Systematic Ground-State Energy-Level Inversions Across the N = 79 and N = 81 Isotonic Chains

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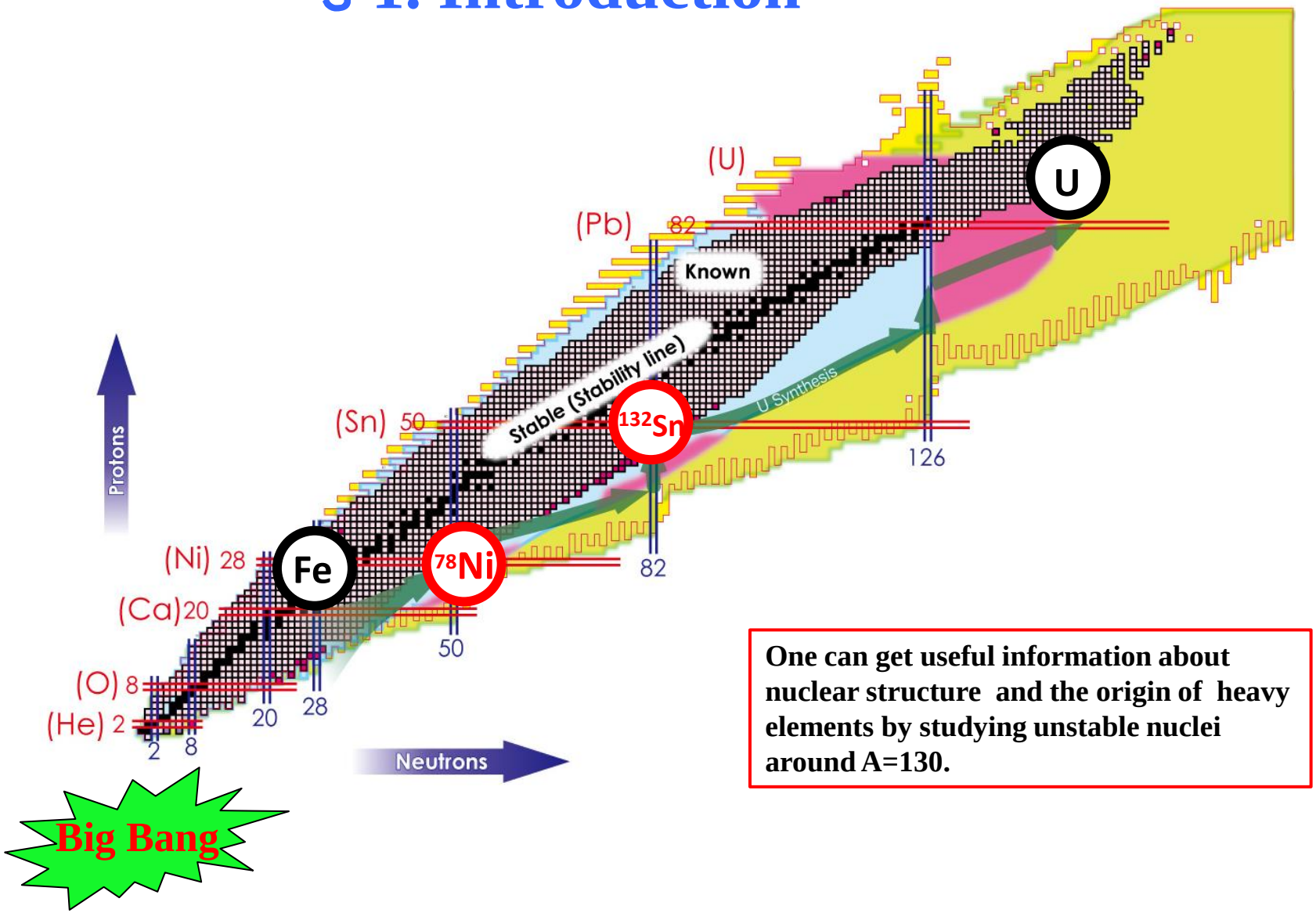
§ 1. Introduction

