The In-Medium Similarity Renormalization Group:
Versatile Computational Many-Body Theory

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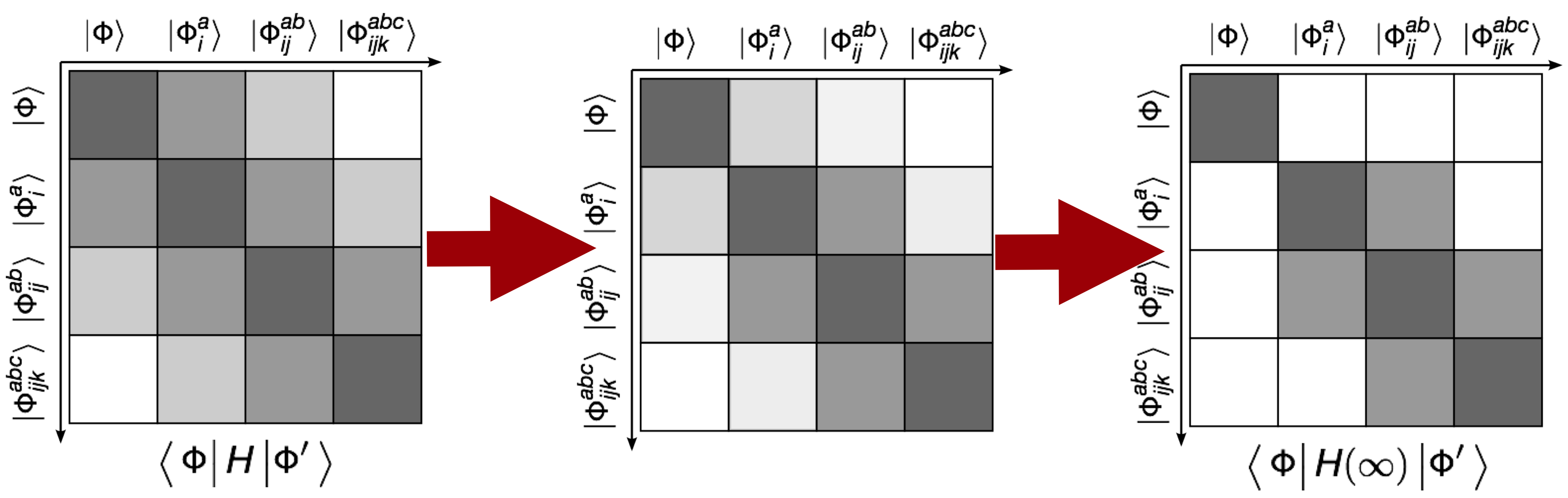
IMSRG in a Nutshell

We **solve** or **pre-process** the many-body problem by performing a **continuous unitary transformation** of the Hamiltonian (and other operators), without constructing exponentially large matrix representations. In practice, we implement the **operator flow equation**

$$\frac{d}{ds}H(s) = [\eta(s), H(s)] \qquad \eta(s) \equiv [H_d(s), H_{od}(s)]$$

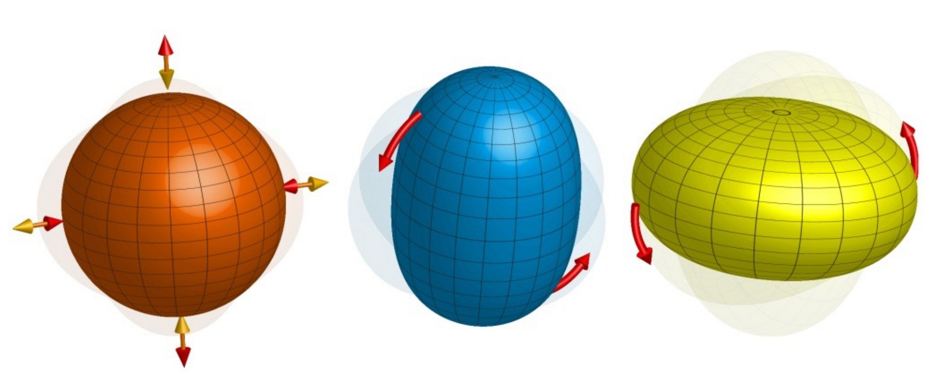
The **dynamical generator** $\boldsymbol{\eta(s)}$ is constructed from suitably defined "diagonal" (retained as $s \to \infty$) and "off-diagonal" parts (suppressed as $s \to \infty$) of the Hamiltonian.

