Two-body currents at finite momentum transfer and applications to M1 transition

TECHNISCHE UNIVERSITÄT DARMSTADT

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in collaboration with:

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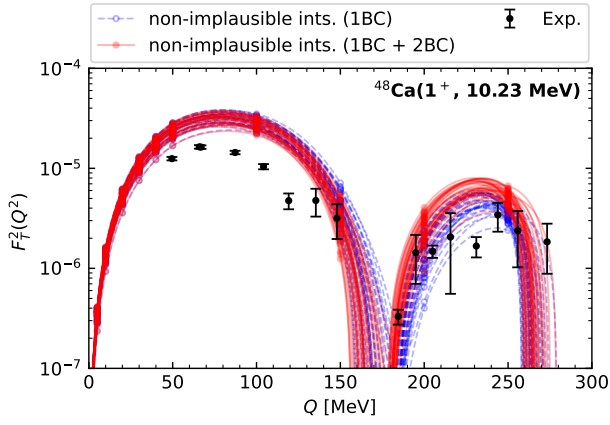
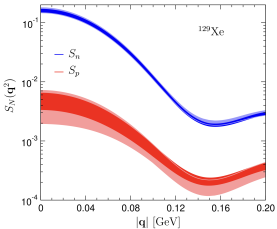


Motivation: 2BCs at finite momentum transfer

- quenching for $0\nu\beta\beta$ decay Menéndez, Gazit, and Schwenk, Phys. Rev. Lett. 107, 062501 (2011)
- neutrinos scattering off nuclei Hoferichter, Menéndez, and Schwenk, Phys. Rev. D 102, 074018 (2020)
- weakly interacting massive particles scattering off nuclei
  Klos, Menéndez, Gazit, and Schwenk, Phys. Rev. D 88 (2013)
- in medium-mass/heavy nuclei: only approximately included
  Menéndez, Gazit, and Schwenk, Phys. Rev. Lett. 107, 062501 (2011)
- **multipole decomposition** for inclusion of two-body currents



Hoferichter *et al.* Phys. Rev. D 102, 074018 (2020)

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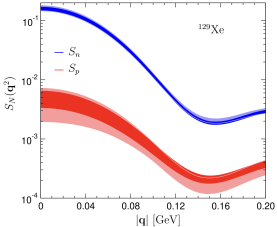

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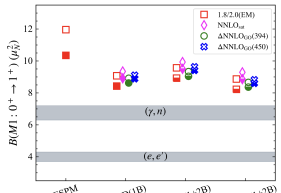
- first applications to well studied **M1 transition in ^{48}Ca**
  Acharya *et al.*, arXiv:2311.11438 [nucl-th] (2023)
- momentum transfer dependence of transition form factor
  Steffen et al., Nucl. Phys. A404, 413 (1983)
- $B(\mathrm{M1})$: experimental discrepancy between (e, e') and (γ, n) measurement Steffen et al., Phys. Lett. B 95, 23 (1980), Tompkins et al., Phys. Rev. C 84, 044331 (2011)



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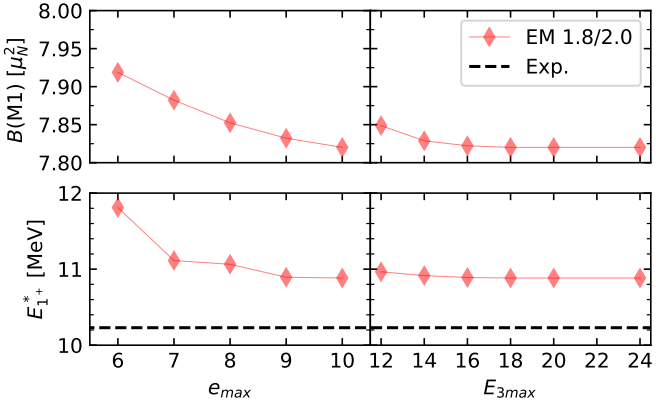
^{48}Ca many-body convergence

