# Effects of Skyrme Tensor Force on the Spin-Isospin Excitations and β-decay half-life

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2013年全国核反应会议

# Collaboratiors

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# outline

- Self-consistent HF+RPA based on Skyrme force
- Skyrme parameter sets with tensor force
- Tensor effects on the excited states
- Test
- GT and SD constraint on the tensor force
- Tensor effect on the β-decay half-life
- Conclusion

# Self-consistent HF+RPA based on Skyrme force

- **Skyrme effective nucleon-nucleon interaction**

$$v_{Skyrme} = v_{central} + v_{LS} + v_{Tensor} + v_{Coulomb} + v_{pair}$$

- **HF used to study the ground state properties, and get the single-particle wave functions.**

- **Self-consistent HF+RPA studys the excitation states**

$$\begin{pmatrix} A & B \\ -B^* & -A \end{pmatrix}\begin{pmatrix} X \\ Y \end{pmatrix} = E_x \begin{pmatrix} X \\ Y \end{pmatrix}$$

The same interactions as those in HF are used
to calculate A,B so that to keep self-consistency.

- **In our code tensor and spin-orbit forces are included.**

# Skyrme parameter sets with tensor force

**The tensor terms postulated by Skyrme: Nucl. Phy. 9, 615(1959)**

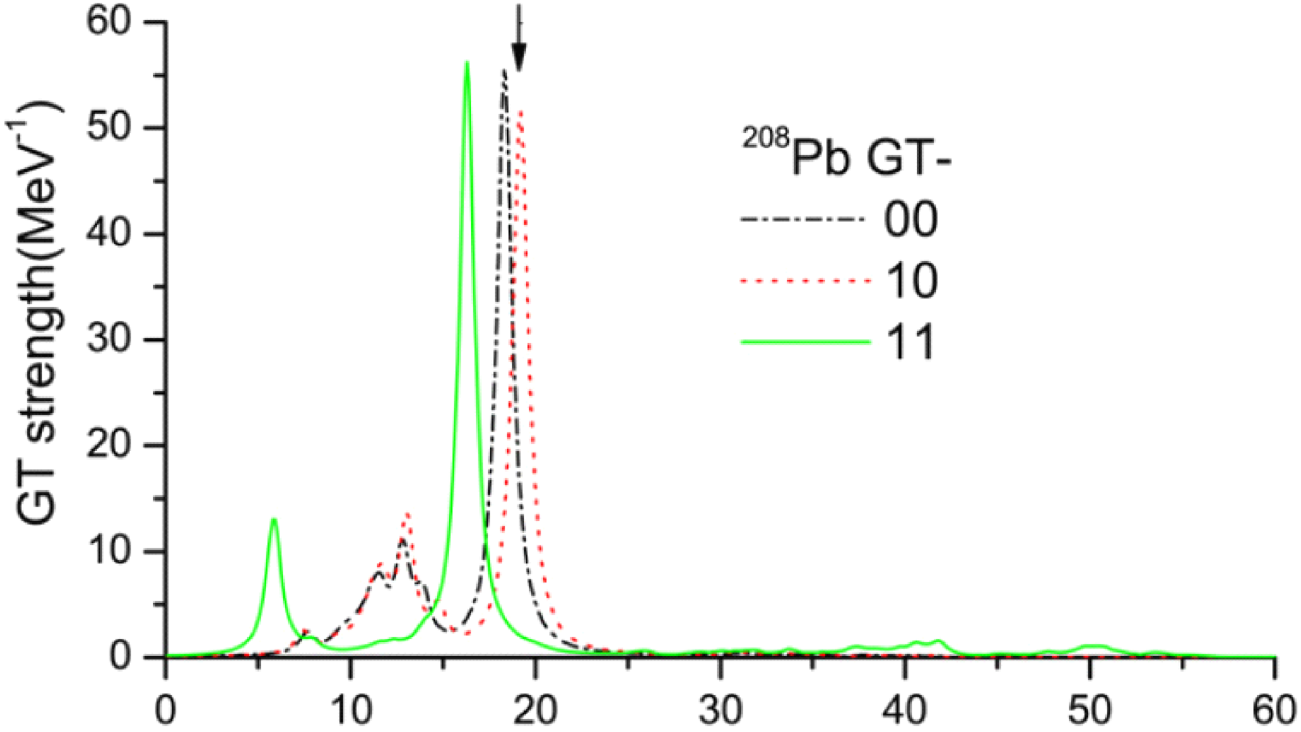
$$V^T = \frac{T}{2}\left\{\left[(\sigma_1\cdot\mathbf{k}')(\sigma_2\cdot\mathbf{k}') - \frac{1}{3}(\sigma_1\cdot\sigma_2)\mathbf{k}'^2\right]\delta(r) + \delta(\mathbf{r})\left[(\sigma_1\cdot\mathbf{k})(\sigma_2\cdot\mathbf{k}) - \frac{1}{3}(\sigma_1\cdot\sigma_2)\mathbf{k}^2\right]\right\}$$

$$+\frac{U}{2}\left\{(\sigma_1\cdot\mathbf{k}')\delta(\mathbf{r})(\sigma_2\cdot\mathbf{k}) + (\sigma_2\cdot\mathbf{k}')\delta(\mathbf{r})(\sigma_1\cdot k) - \frac{2}{3}[(\sigma_1\cdot\sigma_2)\mathbf{k}'\cdot\delta(\mathbf{r})\mathbf{k}]\right\}$$

