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The Legacy of Adelchi Fabrocini

Short-range correlations and Double-Beta Decay

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Short-range correlation effects on the nuclear matrix element of neutrinoless double-β decay

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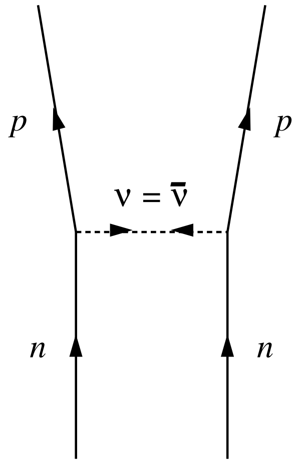
TABLE I. Ratio between the $0\nu\beta\beta$ NME of Eq. (4), computed including central and central plus spin-dependent correlations and the corresponding quantity obtained setting $f(r_{12}) = 1$ and $g(r_{12}) = 0$.

	$f(r_{12})$	$f(r_{12}) + g(r_{12})(\boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2)$
M/M_{SM}	0.77	0.79

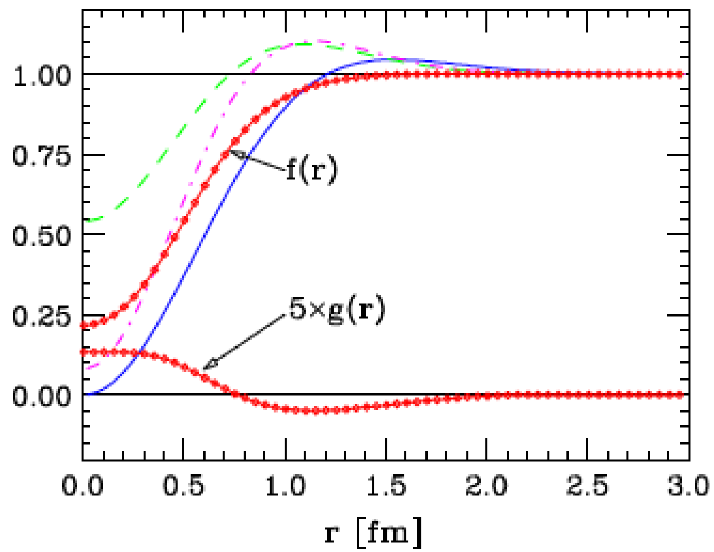


$$\frac{1}{\tau} = G\,|M|^2$$

$$\begin{aligned}
M &= \int d^3\,q e^{i\mathbf{q}\cdot(\mathbf{r}_1-\mathbf{r}_2)} \sum_i \langle A, Z+2|\mathcal{O}(1)|i\rangle \frac{1}{|\mathbf{q}|(|\mathbf{q}|+\omega_i/\hbar)} \langle i|\mathcal{O}(2)|A, Z\rangle \\
&\simeq \int d^3\,q \frac{e^{i\mathbf{q}\cdot(\mathbf{r}_1-\mathbf{r}_2)}}{|\mathbf{q}|(|\mathbf{q}|+<\omega_i/\hbar>)} \langle A, Z+2|\mathcal{O}(1)\mathcal{O}(2)|A, Z\rangle \\
&= \int d^3\,q\, S(\mathbf{q}) \langle A, Z+2|\mathcal{T}(1,2)|A, Z\rangle
\end{aligned}$$