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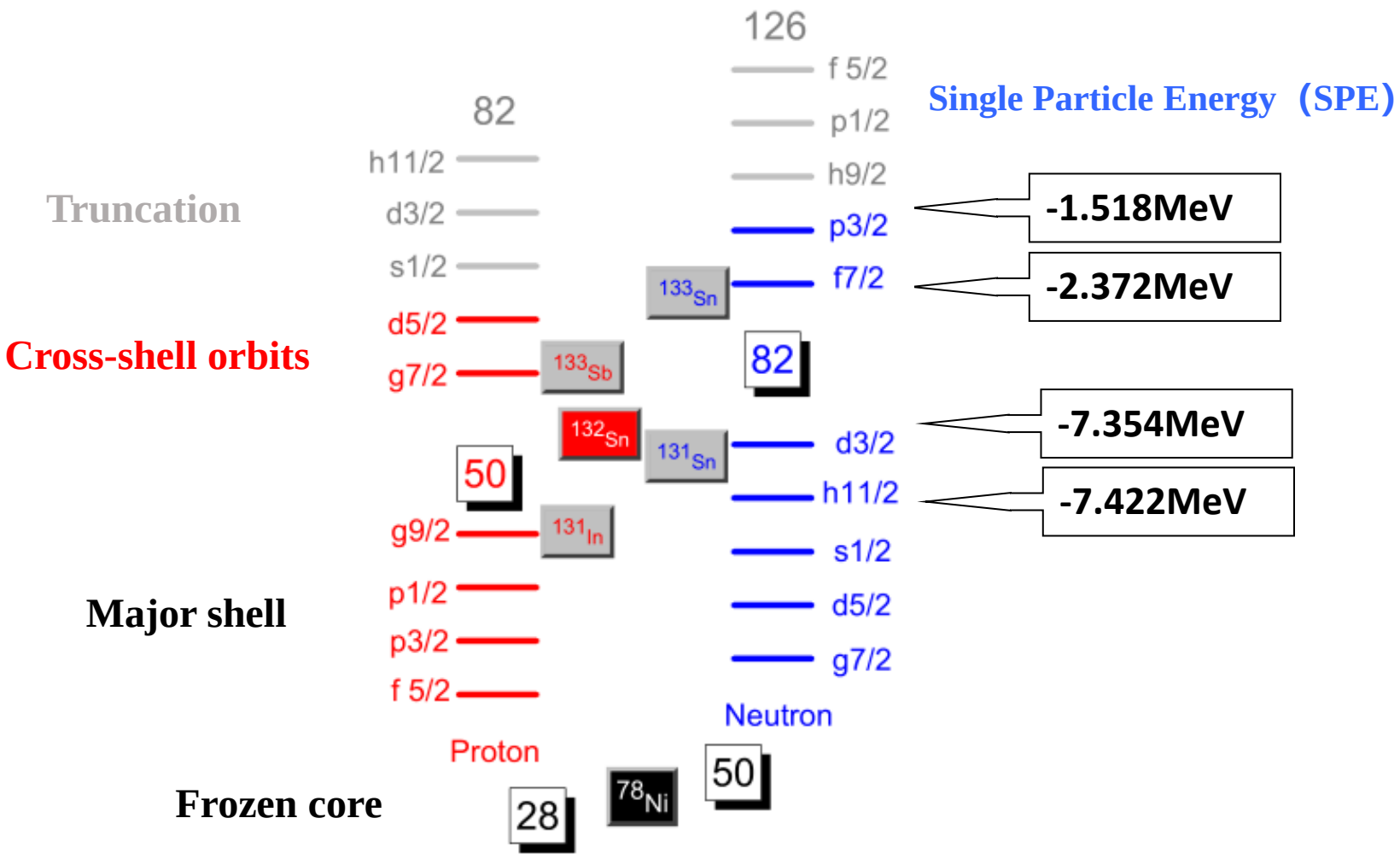
§ 1. Introduction



One can get useful information about nuclear structure and the origin of heavy elements by studying unstable nuclei around A=130.