**Skyrme parameter sets which include tensor force:**

| | | |
|---|---|---|
| **Fl. Stancu *et. al*, PLB68, 108(1977),** <br> **B. A. Brown *et. al*, PRC74, 061303(R)(2006)** | G-Matrix interaction | T >0, U>0 |
| **G. Colò *et. al*, PLB646, 227(2007),** <br> D. M. Brink ***et. al*, PRC75, 061311(2007)** | Single-particle energies | T >0, U<0 |
| **T. Lesinski et. al. PRC76, 014312(2007)** | Ground state properties | T ±, U ± |

# Tensor effects on GT states



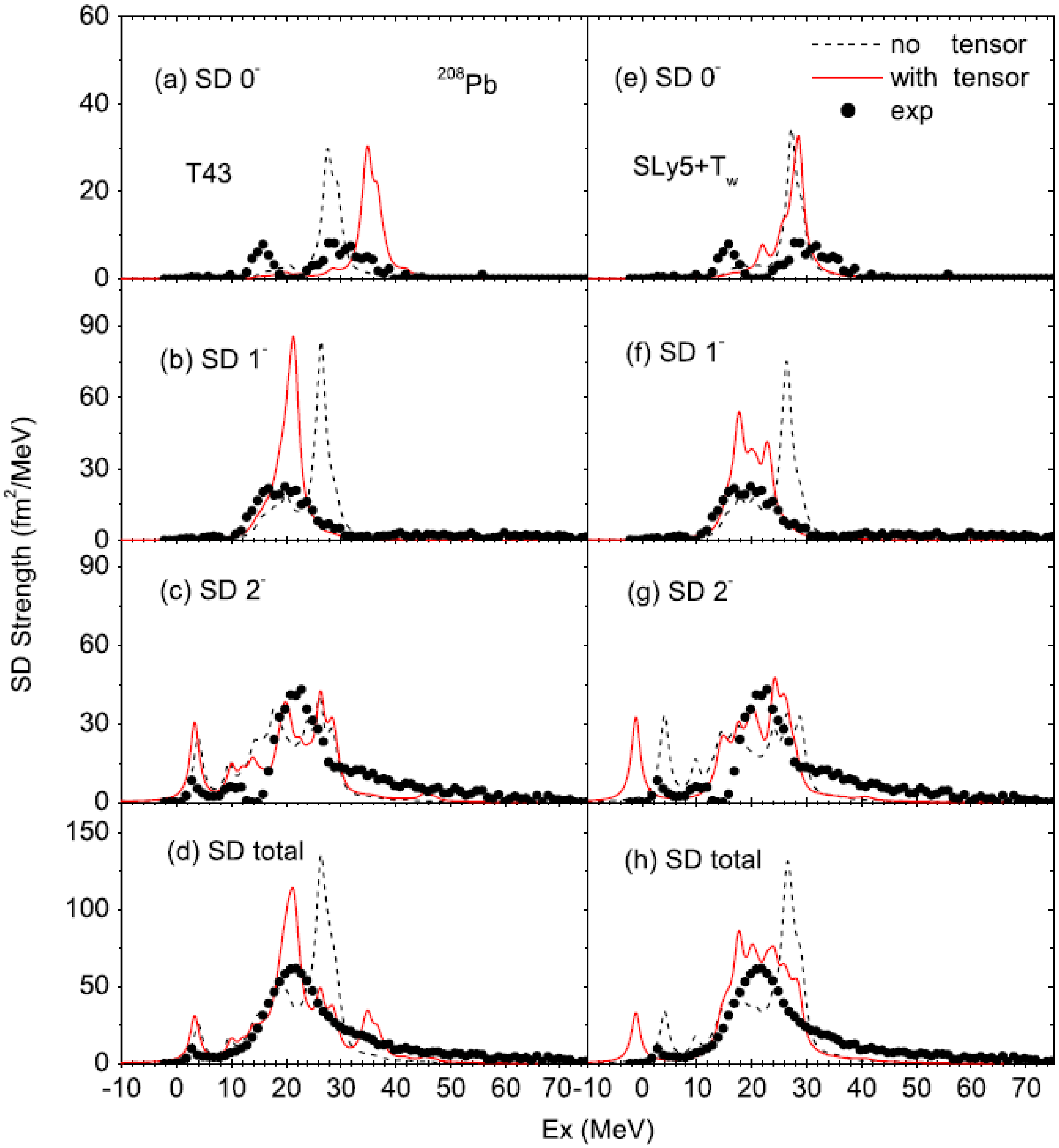

**Bai , Sagawa, Zhang, Zhang, Colò, Xu, Phys. Lett. B675, 28(2009)**

- **Main peak**
- **Low energy tail**
- **10% strength shifted to 2ħω** energy region

