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Isovector and isoscalar spin-multipole giant resonances in the parent and daughter nuclei of double-beta decay triplets

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MAYORANA School

Elina Kauppinen

Motivation

- Neutrinoless double-beta decay is one of the most interesting subjects in nuclear and particle physics.
- If it were detected, it would mean new physics beyond the standard model.
- By studying the spin-multipole giant resonances in mother and daughter double-beta decay nuclei, one could obtain more information about the wave functions of the virtual state of the intermediate nuclei.

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- The poster will present a (semi) recent publication.

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Isovector and isoscalar spin-multipole giant resonances in the parent and daughter nuclei of double-β-decay triplets

Elina Kauppinen * and Jouni Suhonen
Department of Physics, University of Jyväskylä, P.O. Box 35, FI-40014, Jyväskylä, Finland

Intro

- The study of double-beta decay nuclei and their daughter nuclei.
- The strength functions of isovector and isoscalar spin-multipole giant resonances were studied.
- Used theory was quasiparticle random-phase approximation (QRPA).
- Transitions from the ground state to the excited states were calculated.
  - $J^\pi = 0^-, 1^-, 2^-$ ($L = 1$, spin-dipole)
  - $J^\pi = 1^+, 2^+, 3^+$ ($L = 2$, spin-quadrupole)

Studied nuclei:

(^{76}Ge, ^{76}Se)
(^{82}Se, ^{82}Kr)
(^{96}Zr, ^{96}Mo)
(^{100}Mo, ^{100}Ru)
(^{116}Cd, ^{116}Sn)
(^{128}Te, ^{128}Xe)
(^{130}Te, ^{130}Xe)
(^{136}Xe, ^{136}Ba)

Theory (QRPA)

- Nucleons pair with each other
  - Protons with protons and neutrons with neutrons
- Nucleon pairs are handled as quasiparticles that behave like bosons
- QRPA excitation operator can be written as

$$Q^\dagger = \sum_{a \leq b} [X^{\omega}_{ab} A^\dagger_{ab}(JM) - Y^{\omega}_{ab} \tilde{A}_{ab}(JM)]$$

- Two-quasiparticle operators:

$$A^\dagger_{ab}(JM) = \mathcal{N}_{ab}(J)[a^\dagger_a a^\dagger_b]_{JM} \qquad \tilde{A}_{ab}(JM) = -\mathcal{N}_{ab}(J)[\tilde{a}_a \tilde{a}_b]_{JM}$$

Theory

- Transition operators for isovector and isoscalar excitations:

$$\mathcal{O}^{0,v}_{L,JM} = i^l r^l [Y_L \sigma]_{JM} t_0 \qquad \mathcal{O}^{0,s}_{L,JM} = i^l r^l [Y_L \sigma]_{JM}$$

  - Are used to obtain reduced transition nuclear matrix elements
- Transition strengths are calculated as the square of the transition NME:

$$S^L_{nJ^\pi} = |(nJ^\pi || \mathcal{O}^0_{L,J} || \text{QRPA})|^2$$

Example of the results

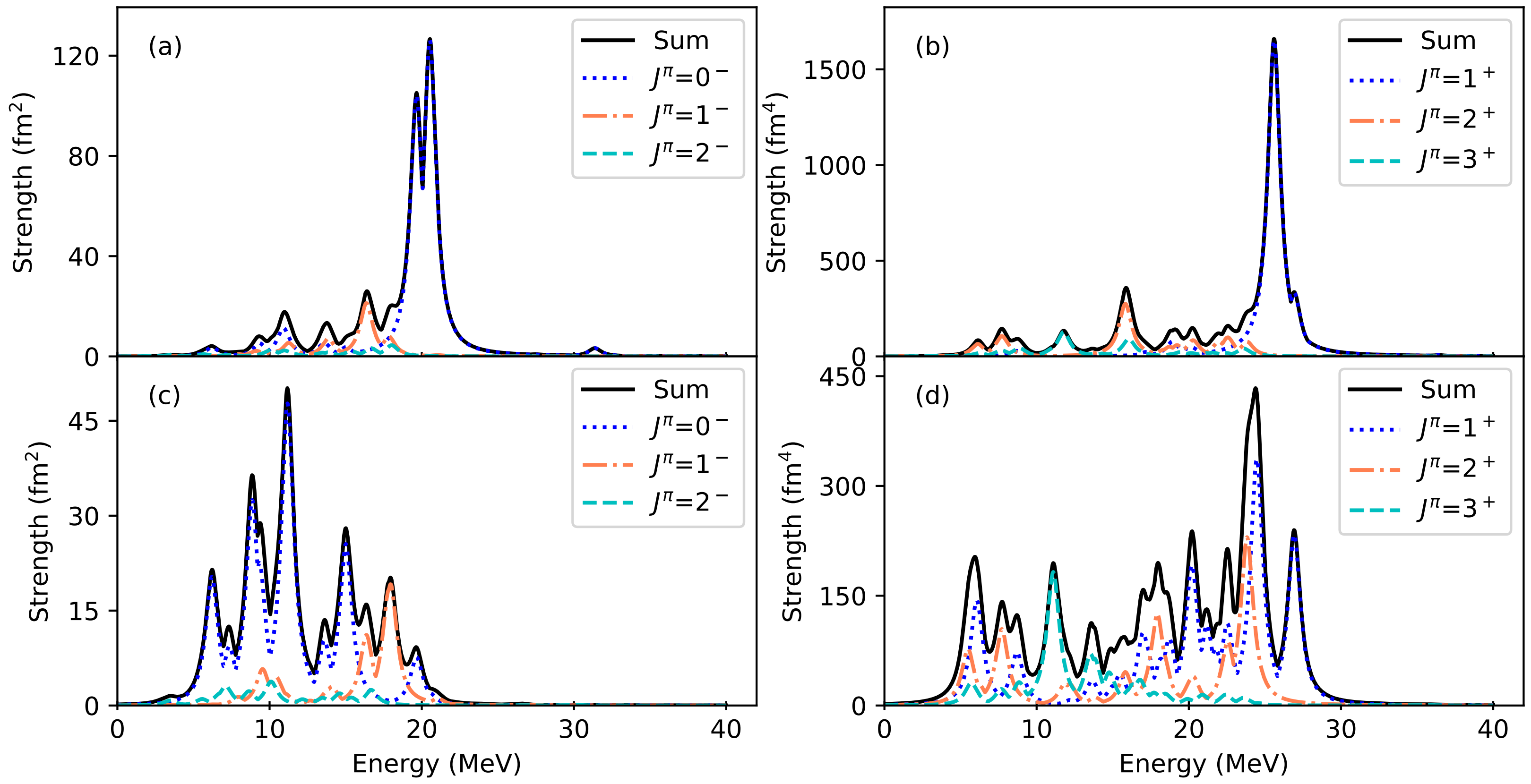
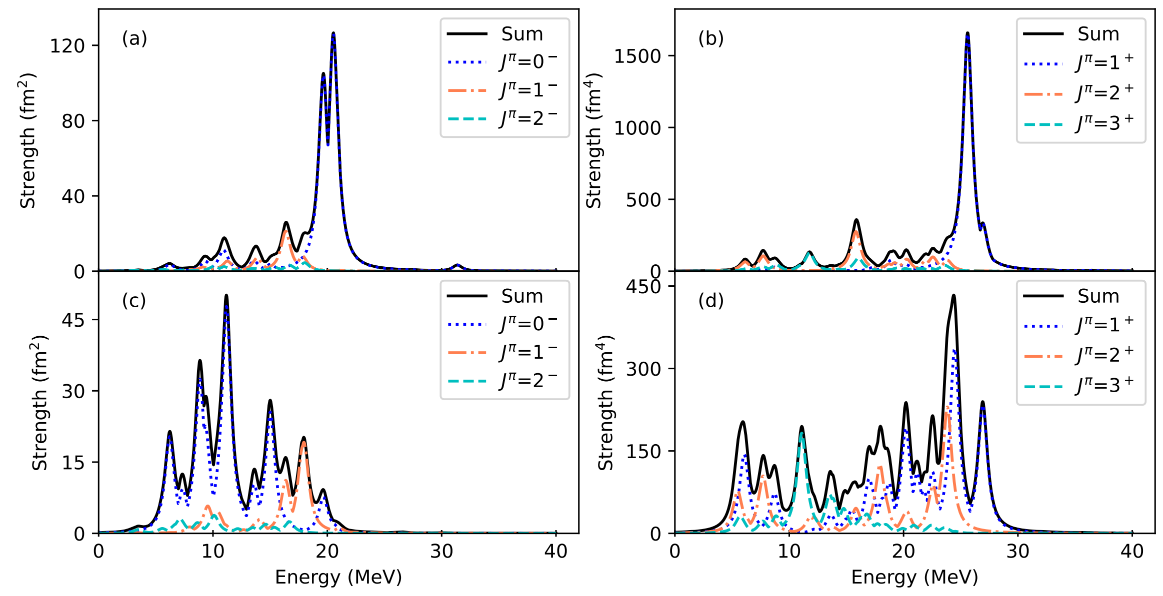