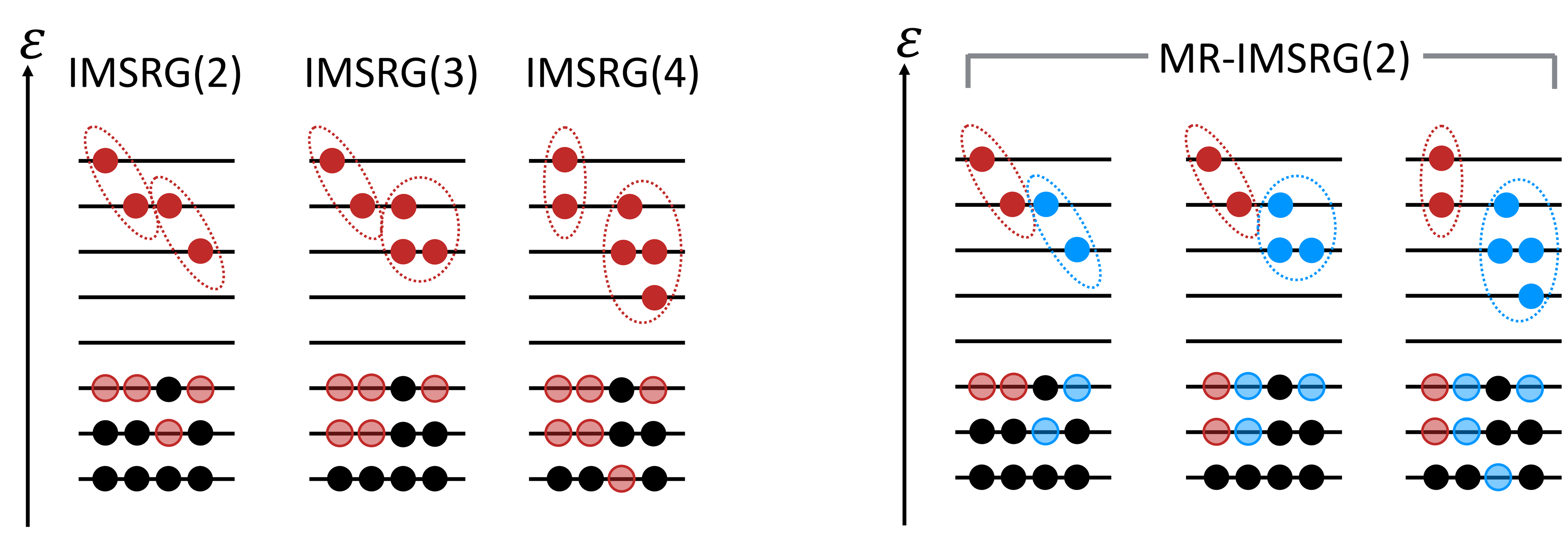


Correlations in Nuclei & Operator Selection

Dynamic correlations: A few nucleons can get excited to high energy.

Static correlations: Excitation energy is spread among many nucleons, e.g., collective excitations due to intrinsic deformation.





