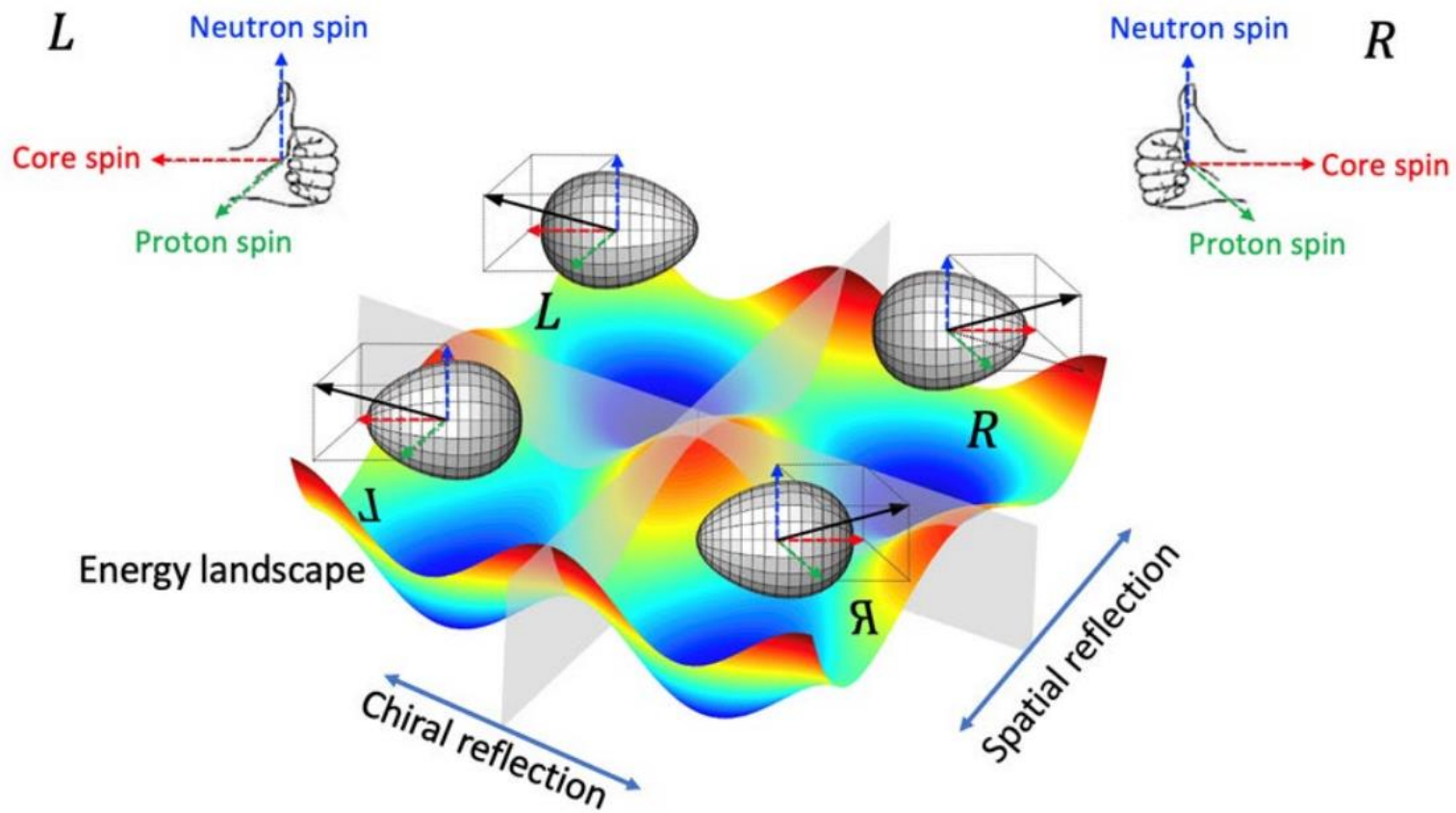
Article

Selection rules of electromagnetic transitions for chirality-parity violation in atomic nuclei

Yuanyuan Wang [a], Xinhui Wu [a], Shuangquan Zhang [a,*], Pengwei Zhao [a], Jie Meng [a,b,c]

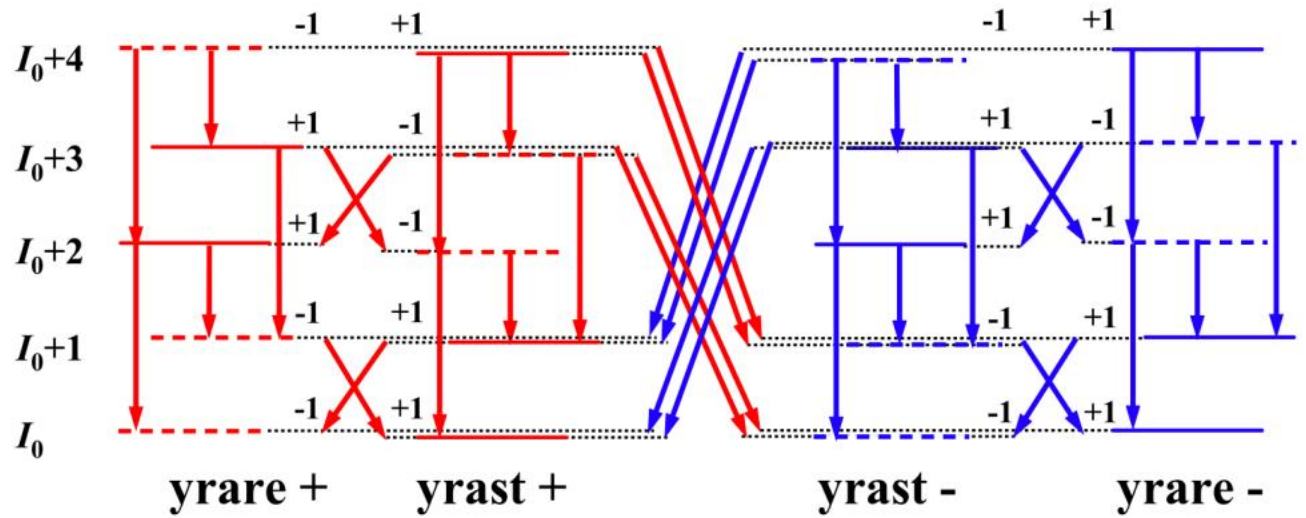
[a] State Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University, Beijing 100871, China
[b] School of Physics and Nuclear Energy Engineering, Beihang University, Beijing 100191, China
[c] Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan



Nuclear Chirality-Parity (ChP) violation

ChP 四重带

从角动量 I_0 下的正、负宇称能量最低态（yrast state）和次低态（yrare state）出发，根据带内 $E2$ 连接得到两对宇称相反的手征双重带，即**ChP** 四重带



- ✓ 自旋增加 $2\hbar$，$\mathcal{B}$ 变号：带内 $E2$ 允许、带间 $E2$ 禁戒
- ✓ 带内和带间的 $M1$ 均随自旋增加交替出现
- ✓ $E3$ 跃迁随自旋增加交替出现，即 yrast+ ↔ yrast-, yrare+ ↔ yrare- 和 yrast+ ↔ yrare-, yrare+ ↔ yrast-