# Tensor effects on Charge-exchange SD

Bai, Zhang, Sagawa, Zhang, Colò, Xu, PRL 105,072501(2010)

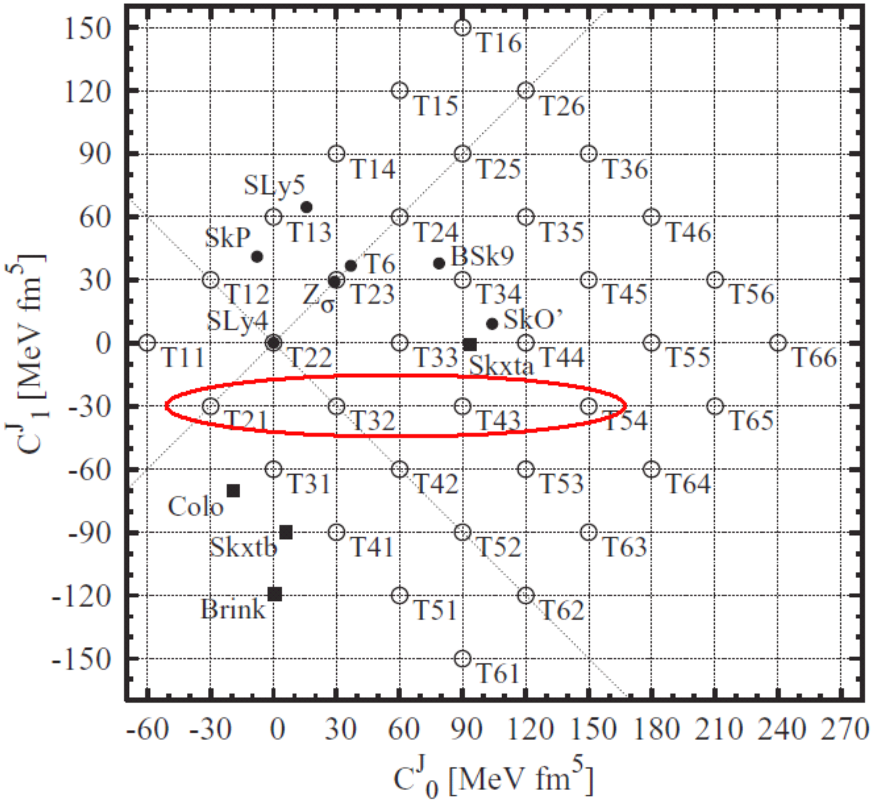
Exp. From
T. Wakasa et. al.,
PRC 84, 014614(2011)

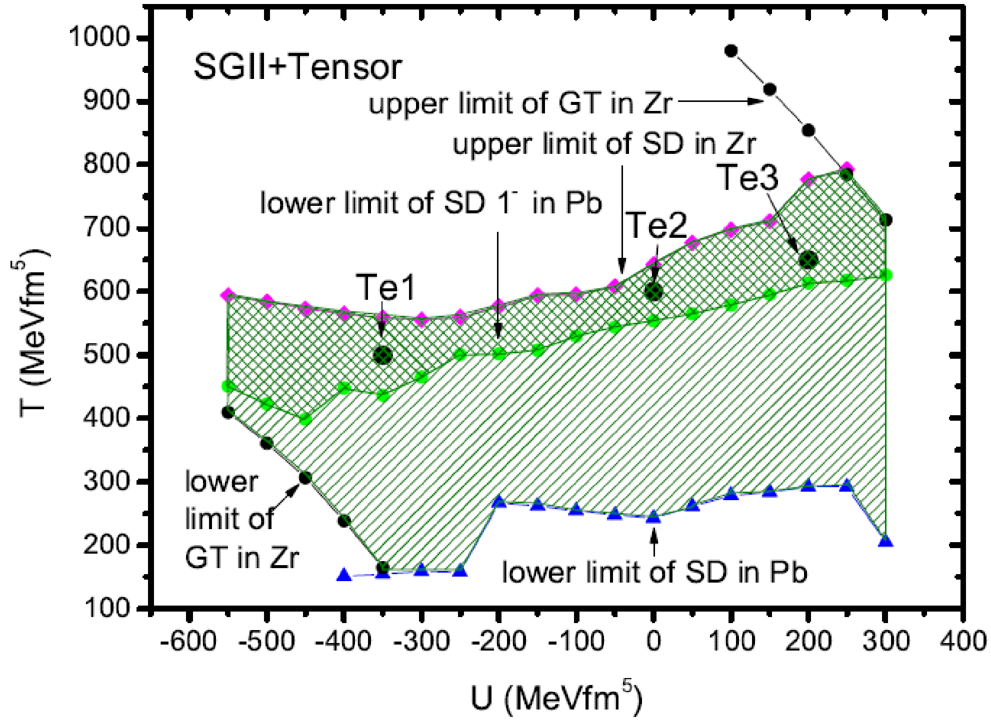



In T43, T >0, U<0
In SLy5+Tw, T>0, U>0

The SD 1- state is shifted downward dramatically by the tensor RPA correlations.