§2. Shell Model Calculations

§ 2.1 Model Space and Single Particle Energies



§ 2.2 The Interaction

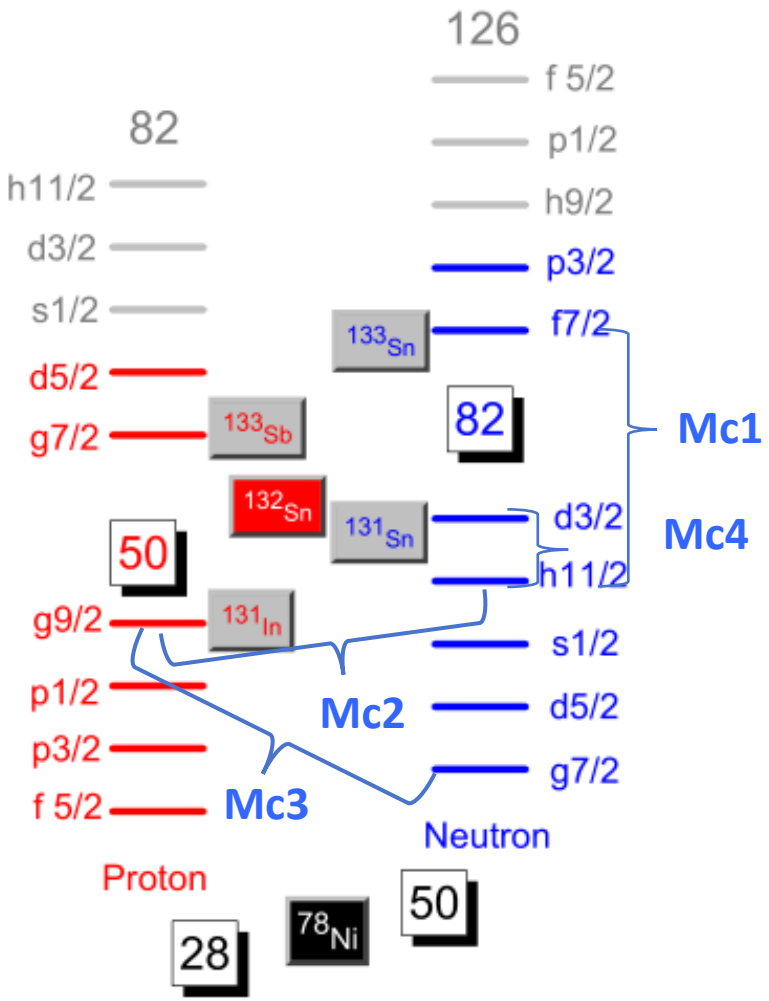
SPE

$$
\begin{aligned}
H &= H_{\rm sp} + H_{P_0} + H_{P_2} + H_{QQ} + H_{OO} + H_{HH} + H_{\rm mc} \\
&= \sum_{\alpha,i} \varepsilon_a^i c_{\alpha,i}^\dagger c_{\alpha,i} - \frac{1}{2} \sum_{J=0,2} \sum_{ii'} g_{J,ii'} \sum_M P_{JM,ii'}^\dagger P_{JM,ii'} \qquad \text{Pairing force} \\
&- \frac{1}{2} \sum_{ii'} \frac{\chi_{2,ii'}}{b^4} \sum_M : Q_{2M,ii'}^\dagger Q_{2M,ii'} : \qquad \text{Quadruple force} \\
&- \frac{1}{2} \sum_{ii'} \frac{\chi_{3,ii'}}{b^6} \sum_M : O_{3M,ii'}^\dagger O_{3M,ii'} : \qquad \text{Octupole force} \\
&- \frac{1}{2} \sum_{ii'} \frac{\chi_{4,ii'}}{b^8} \sum_M : H_{4M,ii'}^\dagger H_{4M,ii'} : \qquad \text{Hex force} \\
&+ \sum_{a \leqslant b, ii'} k_{\rm mc}(ia, i'b) \sum_{JM} A_{JM}^\dagger(ia, i'b) A_{JM}(ia, i'b). \qquad \text{Monopole corrections}
\end{aligned}
$$

参考文献

[1] M. Hasegawa and K. Kaneko, Phys. Rev. C59, 1449(1999).
[2] M. Hasegawa, Y. Sun, et al., Phys. Lett. B 617, 150-156 (2005).
[3] K. Kaneko, Y. Sun et al., Physical Review C, 78, 064312(2008).
[4] Hua Jin et al., Phys. Rev. C84, 044324(2011).
[5] H. K. Wang et al., Phys Rev. C. 88. 054310(2013).

§ 2.3 Monopole corrections



Mc1= (ν h11/2, ν f7/2)=0.52 [1]

Mc2= (πg9/2, ν h11/2)=-0.4 [2]

Mc3= (πg9/2, ν h11/2)=-1.0 [3,4]

Mc4=(νd3/2, ν h11/2)=-0.4 [5]

Mc = (π d5/2, ν f7/2) = -0.7 [6]

Mc = (πg9/2, ν h11/2) = -0.23 [7]

参考文献

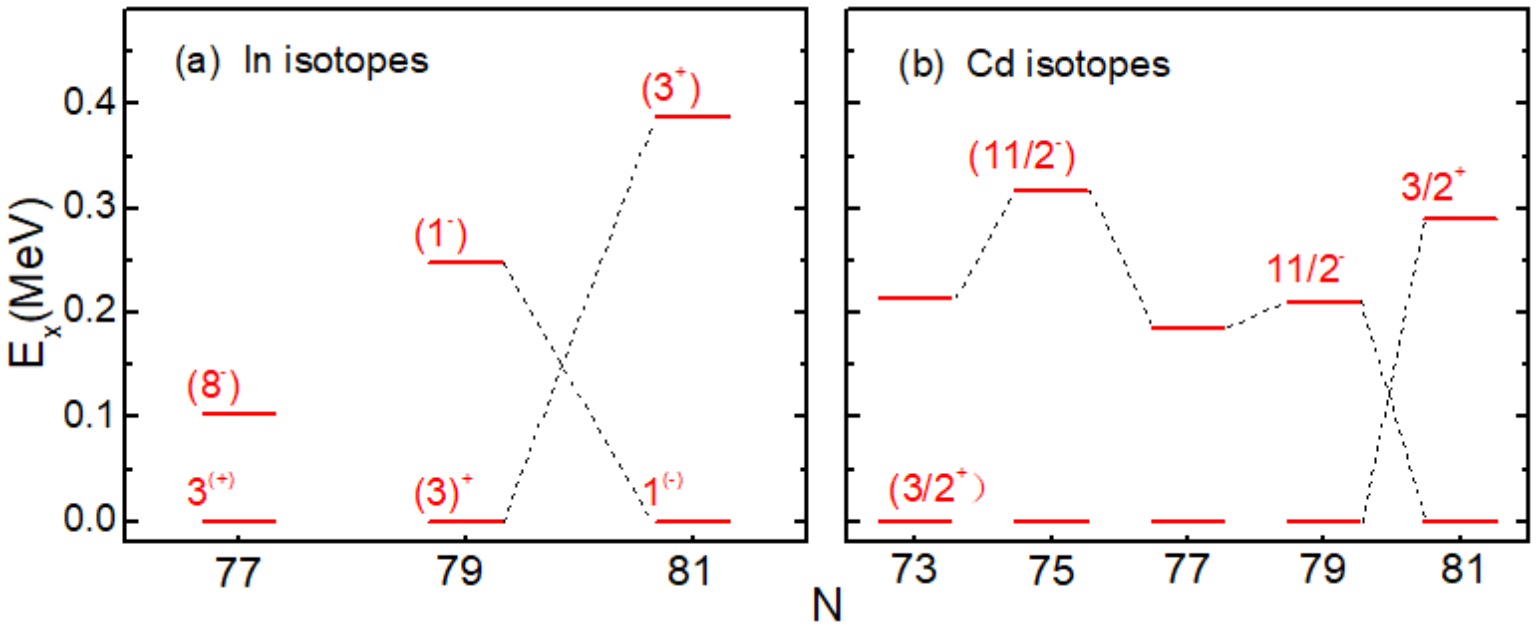
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[4] H. Wantanabe, et. al., Phys. Lett. B792,263(2019).
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[6] H. K. Wang, et. al., Chin. Phys. C 48, 014106 (2024).
[7] H. K. Wang, et. al., Phys. Lett. B849, 138449(2024).