Timeline for nuclear chirality

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NPA 617, 131

Prediction

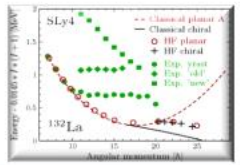
1997

^{130}Cs ^{132}La
^{134}Pr ^{136}Pm
First Evidence

PRL 86, 971

2001

PRL 93, 052501



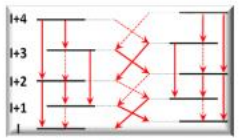
Critical Frequency

2004

^{128}Cs
Lifetime Analysis

PRL 97, 172501

PRL 93, 172502



EM transition Selection Rule

2006

^{133}Ce
First MχD Evidence

PRL 110, 172504

2013

^{106}Ag
Chiral Conundrum Resolution

PRL 112, 202502

2014

PRC 73, 037303

MχD

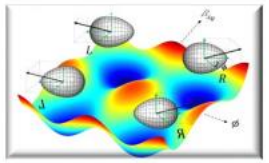
2016

^{78}Br MχD with Octupole Correlations

PRL 116, 112501

2018

Sci. Bull. 65, 2001



Chirality-Parity Violation

2020

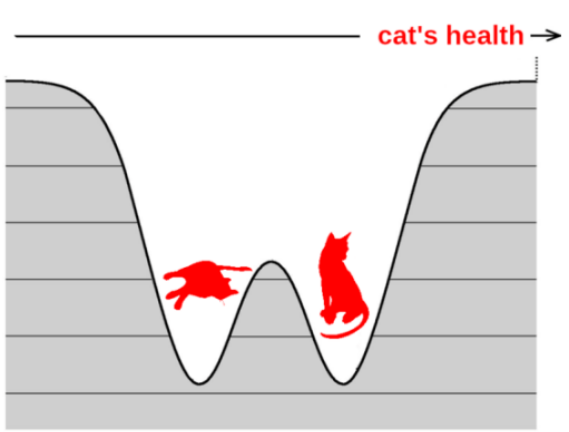
^{128}Cs
g factor

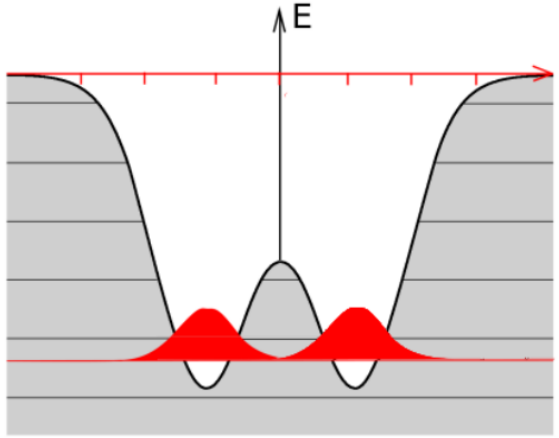
PRL 120, 022502

By Yiping Wang et al

Superimposed states of a cat in the box

Symmetry braking cat inside

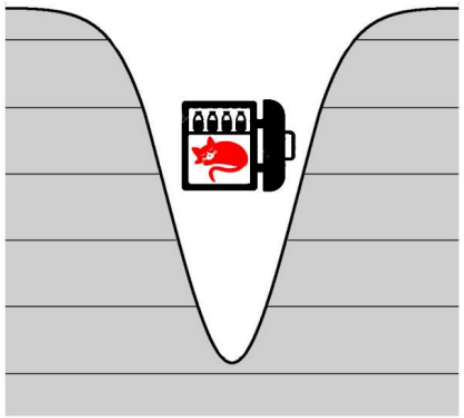


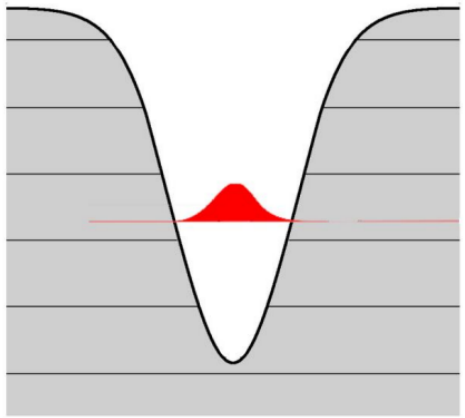


Measured cat's health: hibernated

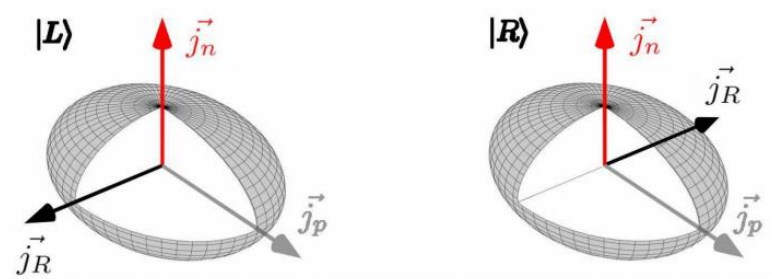
But what if we put a hibernated cat in the box in a first place?