- VS-IMSRG convergencechecked with EM 1.8/2.0 for $B(\mathrm{M1})$ and $E^*_{1^+}$
  Miyagi, Eur. Phys. J. A 59, 150 (2023)
  Stroberg, https://github.com/ragnarstroberg/imsrg.git
  Hebeler et al., Phys.Rev.C 83 031301 (2011)
- $E_{3\mathrm{max}} = 24$ for emax variation
- $\mathrm{emax} = 10$ for $E_{3\mathrm{max}}$ variation
- for further calculations:
  $\mathrm{emax} = 12$ and $E_{3\mathrm{max}} = 24$



Multipole decomposed vector current

$$\vec{j}(\vec{Q}) = 4\pi \sum_{\lambda\mu} (-i)^{\lambda} \left(L_{\lambda\mu}(Q) \vec{Y}^{*}_{\lambda\mu}(\hat{Q}) + T^{\mathrm{el}}_{\lambda\mu}(Q) \vec{\Psi}^{*}_{\lambda\mu}(\hat{Q}) + T^{\mathrm{mag}}_{\lambda\mu}(Q) \vec{\Phi}^{*}_{\lambda\mu}(\hat{Q}) \right)$$

summing over rank λ and its projection μ using the following definitions

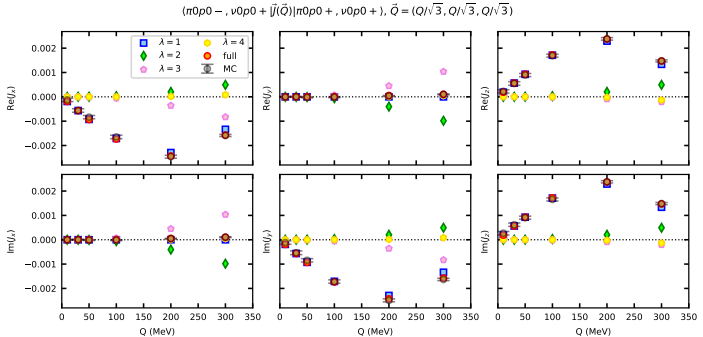
$$\vec{Y}_{LM}(\hat{\vec{x}}) = \hat{\vec{x}} Y_{LM}(\hat{\vec{x}}), \qquad \vec{\Psi}_{LM}(\hat{\vec{x}}) = \sqrt{\frac{1}{L(L+1)}} x \nabla Y_{LM}(\hat{\vec{x}}), \qquad \vec{\Phi}_{LM}(\hat{\vec{x}}) = \vec{Y}_{L,L,M}$$

$$\text{with} \quad \vec{Y}_{JLM}(\theta,\phi) = \sum_{M_{\mathrm{sum}}=-L}^{L} \sum_{\lambda=-1}^{1} Y_{L,M}(\theta,\phi) C^{JM}_{LM_{\mathrm{sum}}1\lambda} \vec{e}_{\lambda}$$

Benchmark for vector 2BC at finite momentum transfer: seagull and pion-in-flight (sum in figure)

$$\vec{j}(\vec{Q}) = 4\pi \sum_{\lambda\mu} (-i)^{\lambda} \left(L_{\lambda\mu}(Q)\vec{Y}^{*}_{\lambda\mu}(\hat{Q}) + T^{\mathrm{el}}_{\lambda\mu}(Q)\vec{\Psi}^{*}_{\lambda\mu}(\hat{Q}) + T^{\mathrm{mag}}_{\lambda\mu}(Q)\vec{\Phi}^{*}_{\lambda\mu}(\hat{Q}) \right)$$

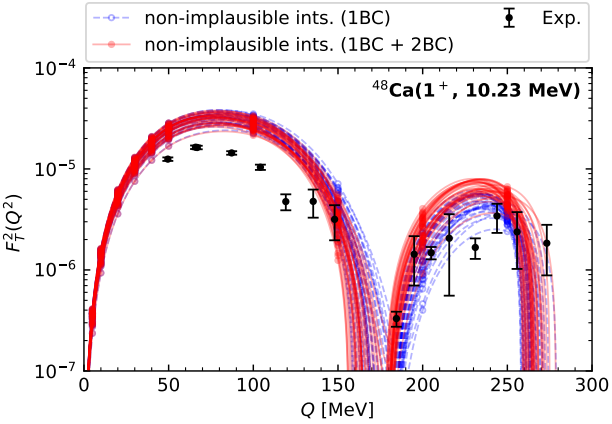
multipole decomposed & Monte-Carlo integral results: agreement for all matrix elements studied