# GT and SD constraint on the tensor force




**Bai, Zhang, Sagawa, Zhang, Colò, Xu, PRC83,054316(2011);**

**The exp.main peak energy of SD and GT in $^{90}$Zr and $^{208}$Pb can be the constraints by requiring the condition**

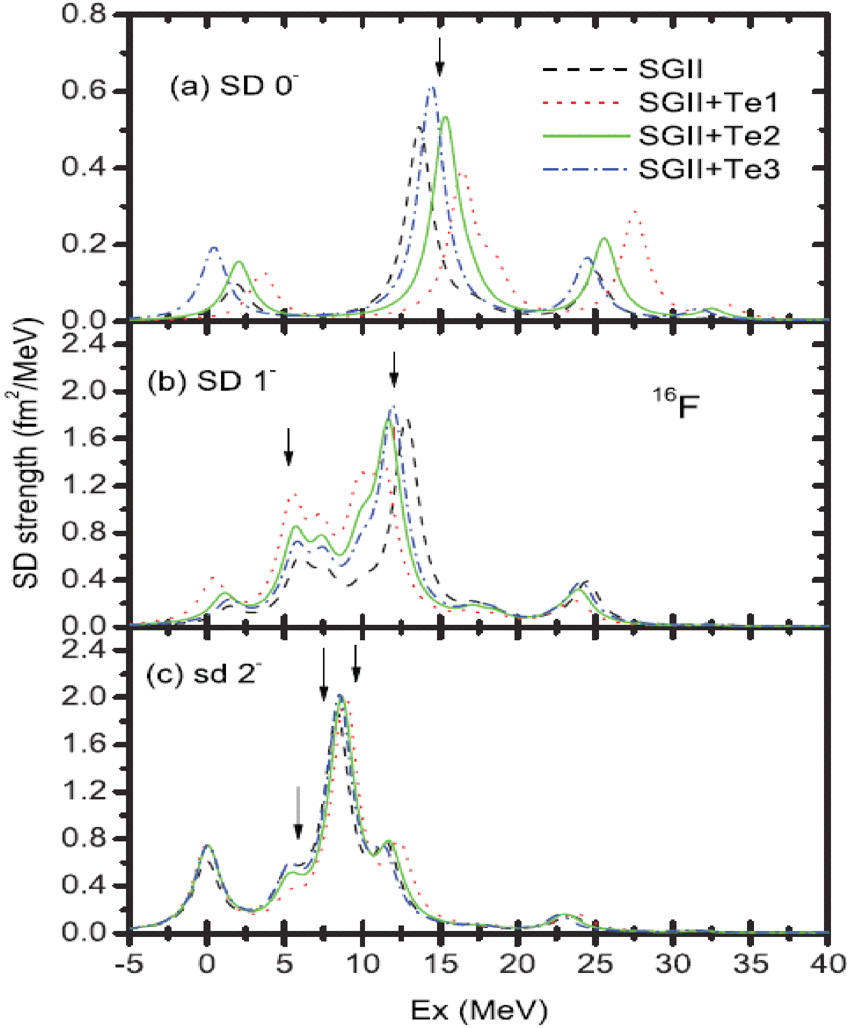
$$\delta_{E_{th}-E_{\exp}} < 2.5 MeV$$

- **In TIJ family, only T21, T32, T43, and T54 fulfill the condition;**
- **SD 1- states strongly constrain the value of T;**
- **Together with SD, GT main peak can be used to constrain value of U.**

PHYSICAL REVIEW C **84**, 044329 (2011)