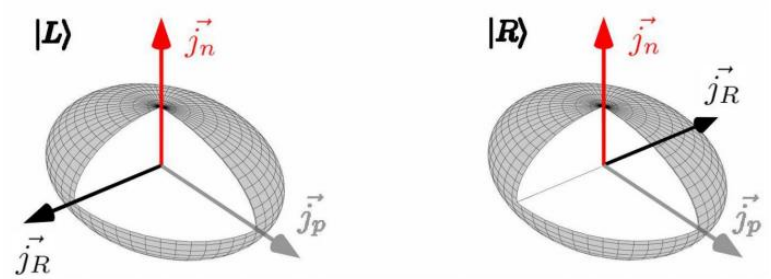
Symmetry conserving cat inside

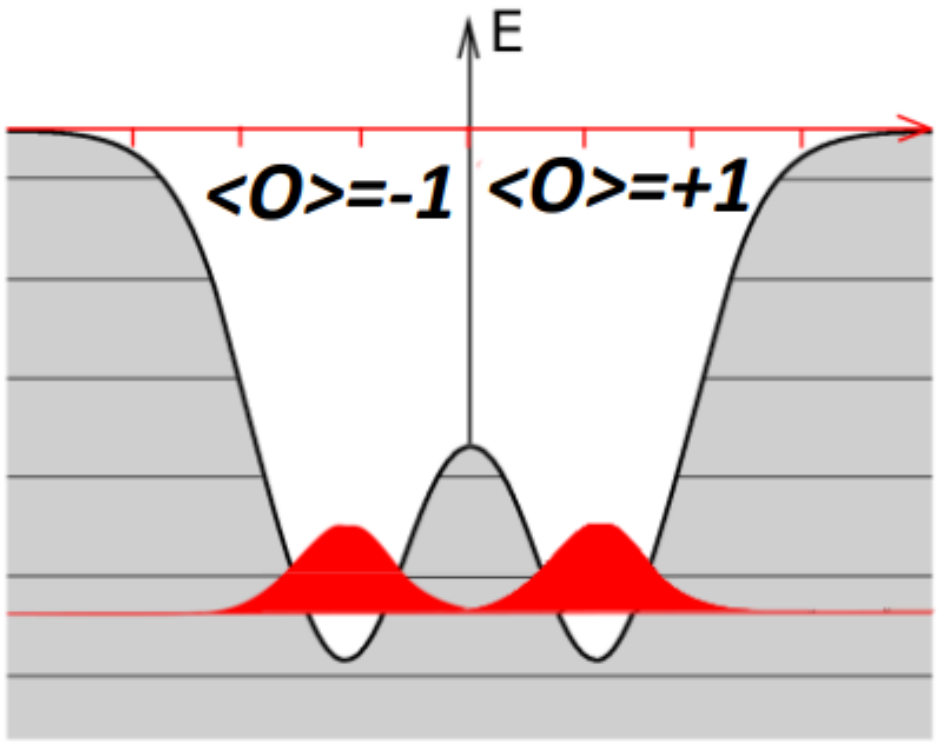


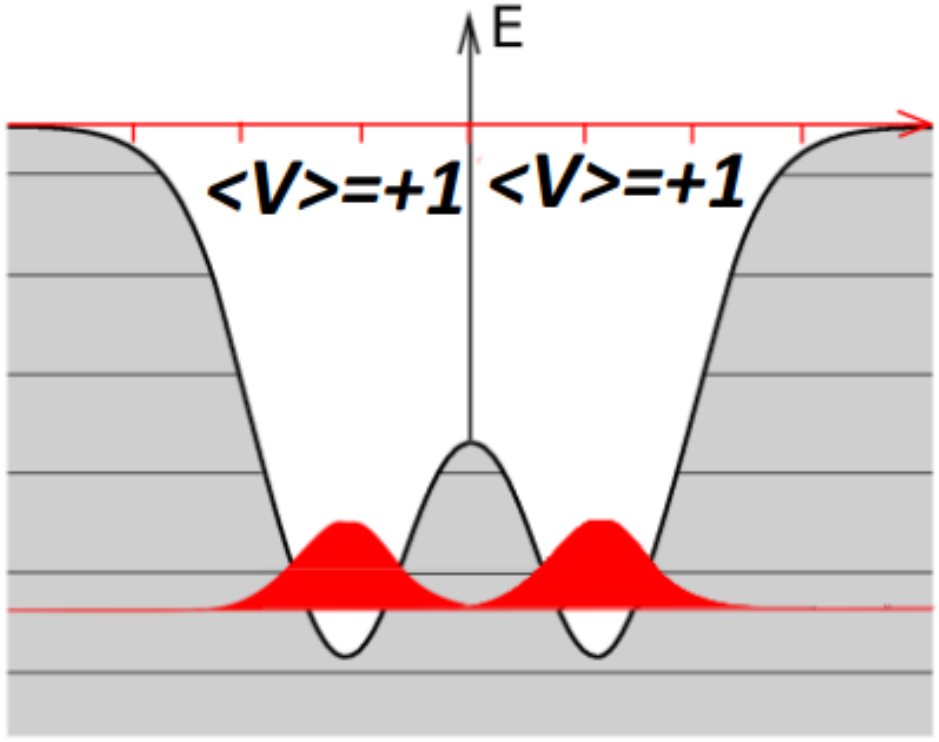


Measured cat's health: hibernated


|L⟩
$\vec{j}_n$
$\vec{j}_p$
$\vec{j}_R$
|R⟩
$\vec{j}_n$
$\vec{j}_R$
$\vec{j}_p$


|L⟩
$\vec{j}_n$
$\vec{j}_p$
$\vec{j}_R$
|R⟩
$\vec{j}_n$
$\vec{j}_R$
$\vec{j}_p$


E
<O>=-1
<O>=+1


E
<V>=+1
<V>=+1

First Measurement of the g Factor in the Chiral Band: The Case of the ^{128}Cs Isomeric State

E. Grodner,[1,2] J. Srebrny,[3] Ch. Droste,[2] L. Próchniak,[3] S. G. Rohoziński,[2] M. Kowalczyk,[3] M. Ionescu-Bujor,[4] C. A. Ur,[5] K. Starosta,[6] T. Ahn,[7] M. Kisieliński,[3] T. Marchlewski,[3] S. Aydin,[8,10] F. Recchia,[9] G. Georgiev,[11] R. Lozeva,[11] E. Fiori,[11] M. Zielińska,[3] Q. B. Chen,[12] S. Q. Zhang,[12] L. F. Yu,[12] P. W. Zhao,[12] and J. Meng[12,13]

[1]*National Centre for Nuclear Research, 05-540 Świerk, Poland*
[2]*Faculty of Physics, University of Warsaw, 02-093 Warsaw, Poland*
[3]*Heavy Ion Laboratory, University of Warsaw, 02-093 Warsaw, Poland*
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[12]*State Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University, Beijing 100871, China*
[13]*Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan*

PHYSICAL REVIEW C
covering nuclear physics

Examination of nuclear chirality with a magnetic moment measurement of the $I = 9$ isomeric state in ^{128}Cs

E. Grodner, M. Kowalczyk, M. Kisieliński, J. Srebrny, L. Próchniak, Ch. Droste, S. G. Rohoziński, Q. B. Chen, M. Ionescu-Bujor, C. A. Ur, F. Recchia, J. Meng, S. Q. Zhang, P. W. Zhao, G. Georgiev, R. Lozeva, E. Fiori, S. Aydin, and A. Nałęcz-Jawecki

Phys. Rev. C **106**, 014318 – Published 28 July 2022

FRONTIERS OF PHYSICS

TOPICAL REVIEW
Volume / Issue / / 2024

The *g*-factor measurement as an ultimate test for nuclear chirality

Ernest Grodner[1,†], Michał Kowalczyk[2,‡], Julian Srebrny[2,§], Leszek Próchniak[2,¶], Chrystian Droste[3,**], Jan Kownacki[2], Maciej Kisieliński[2,††], Krzysztof Starosta[4,‡‡], Takeshi Koike[5]