Transition for factor – Comparison to (e, e') data

Steffen et al., Nucl. Phys. A404, 413 (1983)

- non-implausible interactions using VS-IMSRG with 1BC and with 1BC+2BC
  B. Hu et al., Nat. Phys. 18, 1196 (2022)
  Miyagi, Eur. Phys. J. A 59, 150 (2023)
  Stroberg, https://github.com/ragnarstroberg/imsrg.git
- small 2BC contribution
- similar to $B(M1)$
- $Q \to 0$ limit consistent with $B(M1)$



Correlations

Acharya et al., arXiv:2311.11438 [nucl-th] (2023), https://www.nndc.bnl.gov/nudat3/
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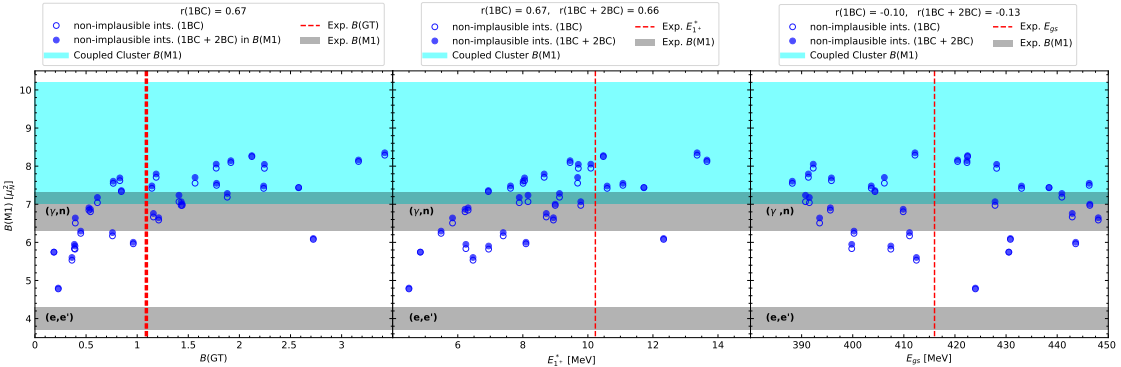

non-implausible interactions favor $B(M1)$ from $(\gamma, \mathbf{n})$ exp. and
show partial overlap with Coupled Cluster calculation

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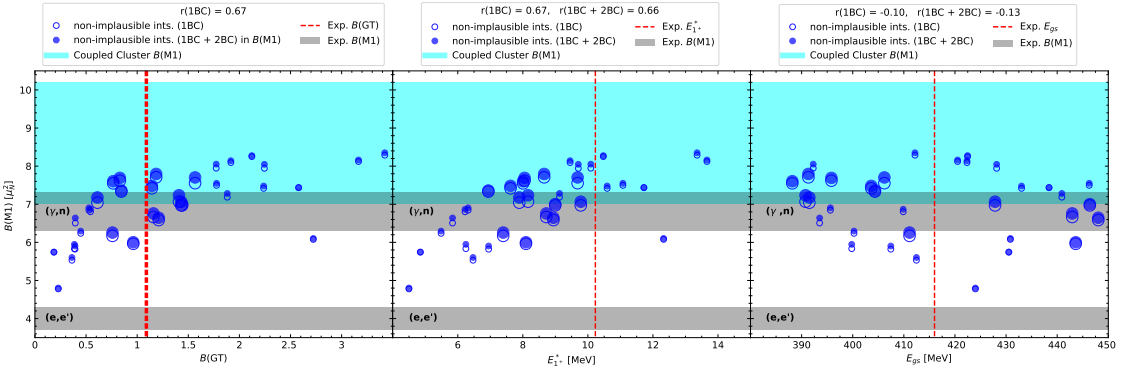

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I want to thank my collaborators, Takayuki, Javier and Achim.

Thank you for your attention and check out my poster