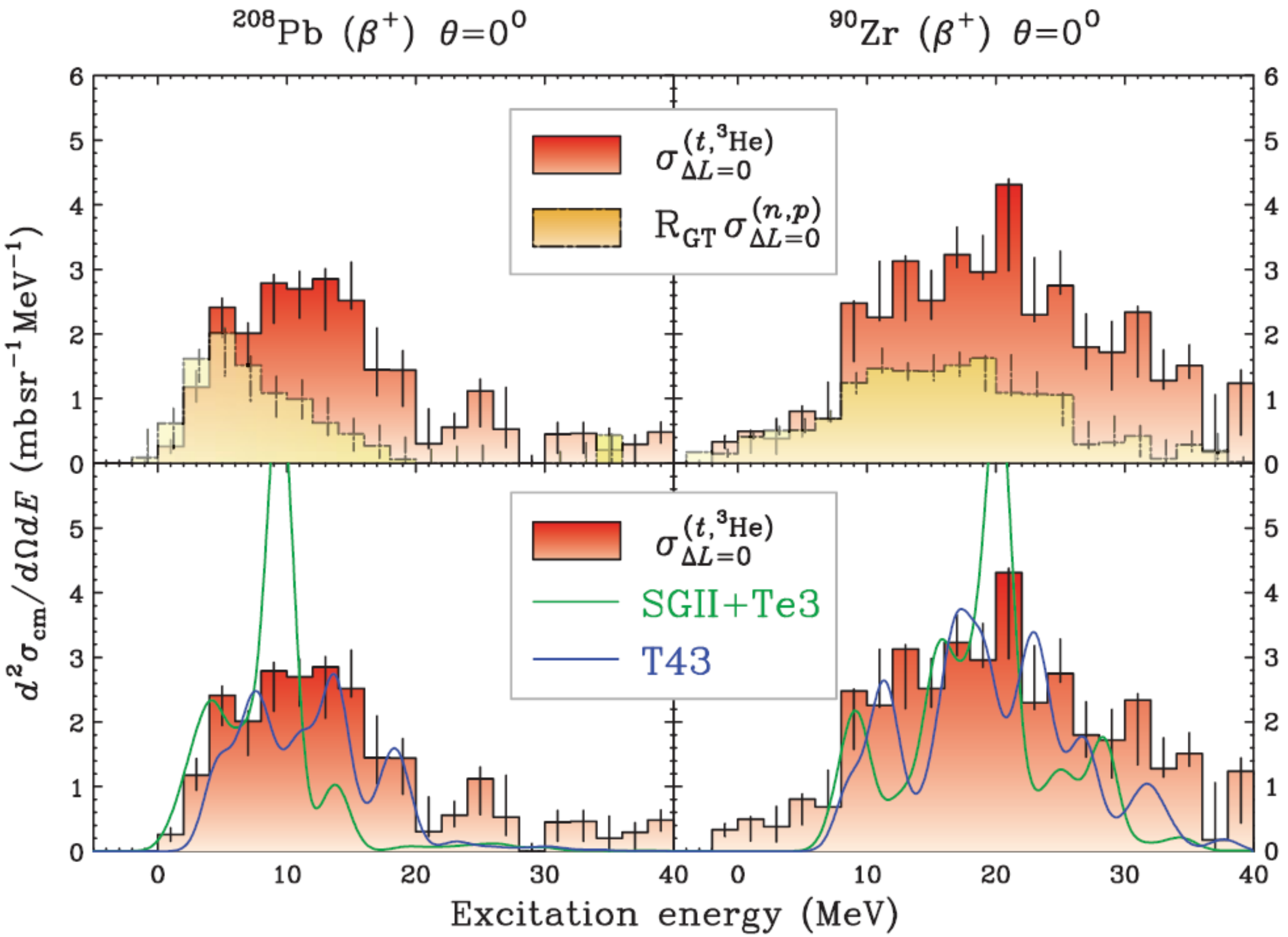
# Spin-dipole excitations in $^{16}$O and tensor correlations