1 National Centre for Nuclear Research, 05-540 Świerk, Poland
2 Heavy Ion Laboratory, University of Warsaw, Pasteura 5a, 02-093 Warsaw, Poland
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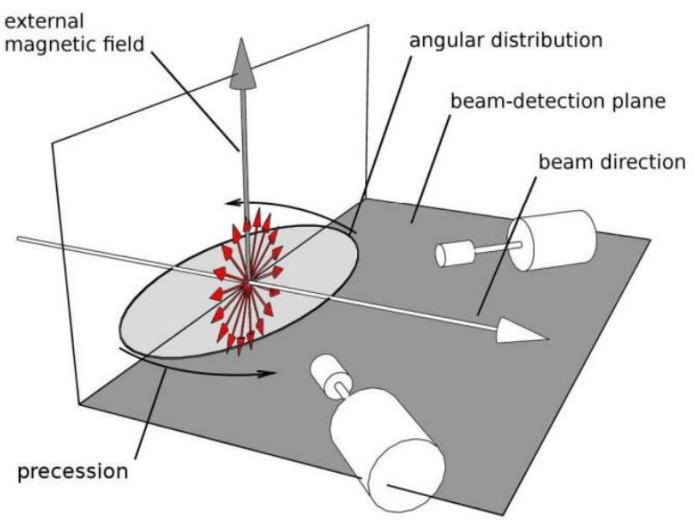
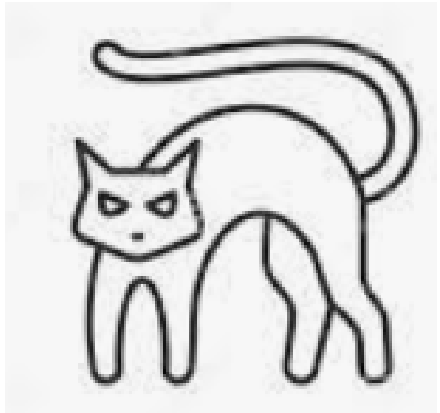
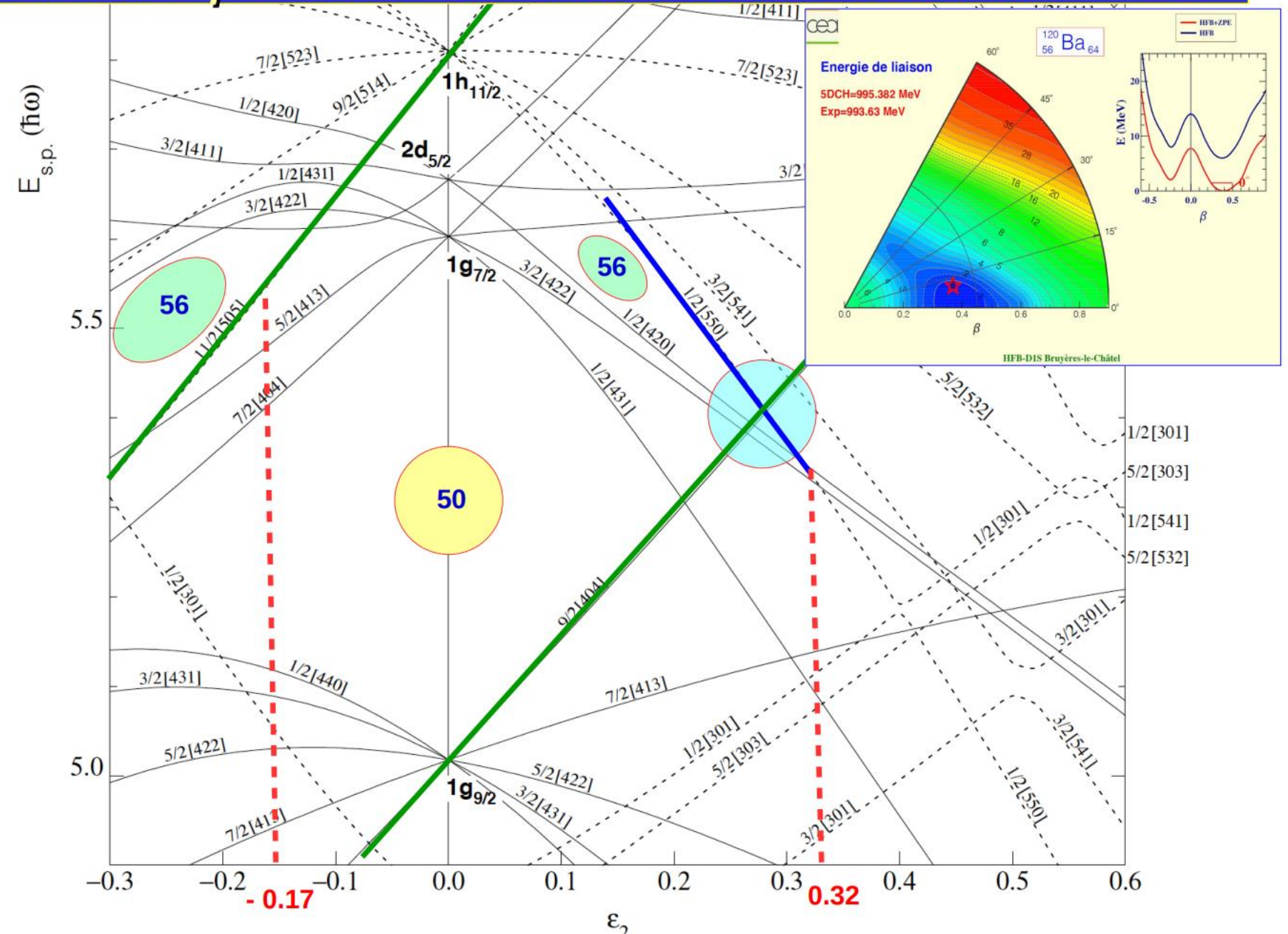
5 Department of Physics, Tohoku University, Sendai, Miyagi 980-8577, Japan
Corresponding authors. E-mail: †grodner.ernest@gmail.com, ‡mkk@fuw.edu.pl, §js@slcj.uw.edu.pl, ¶prochniak@slcj.uw.edu.pl, **cdroste@fuw.edu.pl, ††kisiel@slcj.uw.edu.pl, ‡‡starosta@sfu.ca

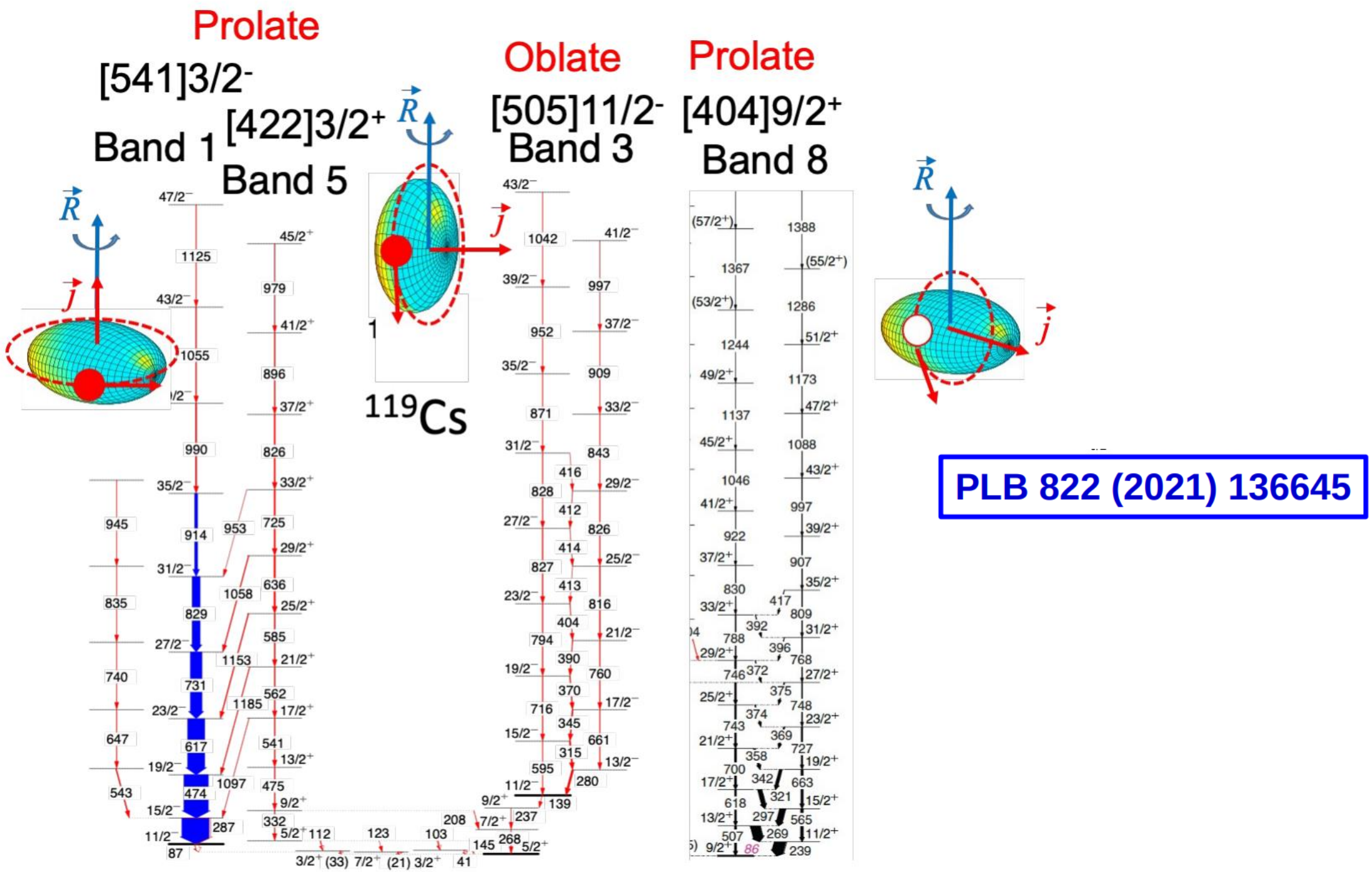


2. Shape coexistence

Oblate-prolate coexistence around Z=56






Prolate
[541]3/2⁻
Band 1
[422]3/2⁺
Band 5
Oblate
[505]11/2⁻
Band 3
Prolate
[404]9/2⁺
Band 8
^{119}Cs
PLB 822 (2021) 136645

PHYSICAL REVIEW C **99**, 041301(R) (2019)