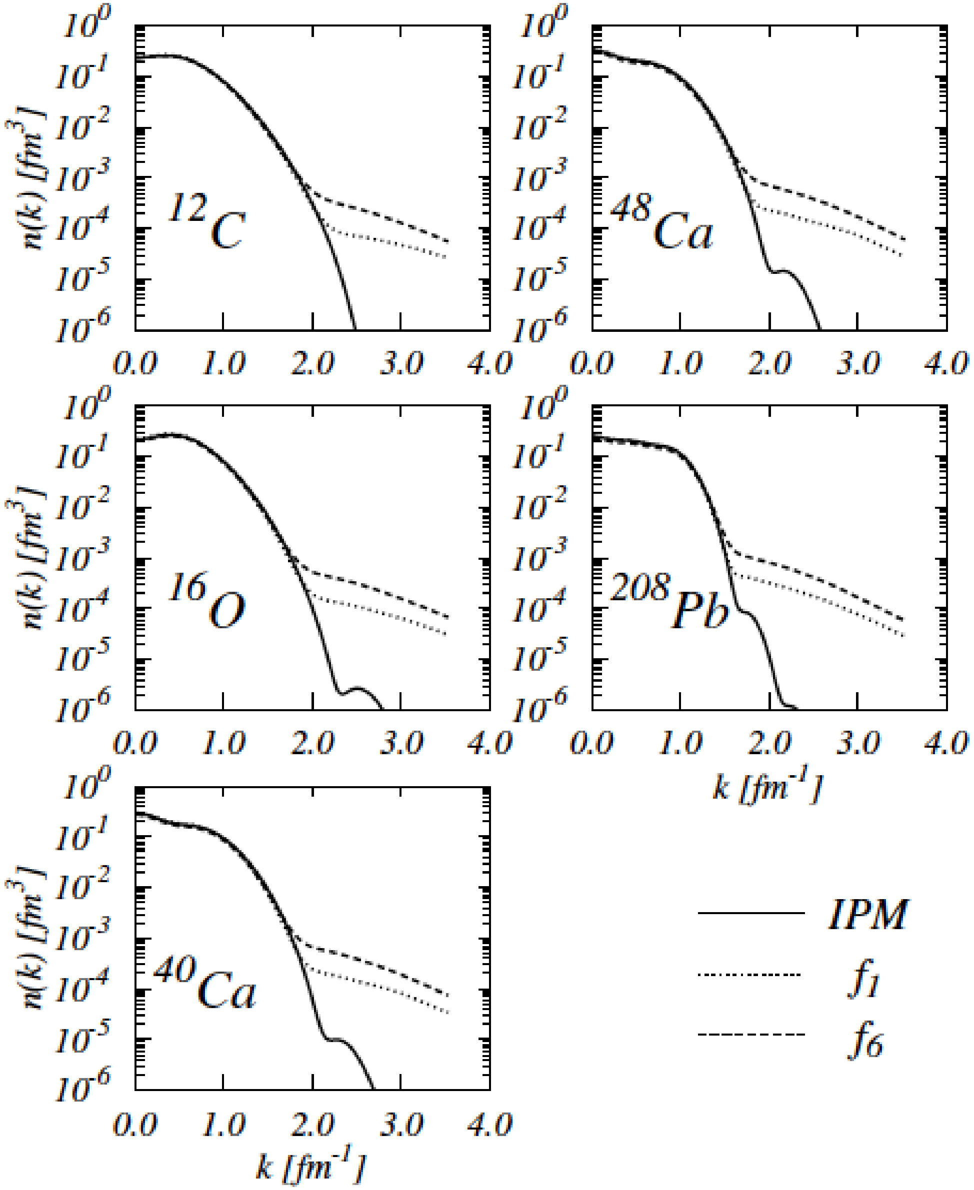
$$\langle A, Z+2|\mathcal{T}(1,2)|A,Z\rangle \longrightarrow \langle A, Z+2|f(r_{12})\mathcal{T}(1,2)f(r_{12})|A,Z\rangle$$

$$\mathcal{T}(1,2) \longrightarrow \mathcal{T}^{\text{eff}}(1,2) = f(r_{12})\mathcal{T}(1,2)f(r_{12})$$



