Correlated Random-Phase Approximation from Coupled Cluster and In-Medium SRG

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Random-Phase Approximation (RPA)

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- Motivation:
  - Description of ground states in medium-mass nuclei well established (CC, IM-SRG, SCGF, …)
  - Different class of observables: Collective excitations

Random-Phase Approximation (RPA)

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- Motivation:
  - Description of ground states in medium-mass nuclei well established (CC, IM-SRG, SCGF, …)
  - Different class of observables: Collective excitations
- RPA:
  - Investigation of excited states and their transitions
  - Use same chiral interactions as in CC, …
  - Improvement through extensions (Second RPA)

RPA

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- Excitation Operator: (p: unocc., h: occ.)

$$\hat{Q}^{\dagger}_{\omega} = \underbrace{\sum_{p,h} \left(X^{\omega}_{ph} \hat{a}^{\dagger}_{p} \hat{a}_{h} - Y^{\omega}_{ph} \hat{a}^{\dagger}_{h} \hat{a}_{p} \right)}_{\text{1p1h}}$$

RPA

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Standard RPA

RPA

- Excitation Operator: (p: unocc., h: occ.)

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Second RPA (SRPA)

Correlations: Via Densities

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- Use density-matrices for evaluation of expectation values:

  Substitute all $\langle \mathrm{HF} | \ldots | \mathrm{HF} \rangle$ with $\langle \Psi | \ldots | \Psi \rangle$

- Current application: Coupled Cluster ⇨ CC-RPA

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- Current application: Coupled Cluster ⇨ CC-RPA

- Derivation of entirely new formalism
- Flexibility: Density matrices from arbitrary many-body methods

Correlations: Via Matrix-Elements

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- Use IM-SRG matrix elements: IM-RPA
- Vanishing of all $v_{pp',hh'}$ matrix elements

  ⇨ Implicit reduction of (S)RPA to (S)TDA

Correlations: Via Matrix-Elements

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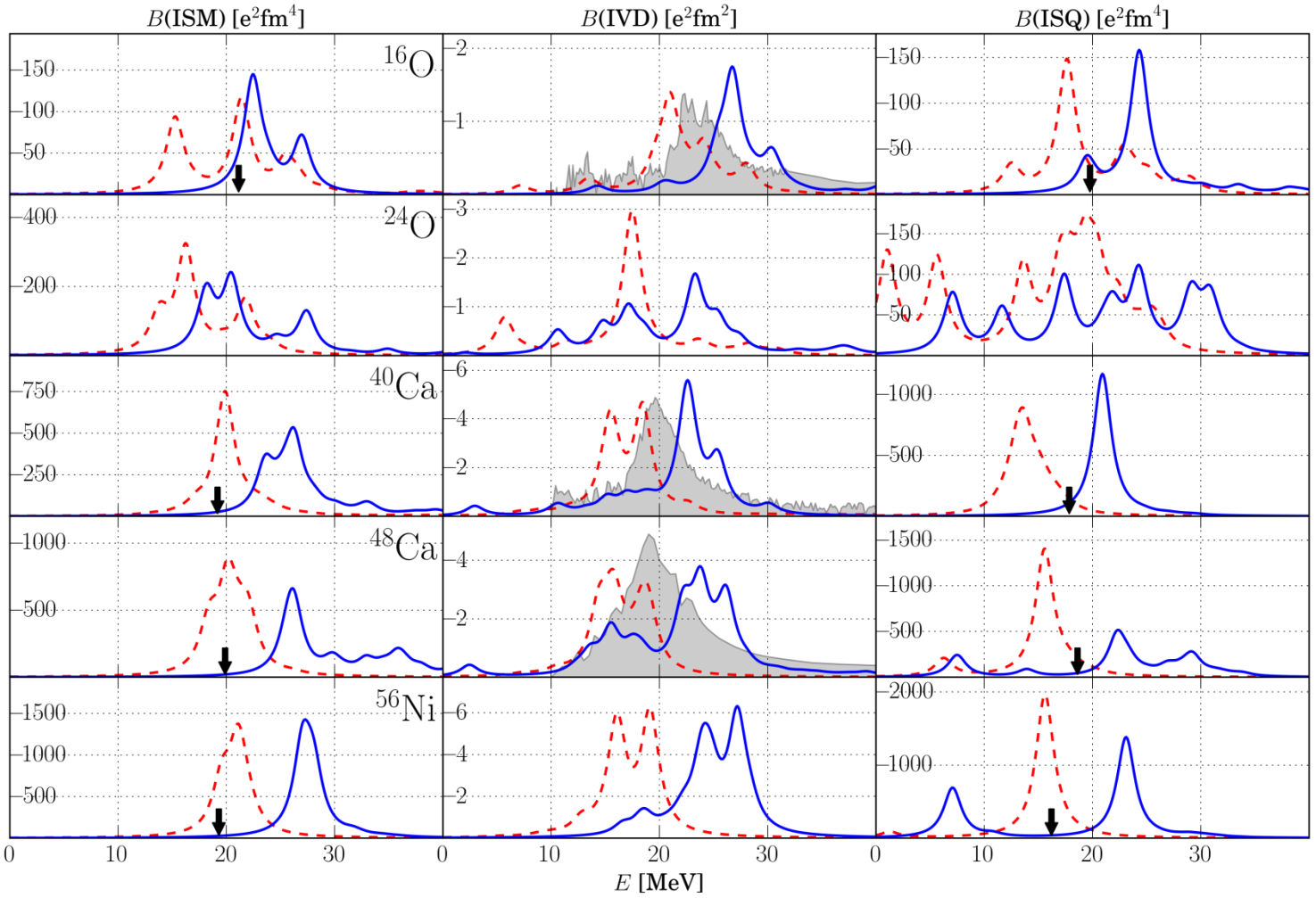
- Use IM-SRG matrix elements: IM-RPA
- Vanishing of all $v_{pp',hh'}$ matrix elements