§3. Systematic Ground-State Energy-Level Inversions Across the N = 79 and N = 81 Isotonic Chains

§3.1 Inversions in Experimental Data
§3.2 The Physical Mechanism
§3.3 Validation along the N = 80 isotonic chain
§3.4 The similarity between ^{126}Ag and ^{128}In
§3.5 Predictions

§ 3.1 Inversions in Experimental Data

Based on the available experimental data, the ground state and the first excited state are inverted from ^{128}**In** to ^{130}**In**. A similar inversion also occurs from ^{127}**Cd** to ^{129}**Cd**.

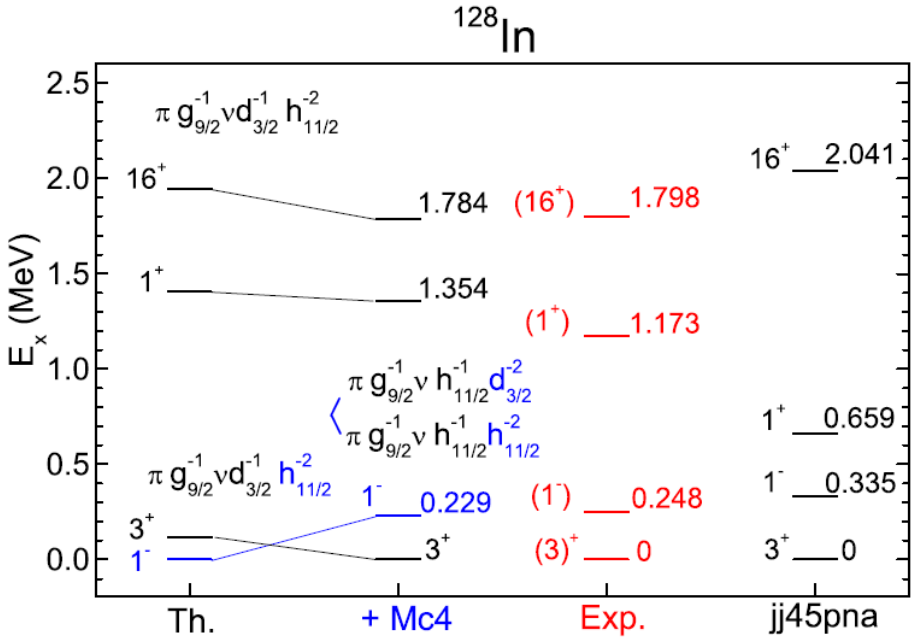


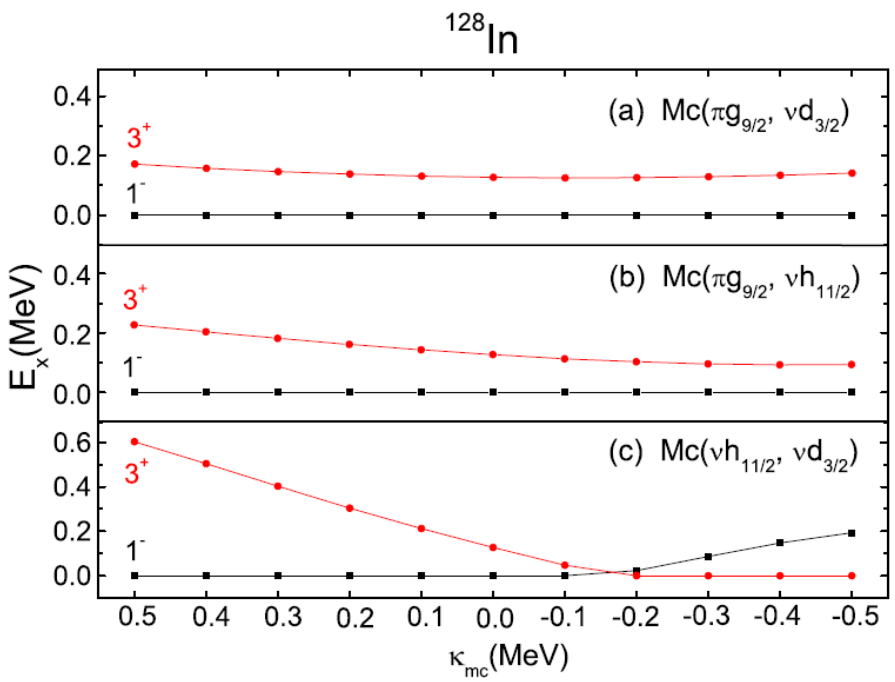
Questions:

1. What is the physical mechanism behind this ground-state inversion?
2. Are there any more similar inversions?

§3.2 The Physical Mechanism

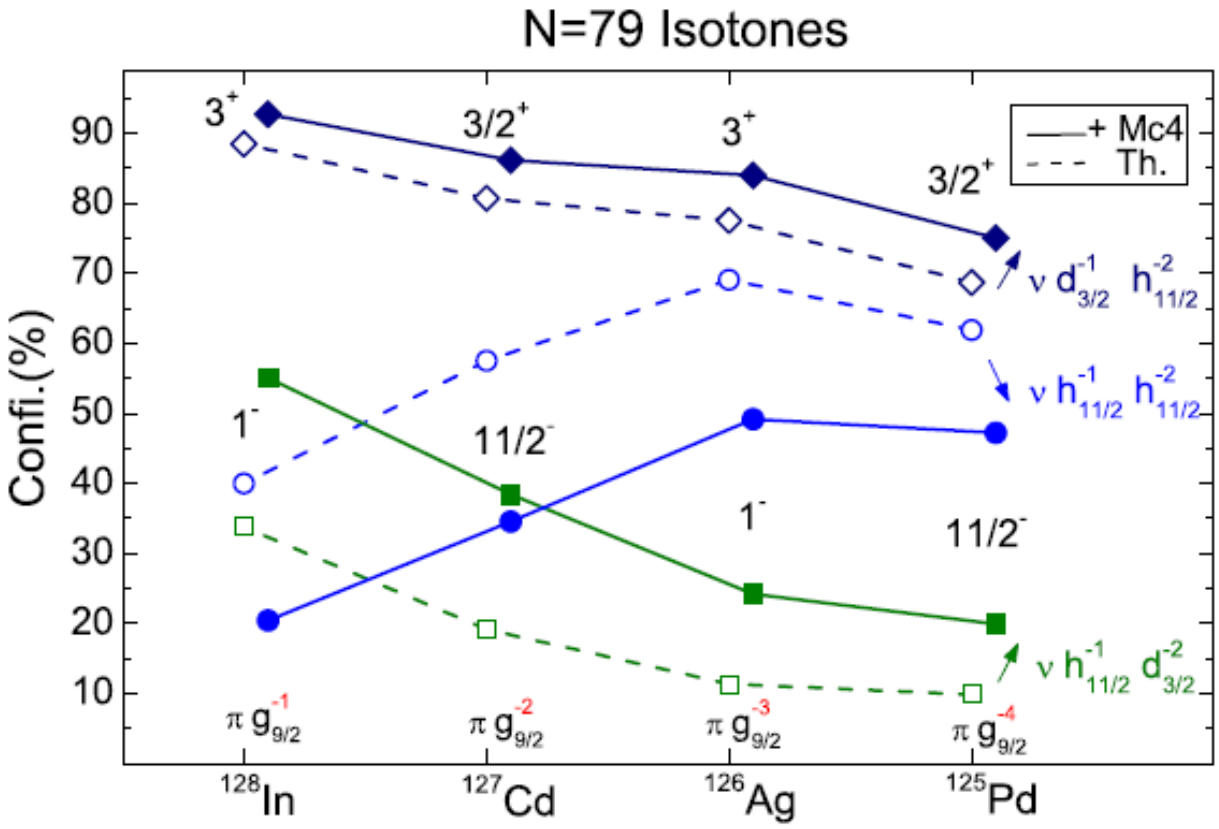
§3.2.1 Clues in ^{128}In





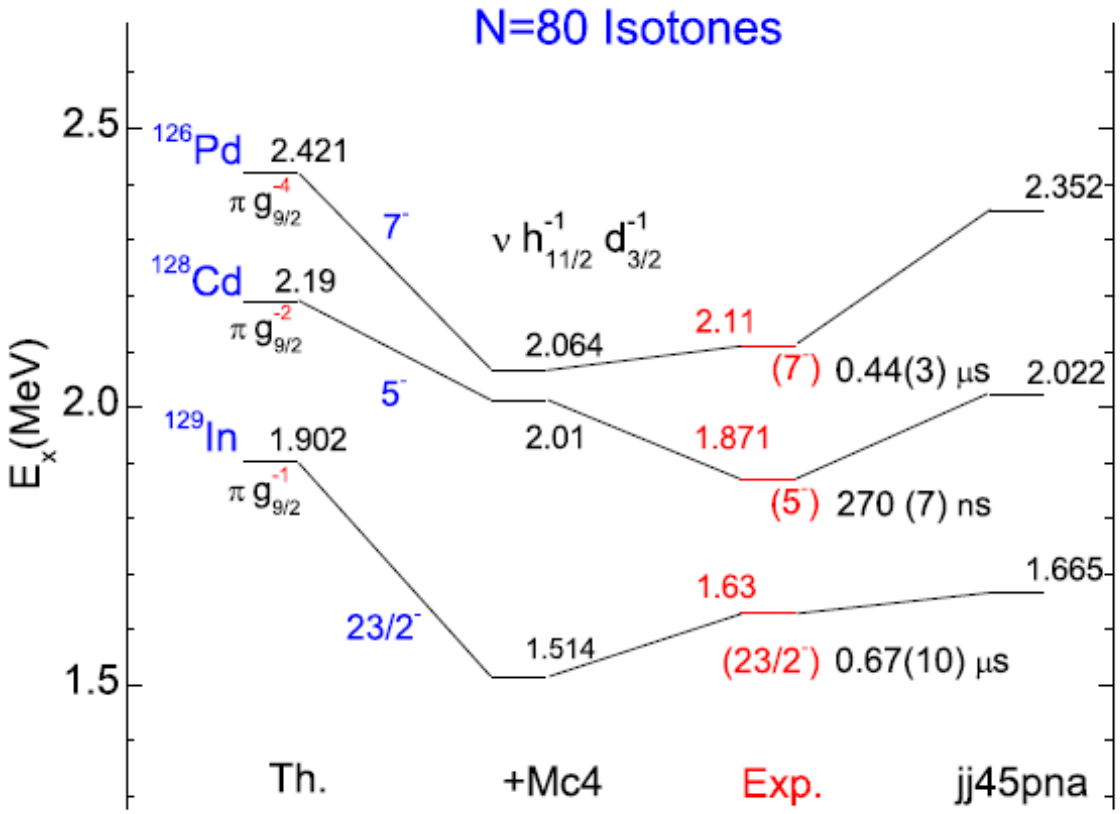
By analyzing the configuration structure of **^{128}In**,
it is found that the monopole interaction **Mc (νd_3/2, νh_11/2)** between the neutron orbitals **νd_3/2** and **νh_11/2** is able to reproduce the ground-state inversion in **^{128}In**.

§3.2.2 The competition in configurations



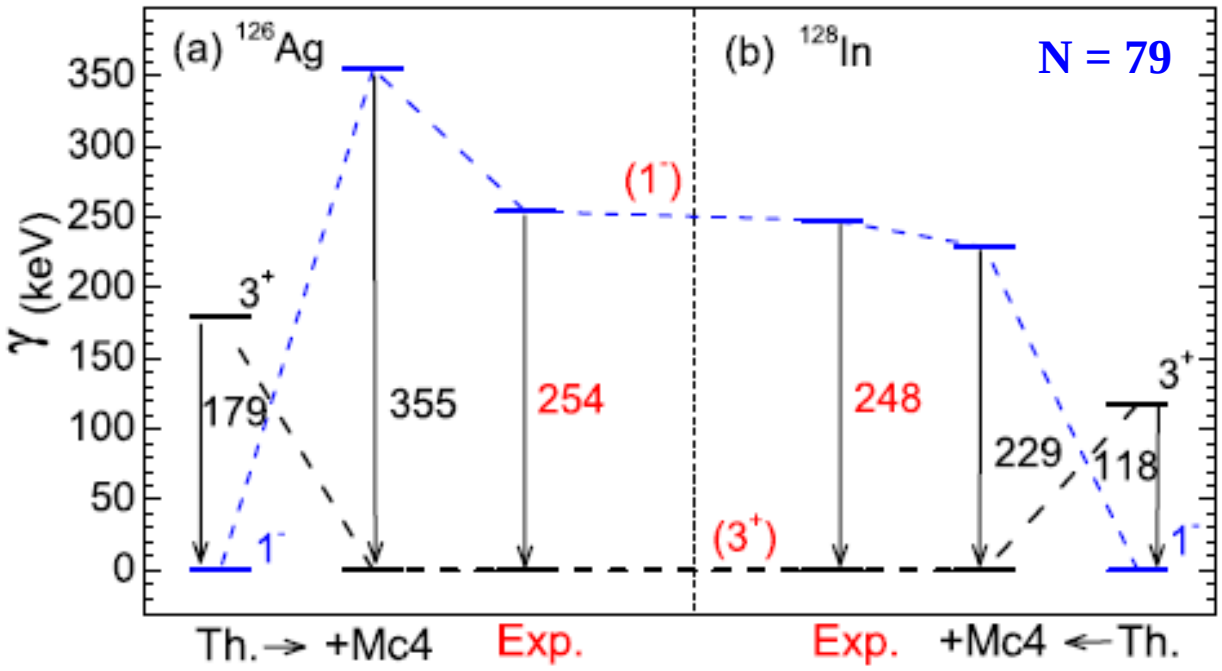
The Competition in Configurations provides the structural explanation for the ground-state inversion. Upon inclusion of the monopole interaction between the neutron orbitals **νh_11/2** and **νd_3/2**, the summed weight of configurations involving these two orbitals increases, whereas the weight of the only **h_11/2** configuration simultaneously decreases.

§3. 3 Validation along the N = 80 isotonic chain



To further assess the validity of Mc4 term, three known isomeric states were chosen along the N = 80 isotonic chain, corresponding to three different nuclei: ^{129}In, ^{128}Cd, and ^{126}Pd.