Rapid Communications

Oblate

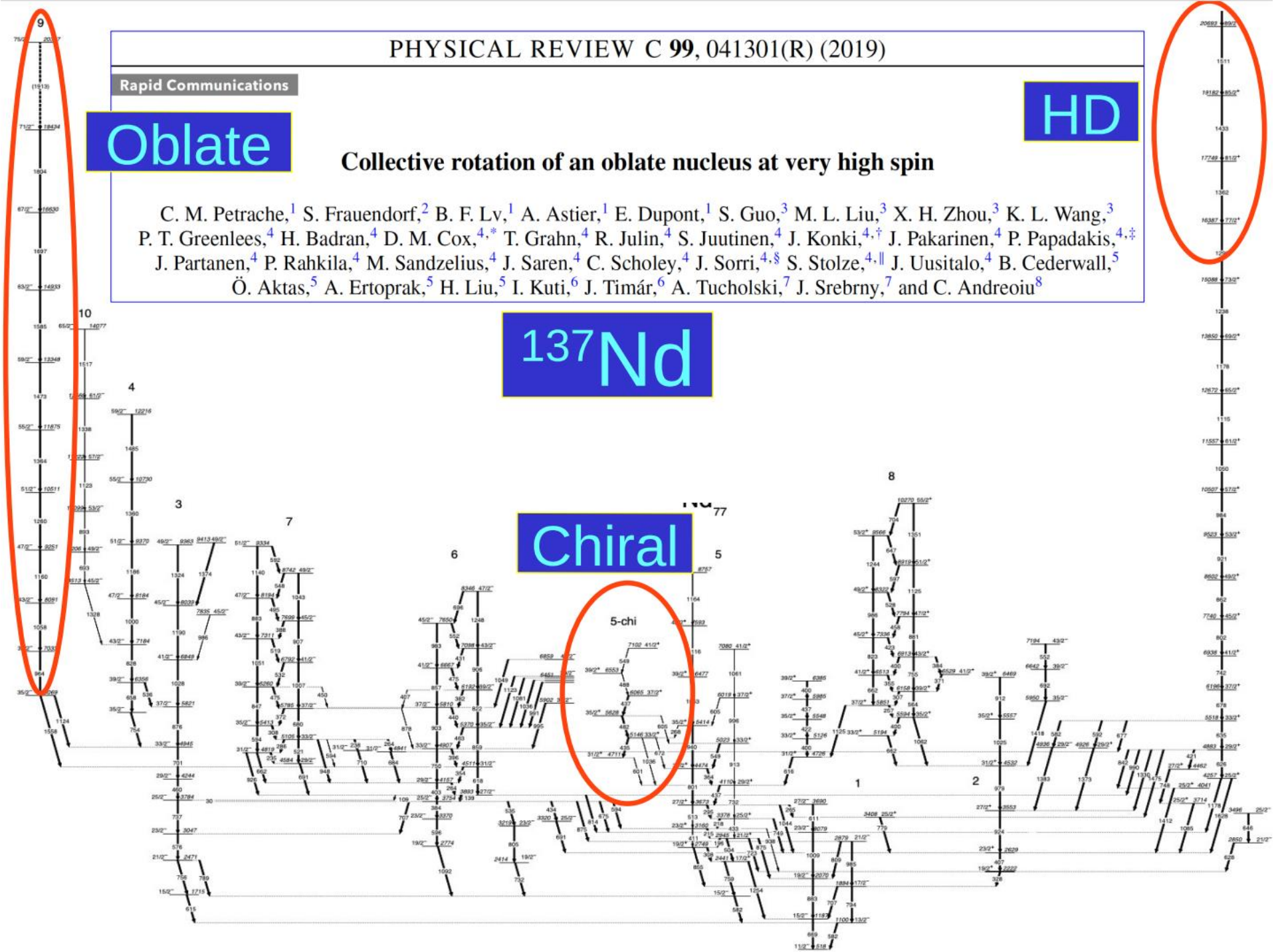
HD

Collective rotation of an oblate nucleus at very high spin

C. M. Petrache,[1] S. Frauendorf,[2] B. F. Lv,[1] A. Astier,[1] E. Dupont,[1] S. Guo,[3] M. L. Liu,[3] X. H. Zhou,[3] K. L. Wang,[3] P. T. Greenlees,[4] H. Badran,[4] D. M. Cox,[4,*] T. Grahn,[4] R. Julin,[4] S. Juutinen,[4] J. Konki,[4,†] J. Pakarinen,[4] P. Papadakis,[4,‡] J. Partanen,[4] P. Rahkila,[4] M. Sandzelius,[4] J. Saren,[4] C. Scholey,[4] J. Sorri,[4,§] S. Stolze,[4,‖] J. Uusitalo,[4] B. Cederwall,[5] Ö. Aktas,[5] A. Ertoprak,[5] H. Liu,[5] I. Kuti,[6] J. Timár,[6] A. Tucholski,[7] J. Srebrny,[7] and C. Andreoiu[8]

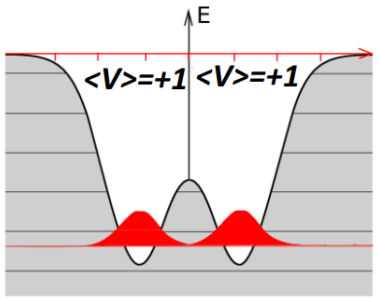
^{137}Nd

Chiral

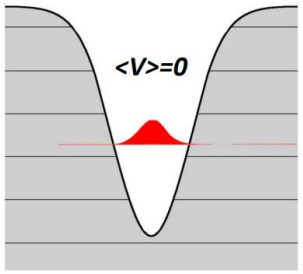


3. Plans for 2024

1. HIL Experiment 110Pd (22Ne, p3n) 128Cs , target thickness 1mg/cm2 (self-supporting)
E(22Ne) 85 MeV, Warsaw Cyclotron + EGALE + PLUNGER



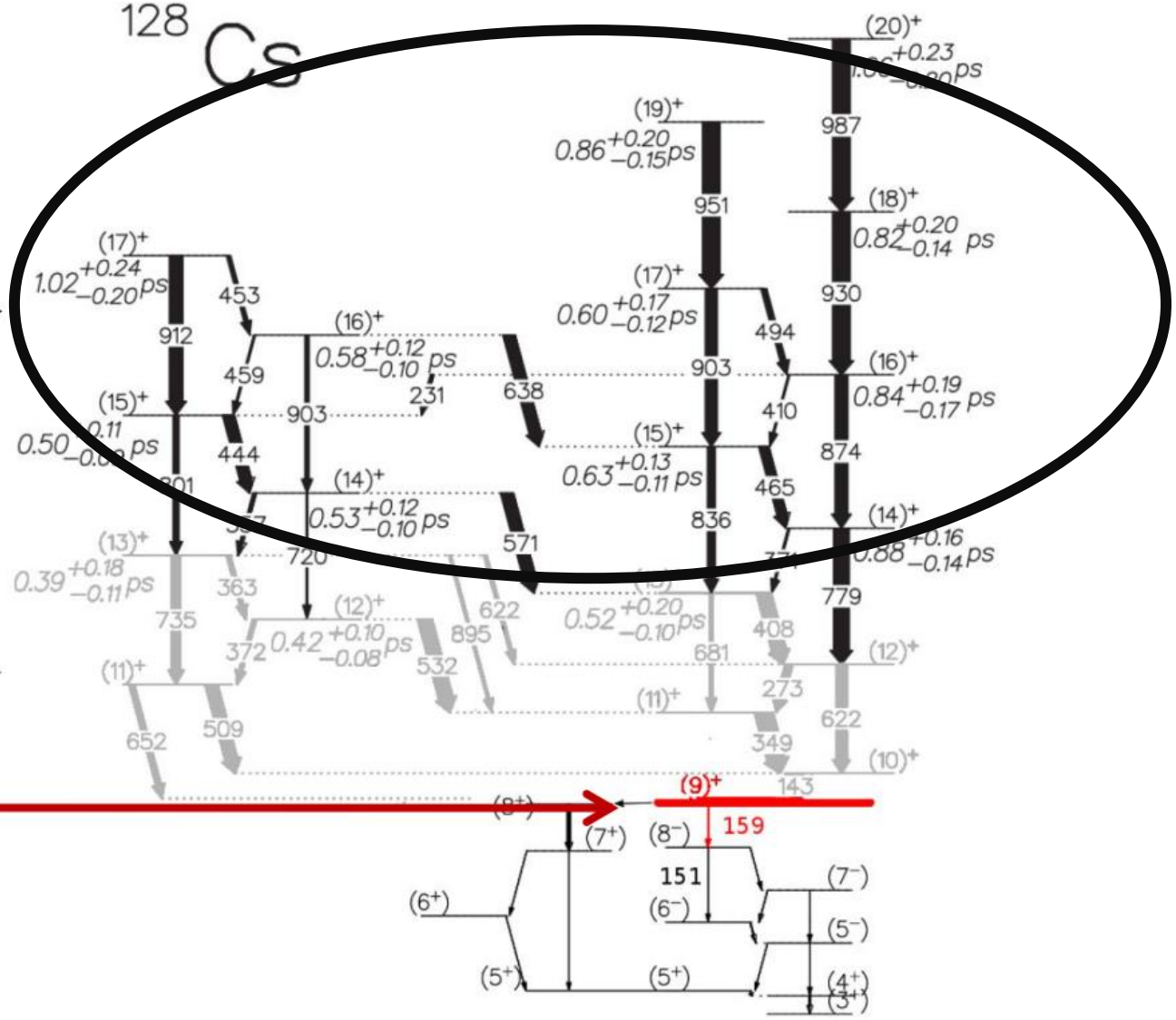
?



