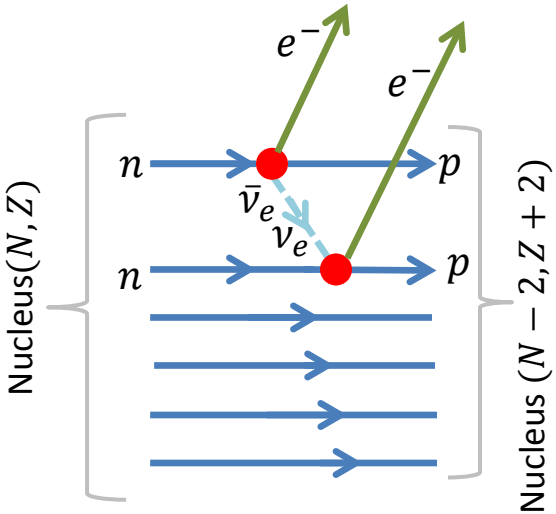
Examination and improvement of nuclear matrix elements of double-β decay in QRPA approach

J. Terasaki, *Inst. for Experimental and Applied Physics, Czech Technical Univ. in Prague*

The goal is to determine the effective mass of the neutrino. The double-β decay of nucleus is used for this purpose.



Neutrinoless double-β decay, which occurs if the neutrino is a Majorana particle.

Principle to determine effective neutrino mass

$$\langle m_\nu \rangle = \left| \sum_{i=1,2,3} U_{ei}^2 m_i \right|$$

U: Pontecorvo–Maki–Nakagawa–Sakata matrix

m_i: eigen mass (i=1,2,3)

$$1/T_{0\nu} = \left|M^{(0\nu)}\right|^2 G_{01} g_A^4 \left(\frac{\langle m_\nu \rangle}{m_e}\right)^2$$

- Half-life: Exp.
- $\left|M^{(0\nu)}\right|^2$: Nuclear matrix element
- G_{01}: Phase-space factor
- g_A: Axial-vector current coupling

Theoretical calculation

Status:
The calculated nuclear matrix elements by various groups are distributed in a range of factor of 2–3.

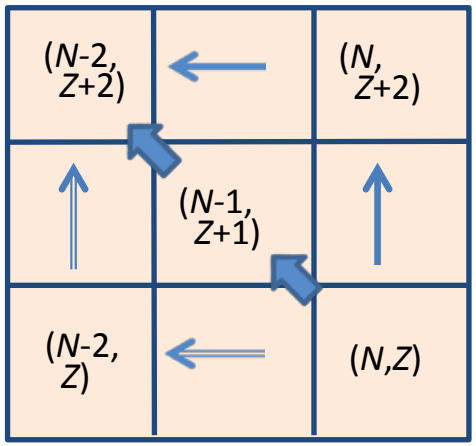
Approximation of nuclear wave function by the quasiparticle random-phase approximation (QRPA)

Nuclear excitation is described as the superposition of two quasiparticle excitations.

- Transition strength function can be well reproduced.
- Sum rule is satisfied.
- Widely used in nuclear and condensed-matter physics.

IMPROVEMENT

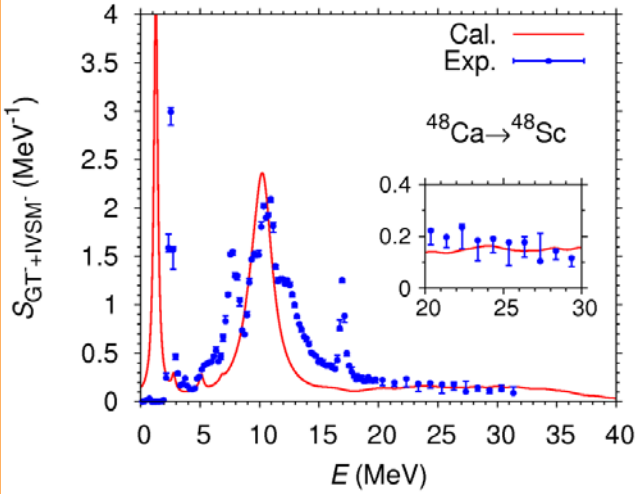
Under a well-established approximation, **virtual-decay paths by two-particle transfers** are possible for the calculation.



These different paths have to give the same nuclear matrix element.

The strength of the isoscalar proton-neutron pairing interaction is determined.

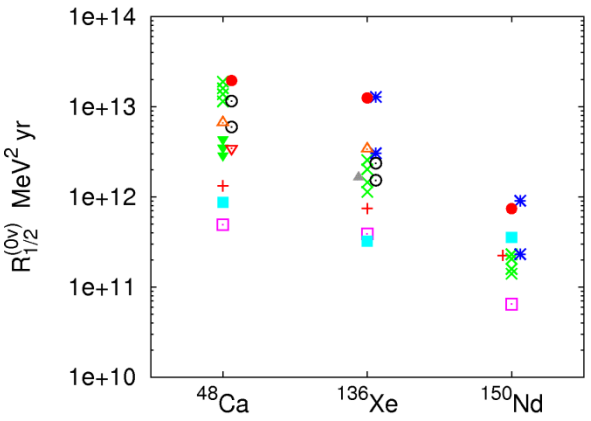
EXAMINATION



The charge-change transition density used for the nuclear matrix element has been confirmed by reproducing the exp. data of the Gamow-Teller strength function.

By-product:
it has been clarified that this charge-change reaction is induced by the Gamow-Teller + isovector spin monopole operators.

RESULT



Reduced half-lives by several groups
$R^{(0\nu)}_{1/2}$
$\propto$ (nuclear matrix element)$^{-2}$
$\propto$ half-life,
are shown above.

My result: red filled circles
Rather large.