§3. 4 The similarity between ^{126}Ag and ^{128}In

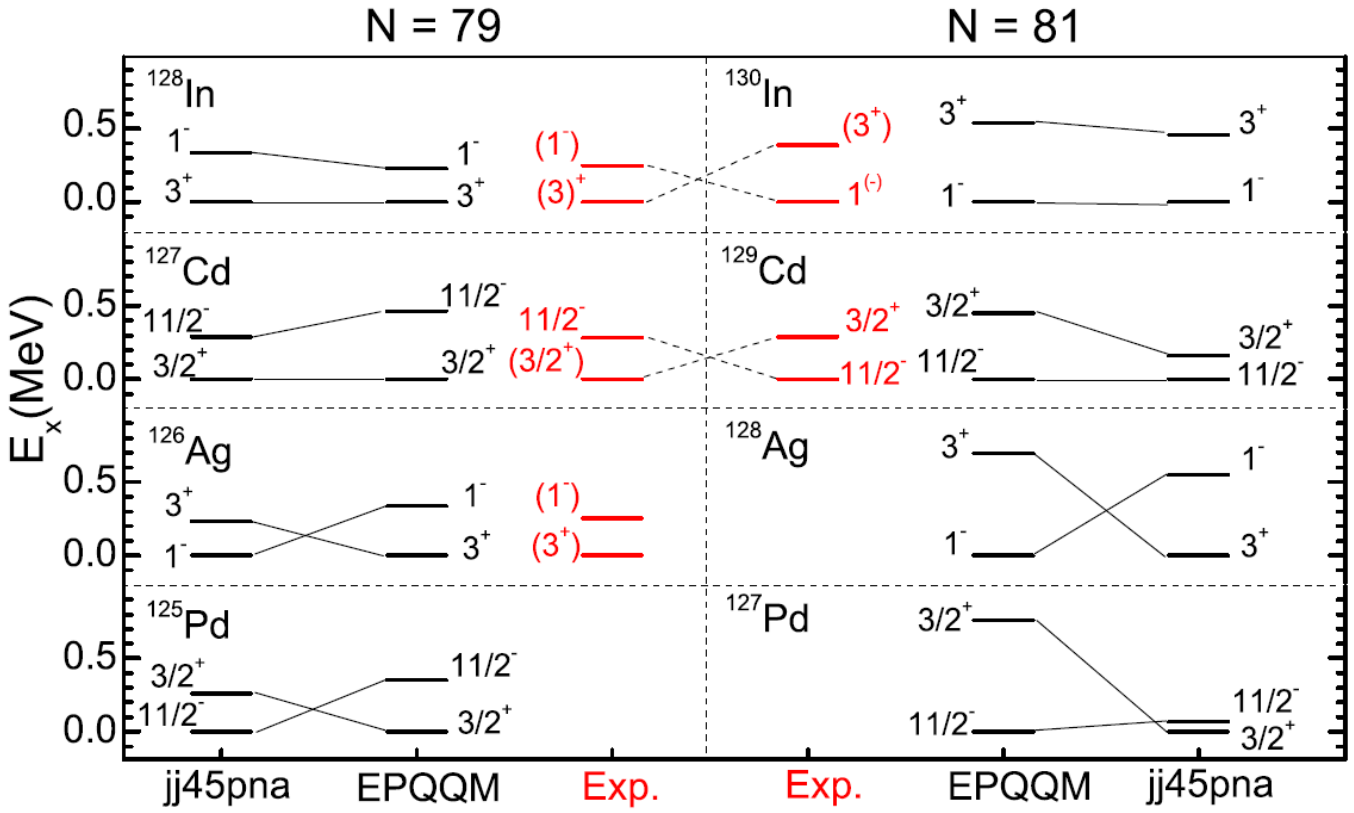


This obtained theoretical result likewise provides a basis for systematic experimental comparison between **^{126}Ag** and **^{128}In** [1].

^{126}Ag and **^{128}In** both lie on the **N = 79** isotonic chain and display similar ground-state inversion phenomena [2].

[1] S. Lalkovski, A. M. Bruce, A. Jungclaus, et al., Phys. Rev. C 87, 034308 (2013).
[2] H. K. Wang, Z. Q. Chen, H. Jin, Z. H. Li et. al., Phys. Rev. C 104, 014301 (2021).

§3.5 Predictions



Using the regularities induced by the monopole interaction found along the **N=79** isotonic chain, one can predict the ground-state spin-parities of **^{128}Ag**, **^{127}Pd**, and **^{125}Pd** [1] **.**