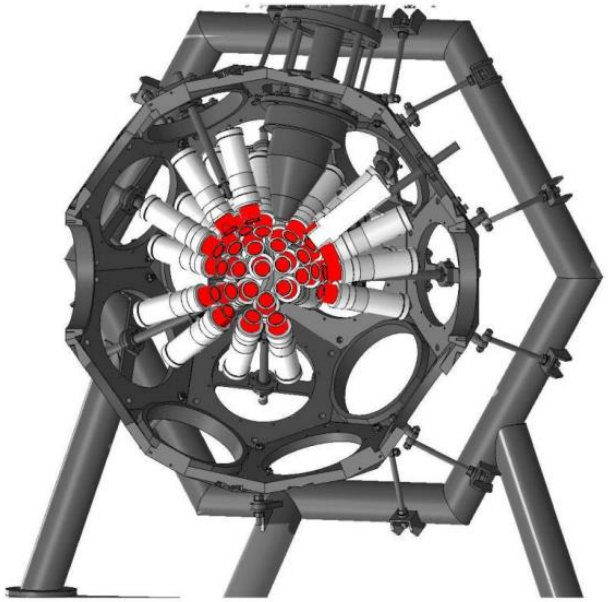
Chiral

unknown

Non-chiral

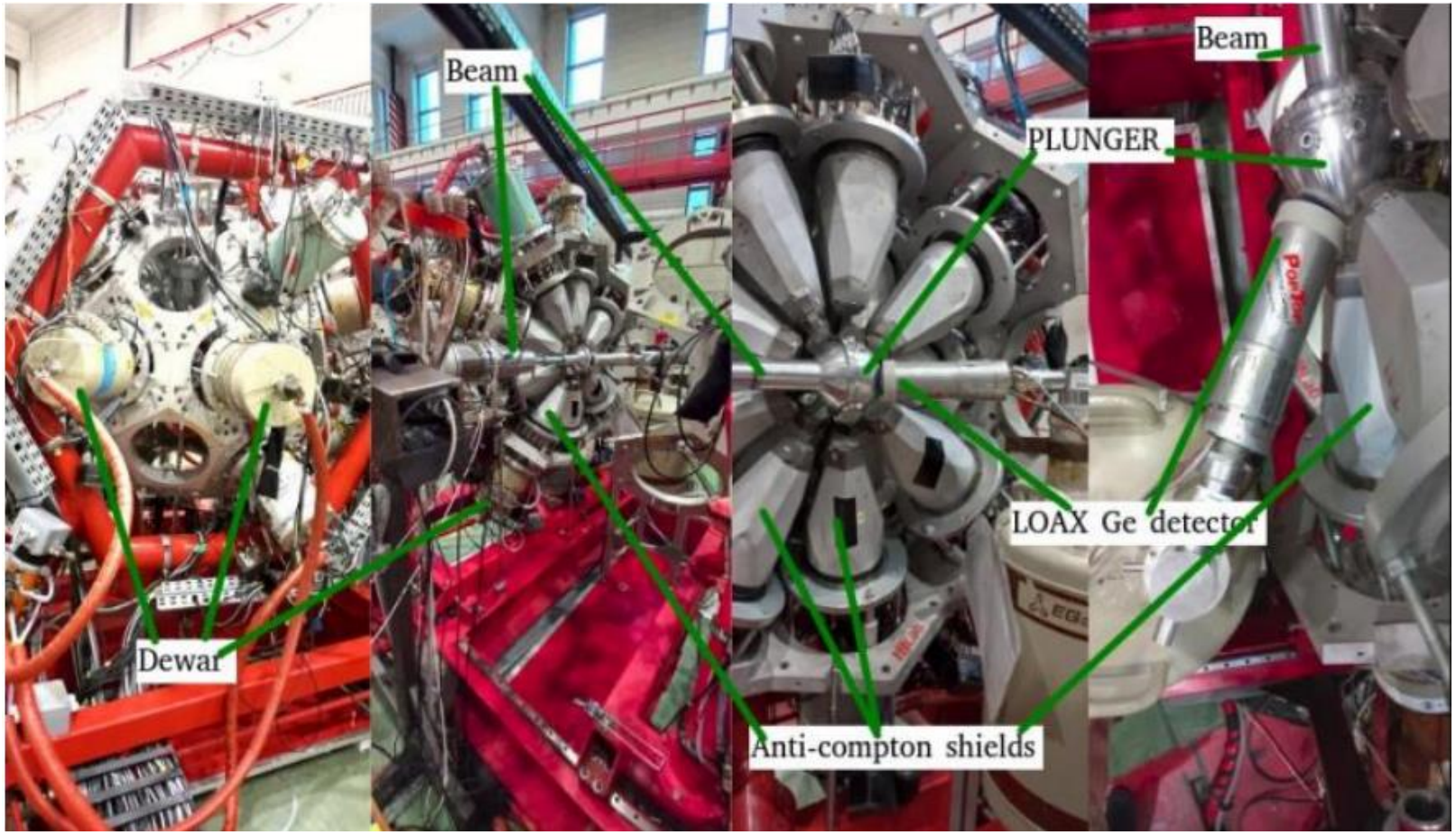


Recent HIL experiment preliminary results:

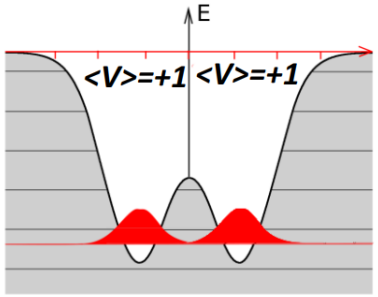


EAGLE-EYE

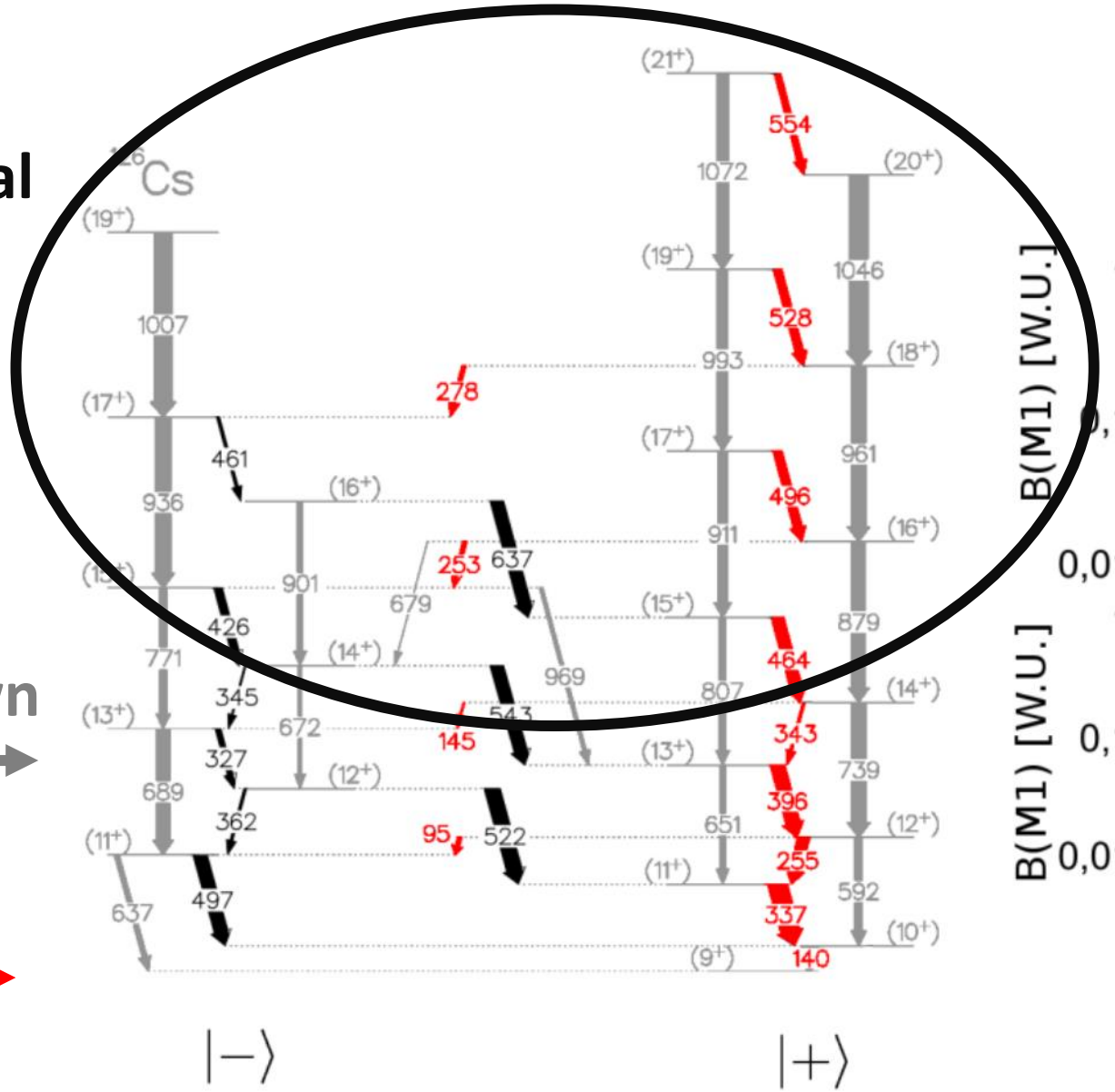
EAGLE + PLUNGER

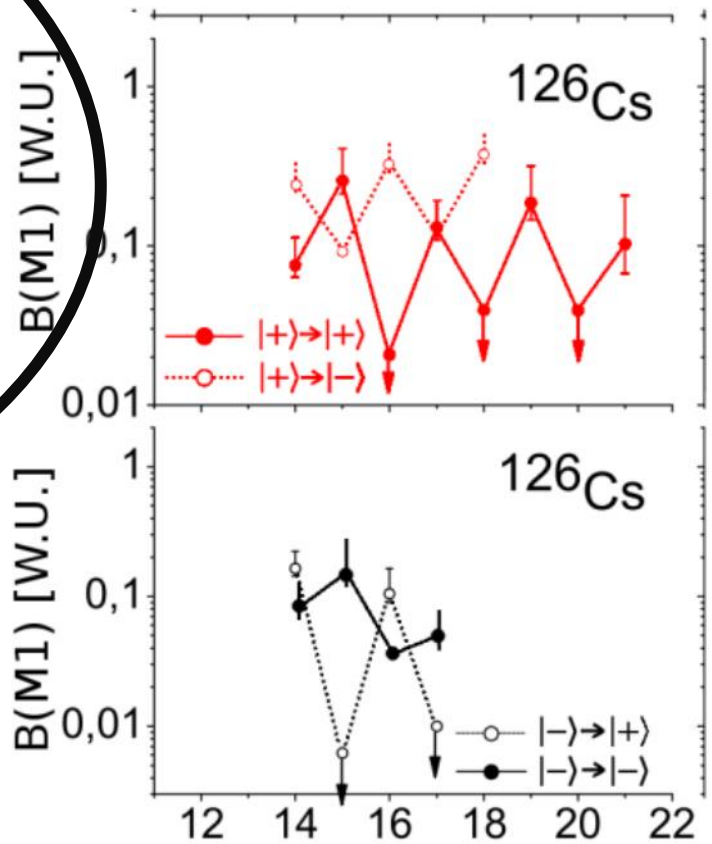


2. HIL Experiment 116Cd (14N, 4n) 126Cs , target thickness 0.8mg/cm2 (Ta backing)
E(14N) 65 MeV, Warsaw Cyclotron + EGALE EYE + PLUNGER



Chiral





?