  ⇨ Implicit reduction of (S)RPA to (S)TDA

- Almost same formalism as HF-(S)RPA
- No unstable (low-lying) solutions in SRPA

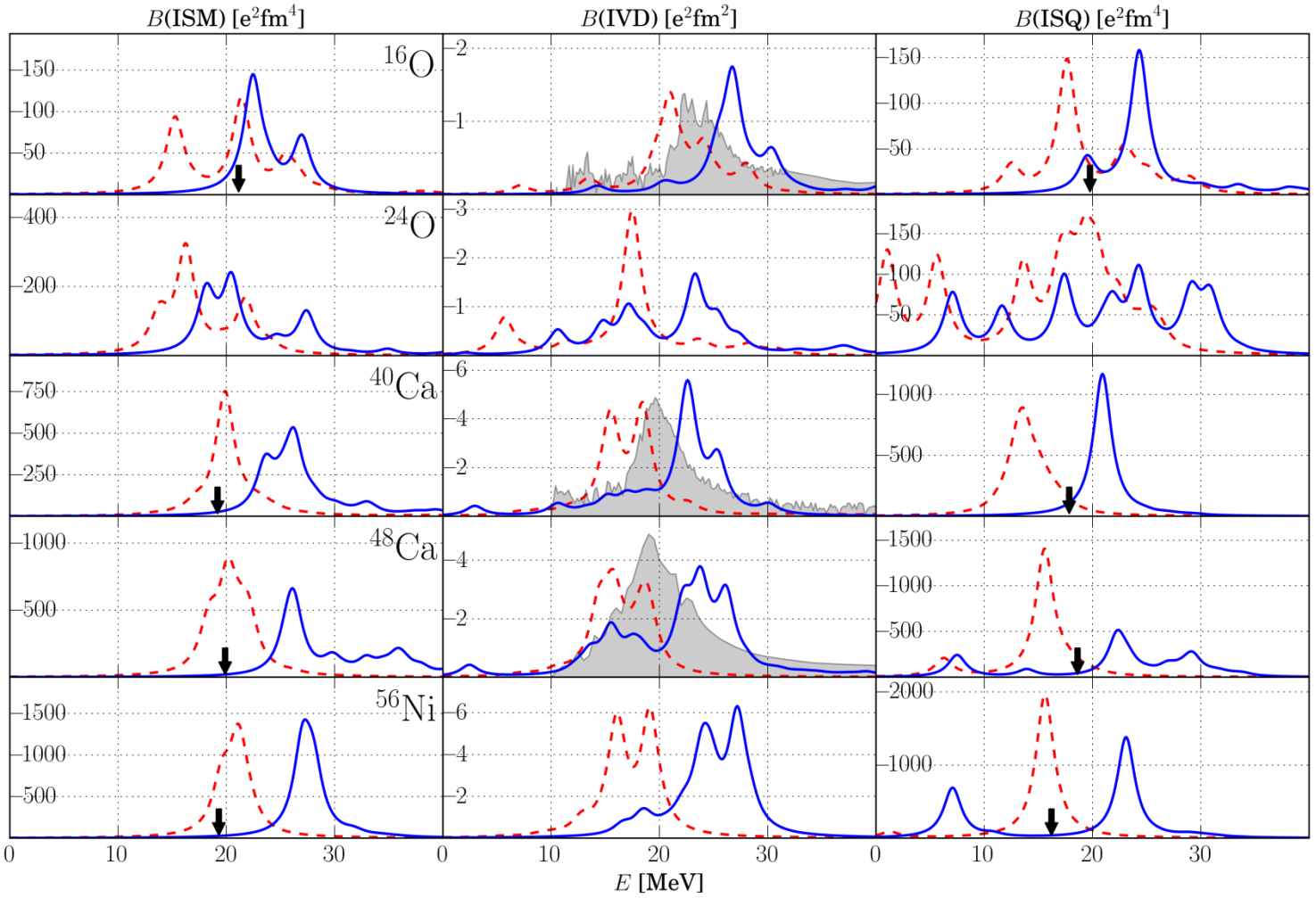
Results – N2LO-SAT



HF-SRPA

IM-SRPA

Results – N2LO-SAT



HF-SRPA

IM-SRPA

Structure similar

Shift to higher energies