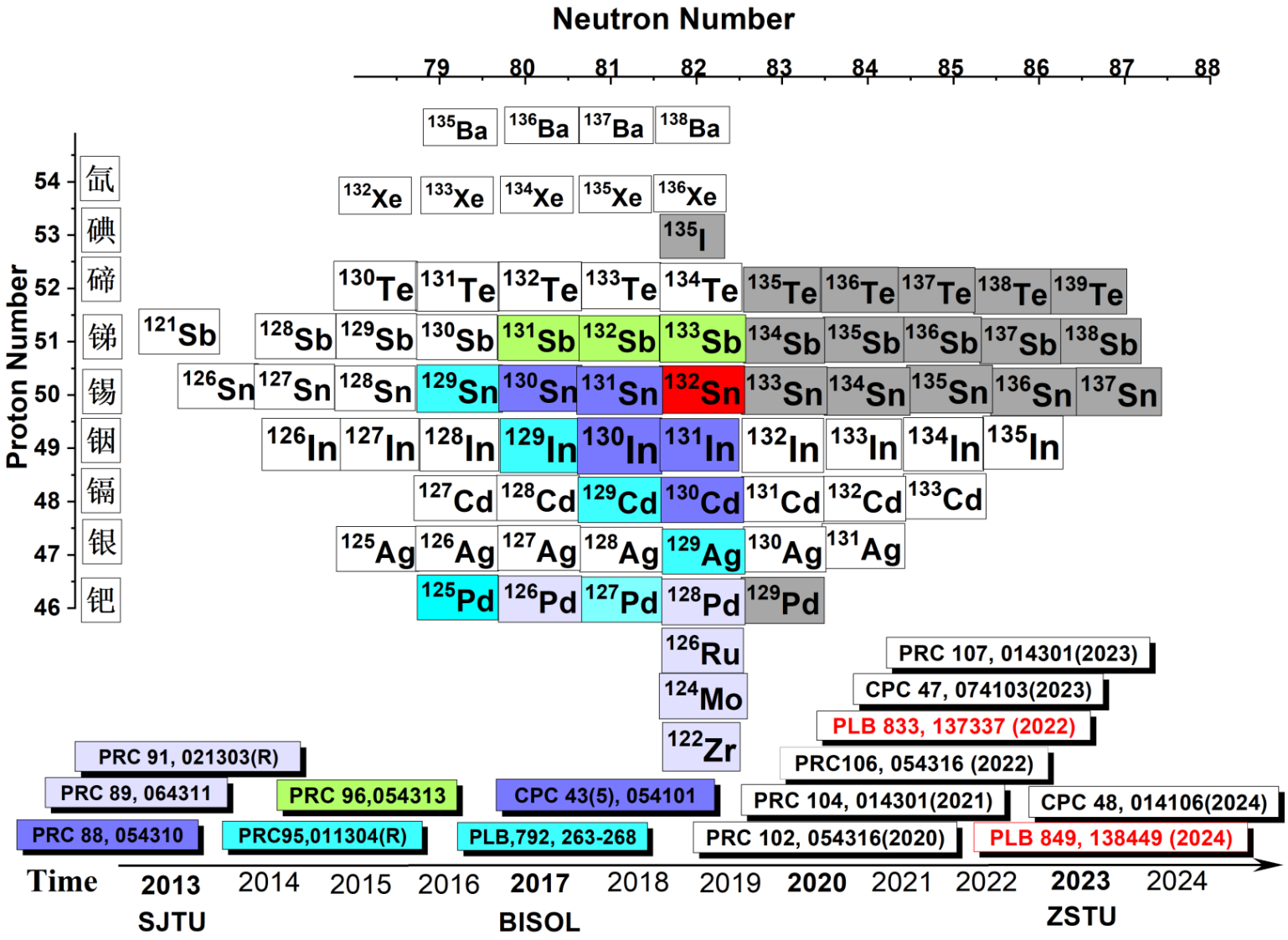
[1] H. K. Wang, Z. Q. Chen, H. Jin, Z. H. Li et. al., Phys. Rev. C 104, 014301 (2021).

§4. Conclusions

(1) A reasonable theoretical explanation is provided for the experimentally observed ground-state inversion from ^{130}**In** to ^{128}**In**, as well as from ^{129}**Cd** to ^{127}**Cd**, based on the monopole interaction between neutron orbitals.

(2) This provides a reliable theoretical basis for the systematic experimental analysis of ^{126}**Ag** and ^{128}**In**.

(3) It also provides reliable theoretical predictions for the ground-state spin-parities of ^{128}**Ag**, ^{127}**Pd**, and ^{125}**Pd.**


Neutron Number
79 80 81 82 83 84 85 86 87 88
Proton Number
54 氙
53 碘
52 碲
51 锑
50 锡
49 铟
48 镉
47 银
46 钯
135Ba 136Ba 137Ba 138Ba
132Xe 133Xe 134Xe 135Xe 136Xe
135I
130Te 131Te 132Te 133Te 134Te 135Te 136Te 137Te 138Te 139Te
121Sb 128Sb 129Sb 130Sb 131Sb 132Sb 133Sb 134Sb 135Sb 136Sb 137Sb 138Sb
126Sn 127Sn 128Sn 129Sn 130Sn 131Sn 132Sn 133Sn 134Sn 135Sn 136Sn 137Sn
126In 127In 128In 129In 130In 131In 132In 133In 134In 135In
127Cd 128Cd 129Cd 130Cd 131Cd 132Cd 133Cd
125Ag 126Ag 127Ag 128Ag 129Ag 130Ag 131Ag
125Pd 126Pd 127Pd 128Pd 129Pd
126Ru
124Mo
122Zr
PRC 107, 014301(2023)
CPC 47, 074103(2023)
PLB 833, 137337 (2022)
PRC106, 054316 (2022)
PRC 104, 014301(2021)
CPC 48, 014106(2024)
PRC 102, 054316(2020)
PLB 849, 138449 (2024)
PRC 91, 021303(R)
PRC 89, 064311
PRC 96,054313
CPC 43(5), 054101
PRC 88, 054310
PRC95,011304(R)
PLB,792, 263-268
Time
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
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Thank you very much for your attention









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