C. L. Bai,[1] H. Sagawa,[2] G. Colò,[3] H. Q. Zhang,[4] and X. Z. Zhang[4]

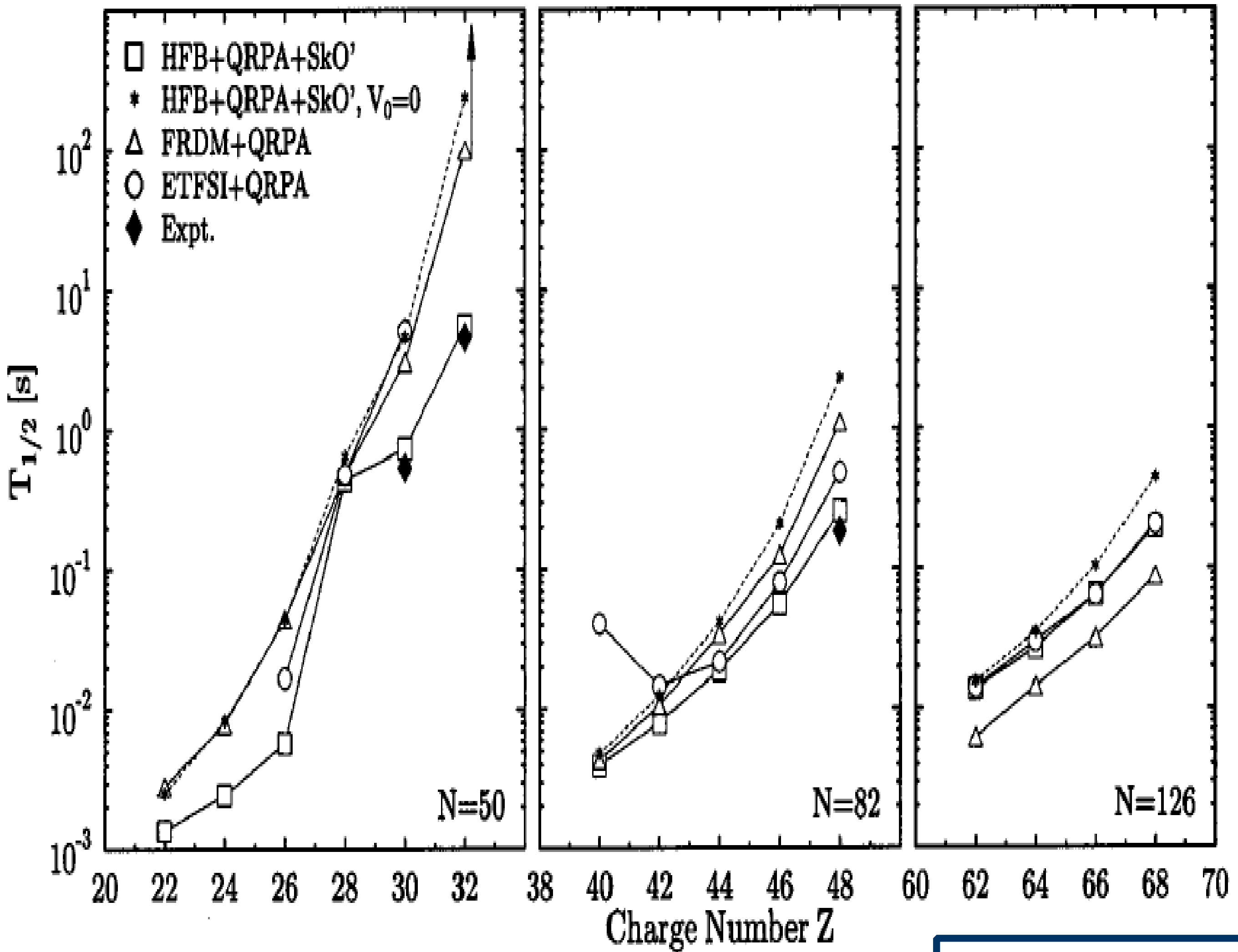


# Identification of the $\beta^+$ Isovector Spin Monopole Resonance via the $^{208}$Pb and $^{90}$Zr($t$, $^3$He) Reactions at 300 MeV/$u$

K. Miki,[1,2,*,†] H. Sakai,[1,2] T. Uesaka,[3] H. Baba,[2] C. L. Bai,[4] G. P. A. Berg,[5] N. Fukuda,[2] D. Kameda,[2] T. Kawabata,[6] S. Kawase,[3] T. Kubo,[2] S. Michimasa,[3] H. Miya,[3] S. Noji,[1] T. Ohnishi,[2] S. Ota,[3] A. Saito,[3] Y. Sasamoto,[3] H. Sagawa,[7] M. Sasano,[2] S. Shimoura,[3] H. Takeda,[2] H. Tokieda,[3] K. Yako,[1] Y. Yanagisawa,[2] and R. G. T. Zegers[8]



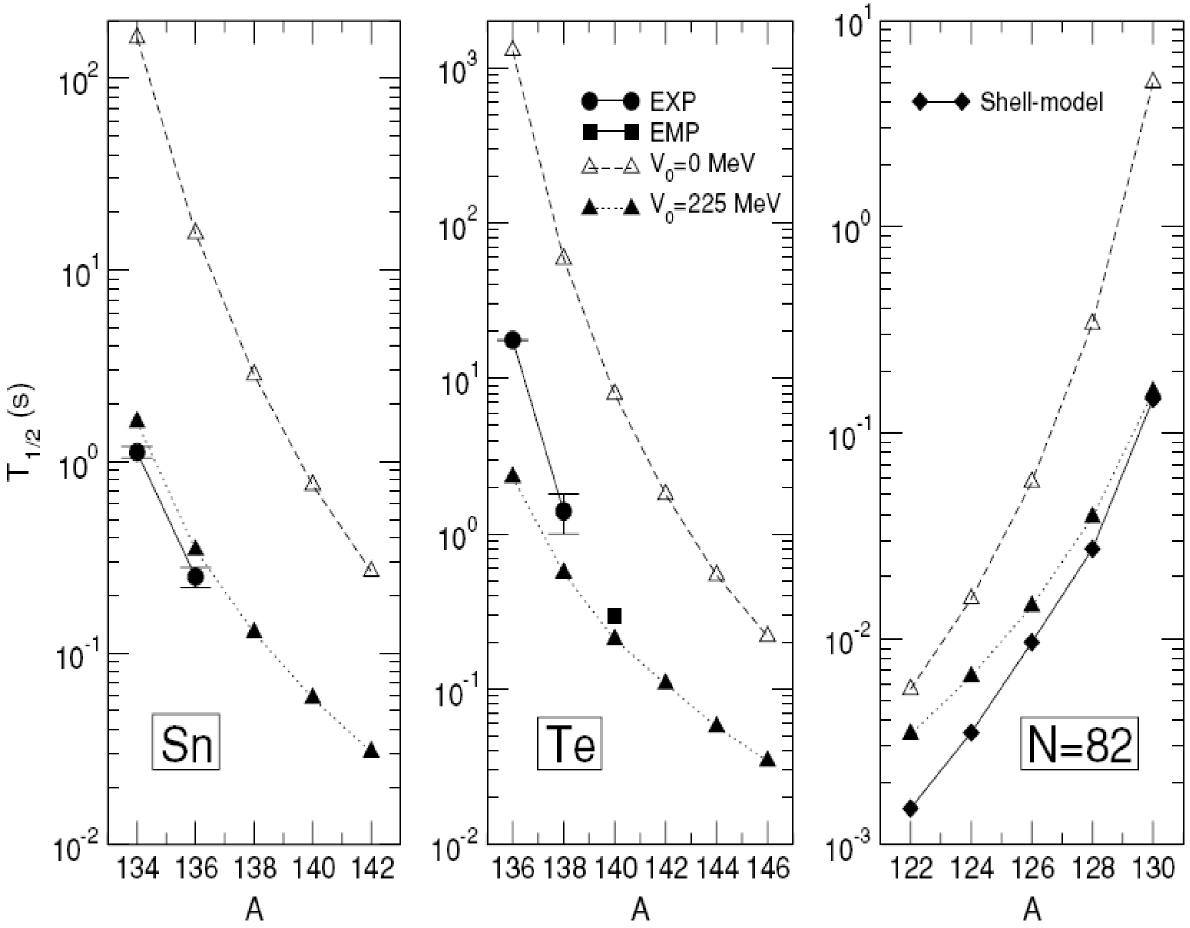
# β -decay half-life in open-shell nuclei