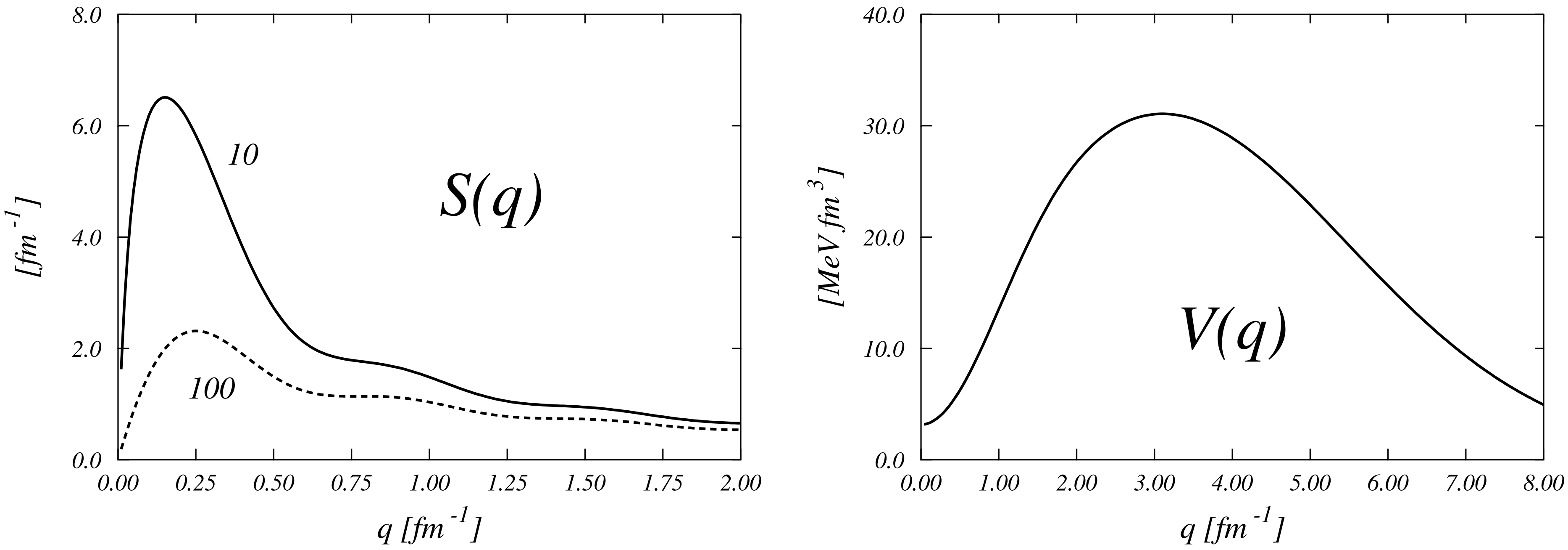
$$\langle A, Z|A,Z\rangle \neq \langle A, Z|f^2(r_{12})|A,Z\rangle$$

Authors	Method	Ref.	M/M_{MF}
M. Kortelainen *et al.*	SM	PLB 647 (2007) 128	0.7
F. Šimkovic *et al.*	QRPA	PRC 77(2008) 045503	~ 0.8
F. Šimkovic *et al.*	QRPA	PRC 79(2009) 055501	$0.7, 0.5$
M. Horoi S. Stoica	QRPA	PRC 81 (2010) 024321	0.8,1.2,1.1



A. Fabrocini

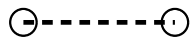
$$\Delta x \Delta p \simeq \hbar c \simeq 2.0\text{fm}^{-1}\, 0.5\text{fm}$$

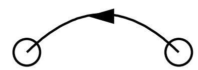


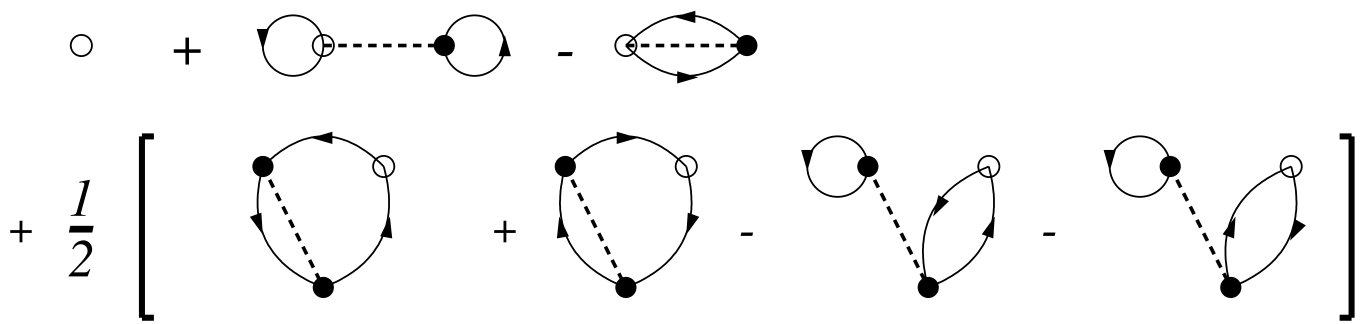
S(q)
10
100
[fm^-1]
q [fm^-1]
8.0
6.0
4.0
2.0
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
V(q)
[MeV fm^3]
q [fm^-1]
40.0
30.0
20.0
10.0
0.0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