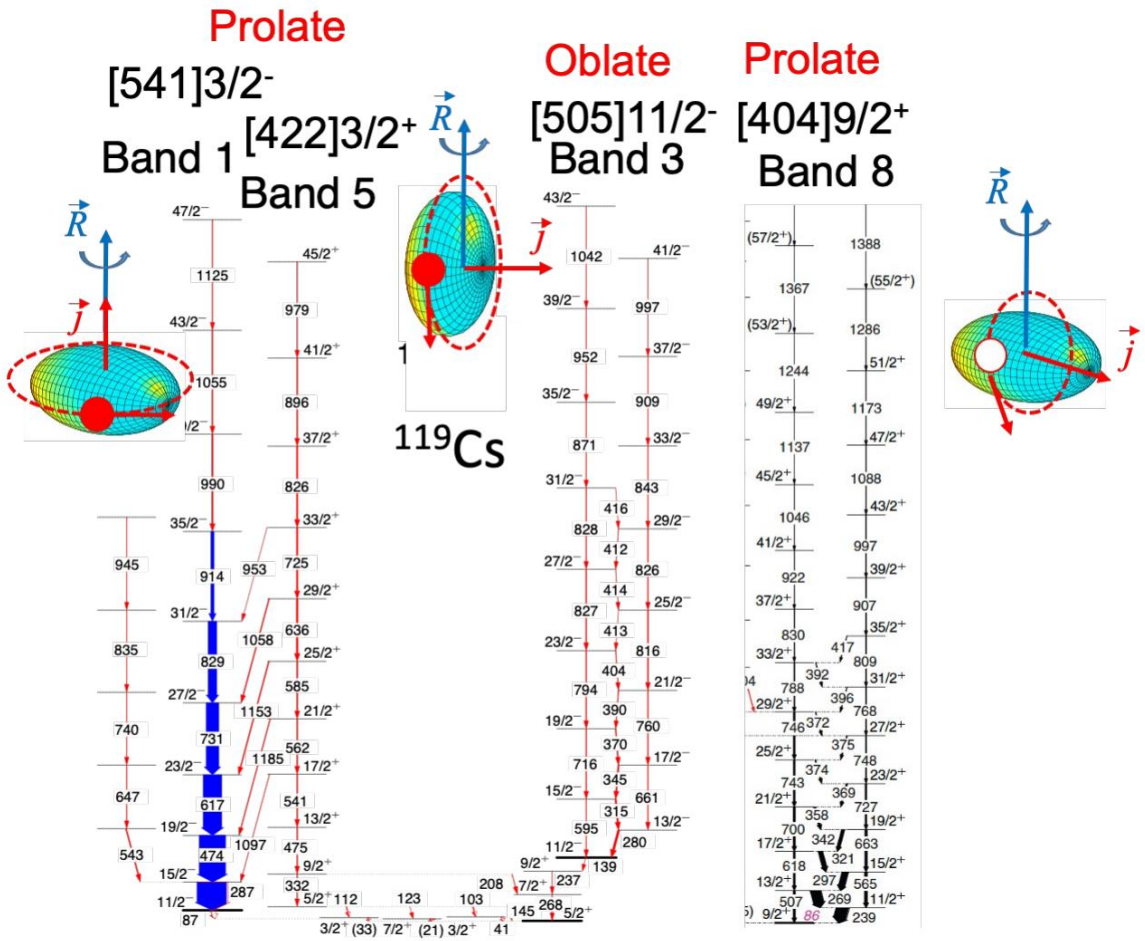
unknown

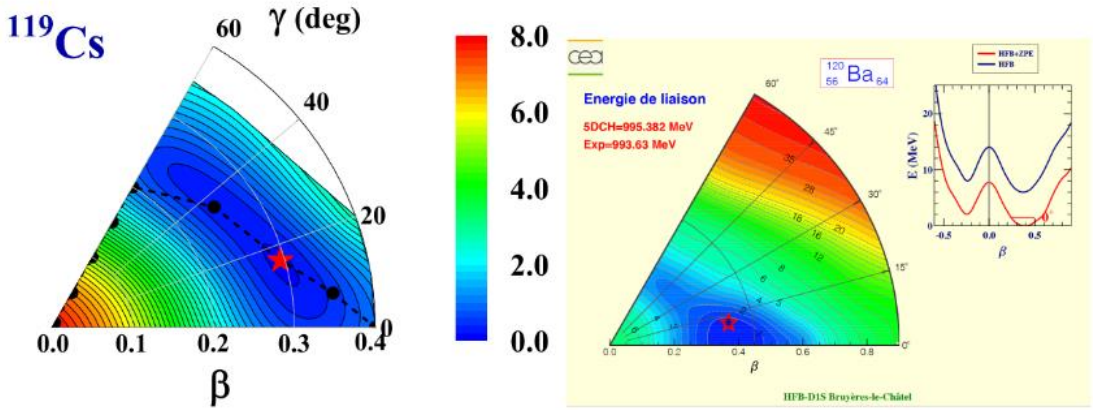
No isomeric

bandhead seen

3. HIL Experiment 106Cd (20Ne, xn xp) 115Te , 116I, 118I, 118Xe, 1129Xe, 119Cs, 121Cs, 122Cs, 121Ba, 122Ba, 122La
E(14N) 65 MeV, Warsaw Cyclotron + EGALE + DIAMANT

DSA lifetime measurements of states identified rotational bands





4. HIL Experiment 65Cu (11B, 1p3n) 72As
E(11B) 50 MeV, Warsaw Cyclotron + EGALE. DSA measurement

Examine the chiral geometry indicated by the g-factor in ^{72}As

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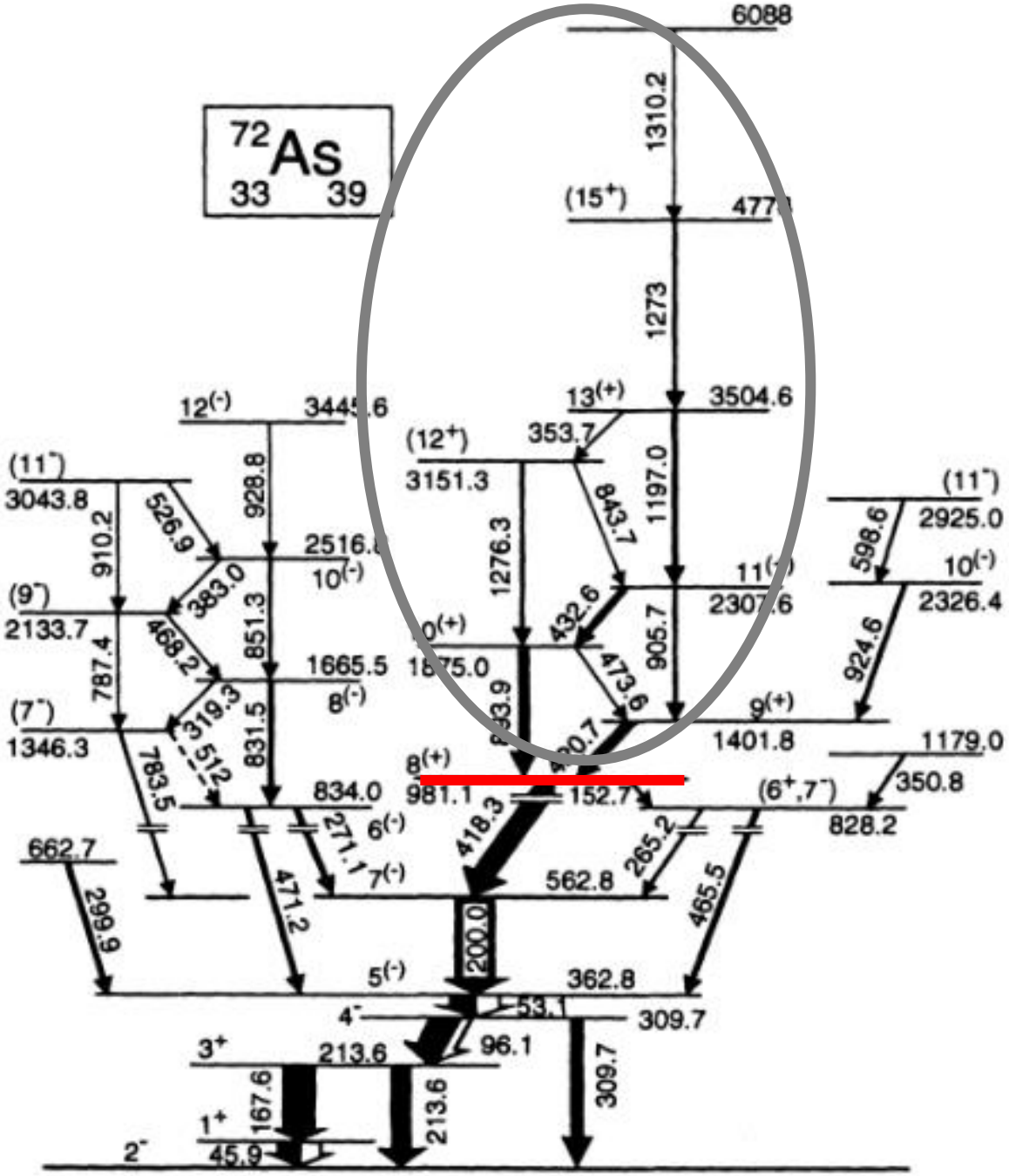
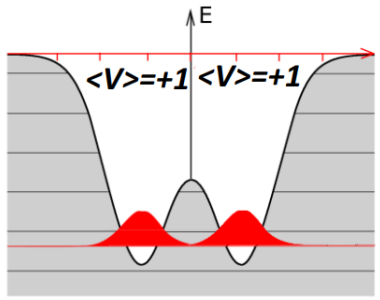


unknown

?

Chiral



Thank You