J. Engel, et. Al. Phys. Rev. C 60, 014320(1999)

T=0 pairing is used in QRPA Calculation with Skyrme force.

# β -decay half-life in open-shell nuclei




**T=0 pairing is used In relativistic QRPA Calculations.**

**T. Niksic, et. al. Phys. Rev. C 71, 014308(2005)**

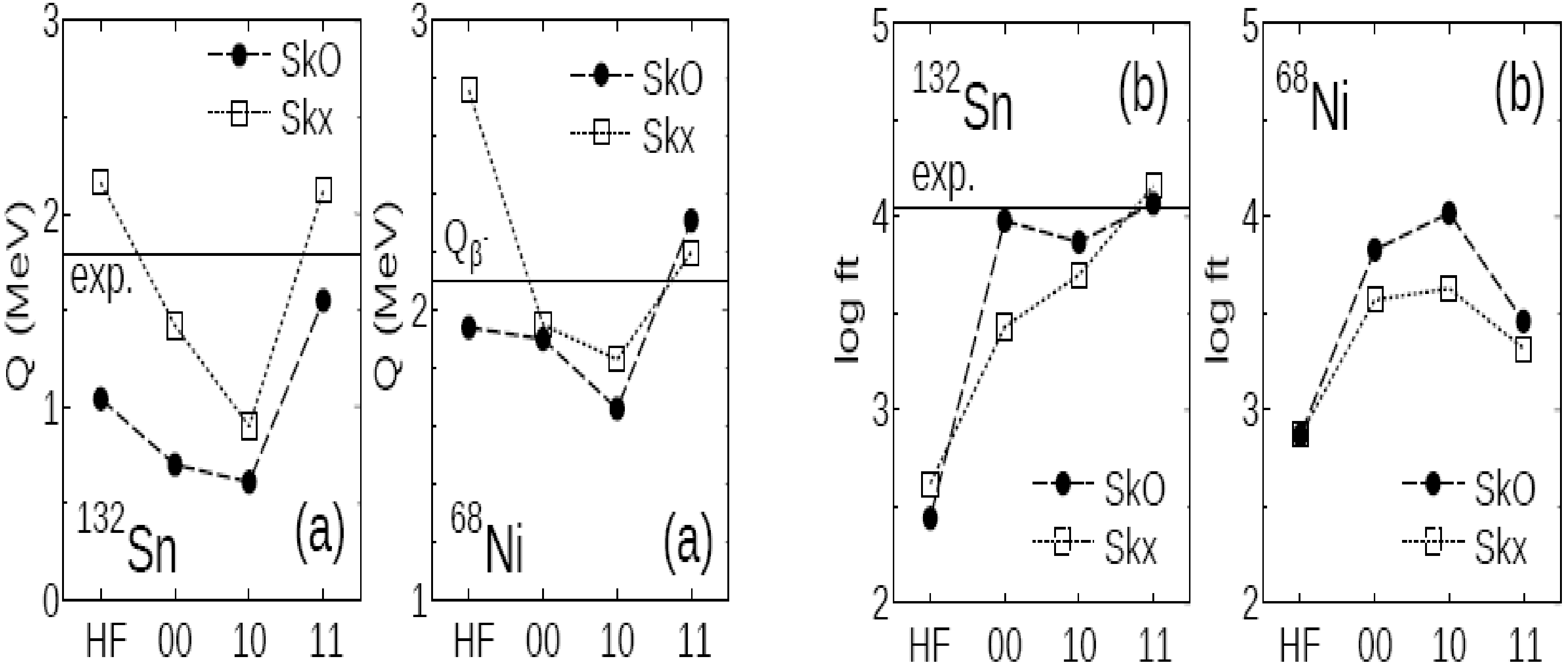
PHYSICAL REVIEW C **71**, 014308 (2005)