$$
\begin{aligned}
\rho(\mathbf{r}) &= \frac{1}{\langle\Psi|\Psi\rangle}\int d^3 r_2\, d^3 r_3 \cdots d^3 r_A \Psi^*(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A)\Psi(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A) \\
&= \frac{1}{\langle\Psi|\Psi\rangle}\int d^3 r_2\, d^3 r_3 \cdots d^3 r_A \Phi^*(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A) F^\dagger F \Phi(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A)
\end{aligned}
$$

$$
F^\dagger F = \prod_{ij} f^2(r_{ij}) = \prod_{ij}[1 + h(r_{ij})]
$$

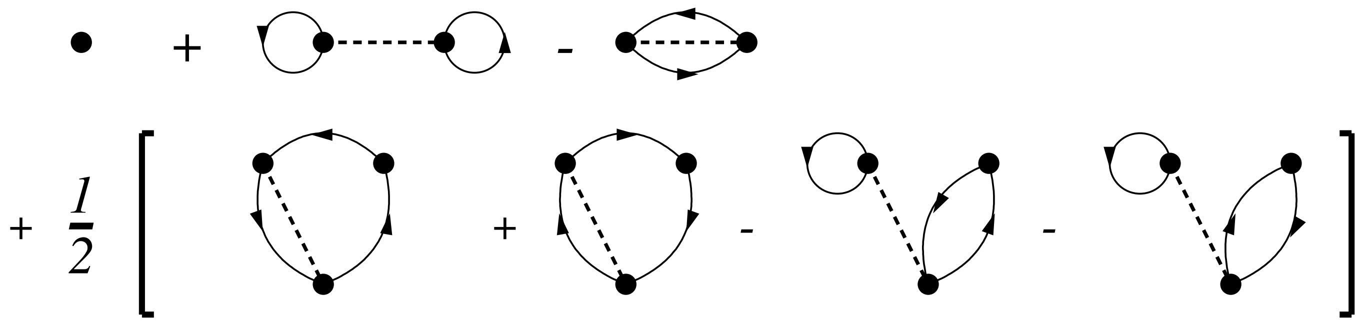
$h(r_{12}) \rightarrow$ 

$\rho^{\mathsf{MF}}(\mathbf{r}_1, \mathbf{r}_2) = \sum_{\alpha < \epsilon_{\mathsf{F}}} \phi^*_\alpha(\mathbf{r}_1)\phi_\alpha(\mathbf{r}_2) \rightarrow$ 



$$\int d^3r_3\, \rho(\mathbf{r}_1,\mathbf{r}_3)\rho(\mathbf{r}_3,\mathbf{r}_2) = \rho(\mathbf{r}_1,\mathbf{r}_2)$$

$$\int d^3r_1\, \rho(\mathbf{r}_1,\mathbf{r}_1) = \int d^3r_1\, \rho(\mathbf{r}_1) =$$



$$= A$$

$$\int d^3r_1\, \rho^{\mathsf{MF}}(\mathbf{r}_1) = \int d^3r_1 \sum_\alpha |\phi_\alpha(\mathbf{r}_1)|^2 = A$$

$$\rho(\mathbf{r}_1, \mathbf{r}_2) = \frac{1}{\langle \Psi | \Psi \rangle} \int d^3 r_3 \cdots d^3 r_A \Psi^*(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A) \Psi(\mathbf{r}_1, \mathbf{r}_2, \cdots \mathbf{r}_A)$$

$$\rho^{\mathsf{MF}}(\mathbf{r}_1, \mathbf{r}_2) = \rho^{\mathsf{MF}}(\mathbf{r}_1) \rho^{\mathsf{MF}}(\mathbf{r}_2) - \rho^{\mathsf{MF}}(\mathbf{r}_1, \mathbf{r}_2) \rho^{\mathsf{MF}}(\mathbf{r}_2, \mathbf{r}_1)$$