Figure: Isovector and isoscalar strength functions for ^{136}Xe. (a) isovector, $L = 1$, (b) isovector $L = 2$, (c) isoscalar $L = 1$, and (d) isoscalar $L = 2$.

Observations of the obtained results

- How widely the peaks are spread depends on the type of the excitation.
  - Isoscalar are more spread in energy.
  - Isovector strength tend to locate in one or few peaks.



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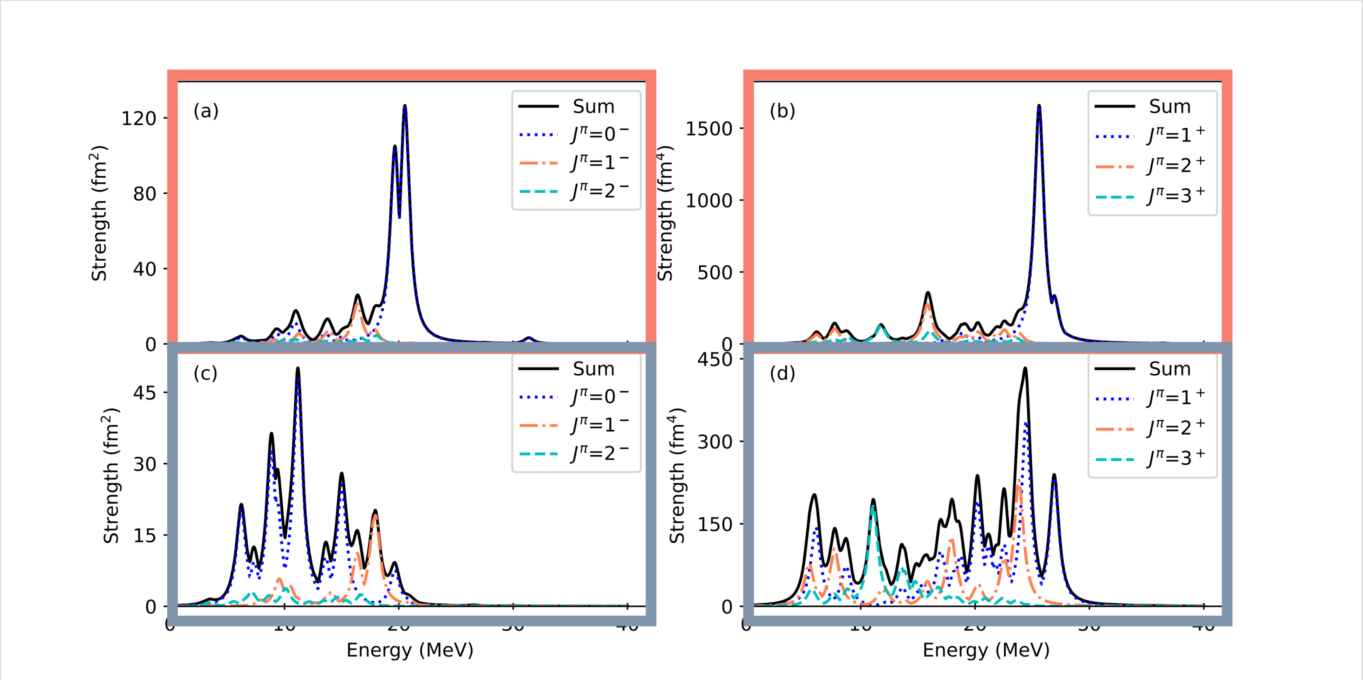
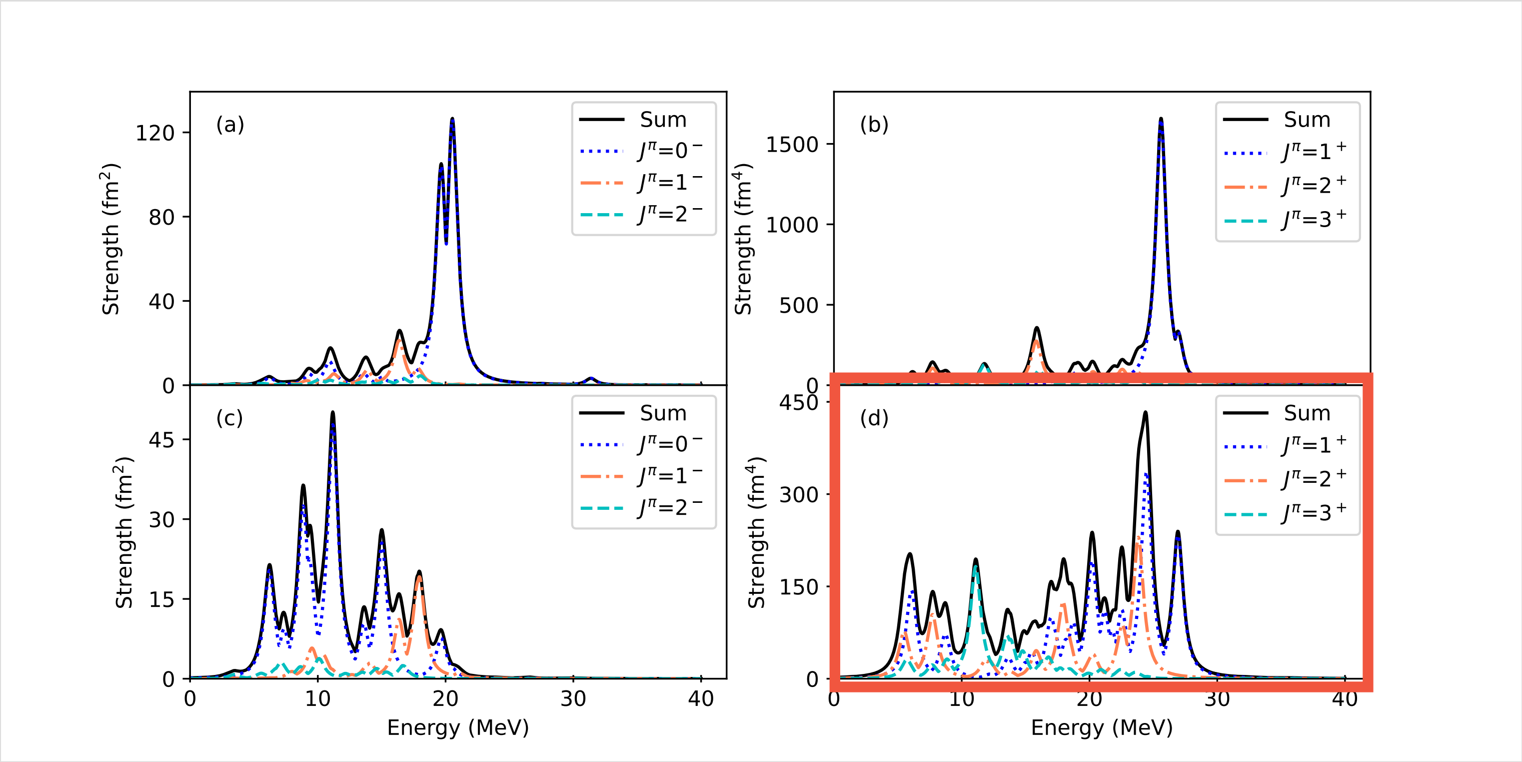


Observations of the obtained results

- Only isoscalar strength functions show notable contributions for all the states.



Conclusions

- Comparison of the results obtained in this study with potential future experimental data may shed light on the reliability of the QRPA-based framework describing the wave functions of nuclear states relevant to two-neutrino and neutrinoless double-beta decay.

- More on the poster!

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Thank you!