# $\beta$-decay rates of $r$-process nuclei in the relativistic quasiparticle random phase approximation

T. Nikšić, T. Marketin, and D. Vretenar N. Paar P. Ring

reproduces the data in the $N \approx 82$ region. $T = 0$ pairing, however, does not help in the case of Ni isotopes and for $^{132}$Sn, and the model overestimates the half-lives on Ni nuclei and predicts a $\beta$-stable $^{132}$Sn. Therefore, we have not been able, as suggested in Ref. [4], to adjust the strength of the $T = 0$ pairing on experimental data and extend the calculation to other mass regions or even to other isotopic chains in the same mass region. This problem could be due, however, to

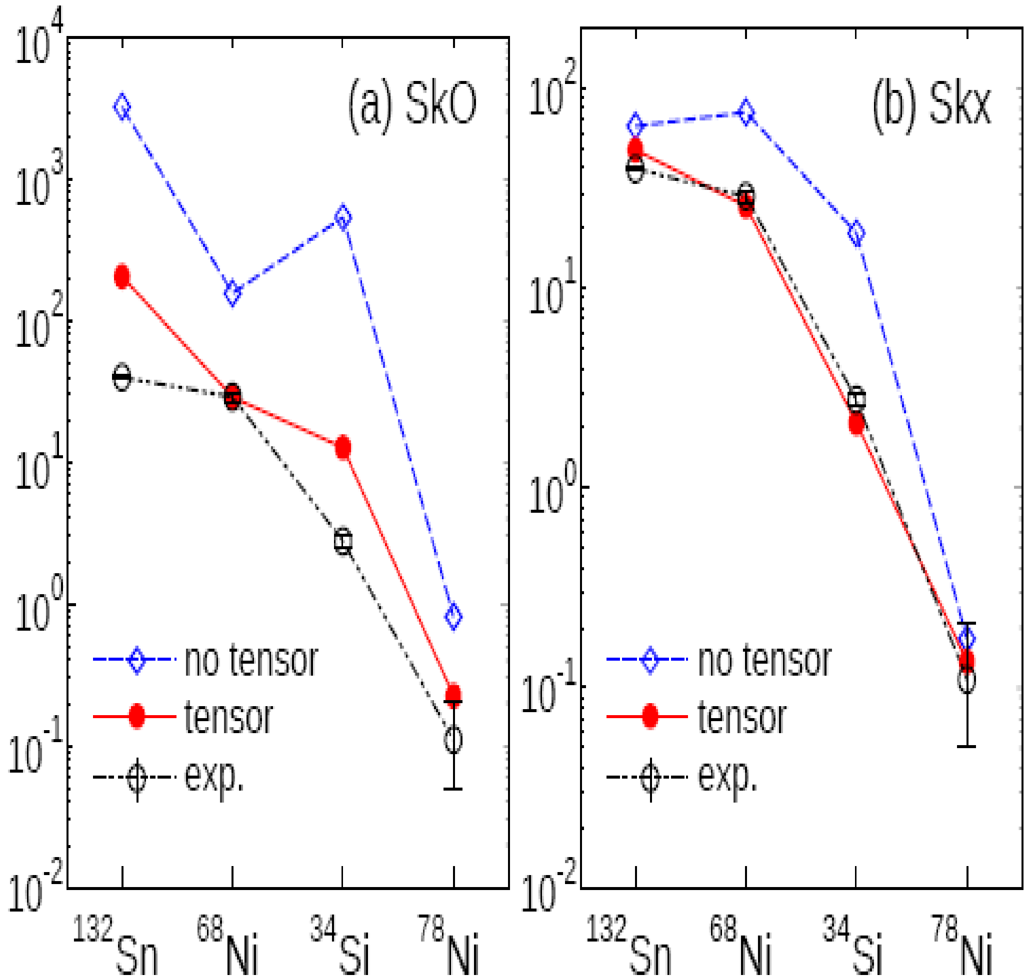
# β -decay half-life in closed-shell nuclei




**The inclusion of tensor force in self-consistent RPA calculation improve the Result of Q and logft values.**


**F. Minato and C. L. Bai, Phys. Rev. Lett 110, 122501(2013)**

# β -decay half-life in closed-shell nuclei




**Tensor RPA correlations improve the β-decay half-life calculations in closed-shell nuclei.**

**F. Minato and C. L. Bai, Phys. Rev. Lett 110, 122501(2013)**

# Conclusion and outlook

- Tensor force have strong effects on the main peak energy of GT and charge-exchange SD transitions in closed shell nuclei.

- GT and SD main peak energies can be used to constrain the strengths of tensor force in a small area;

- In open-shell nuclei, T=0 pairing plays an important role in β -decay, in closed-shell Nuclei, where the T=0 pairing is negligible the tensor force play an important role.

Many Thanks for your attention