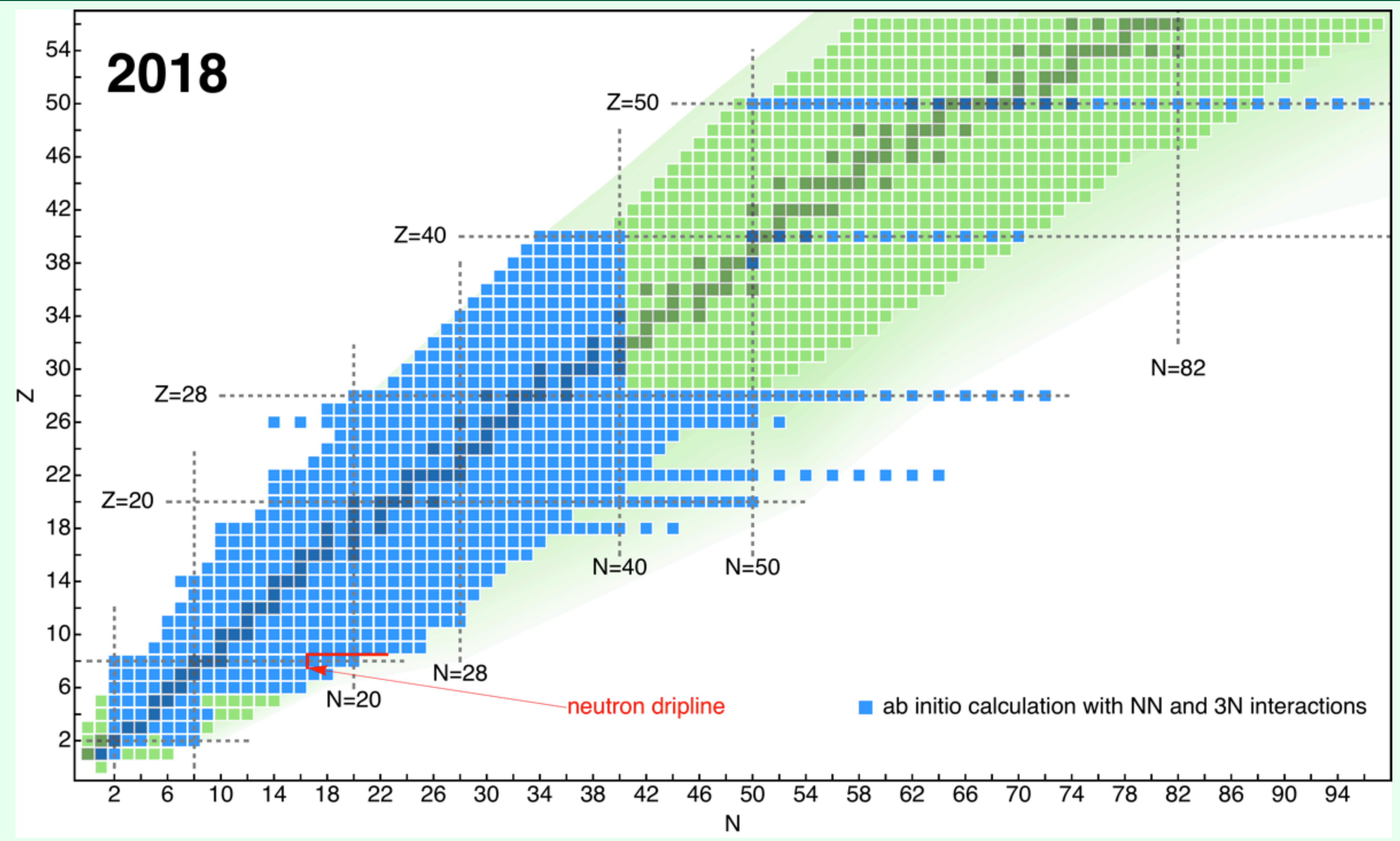
Uncorrelated basis operators **Correlated basis operators**

By choosing appropriate basis operators (e.g., to incorporate physics of deformed nuclei) we obtain efficient and robust implementations of the IMSRG flow.

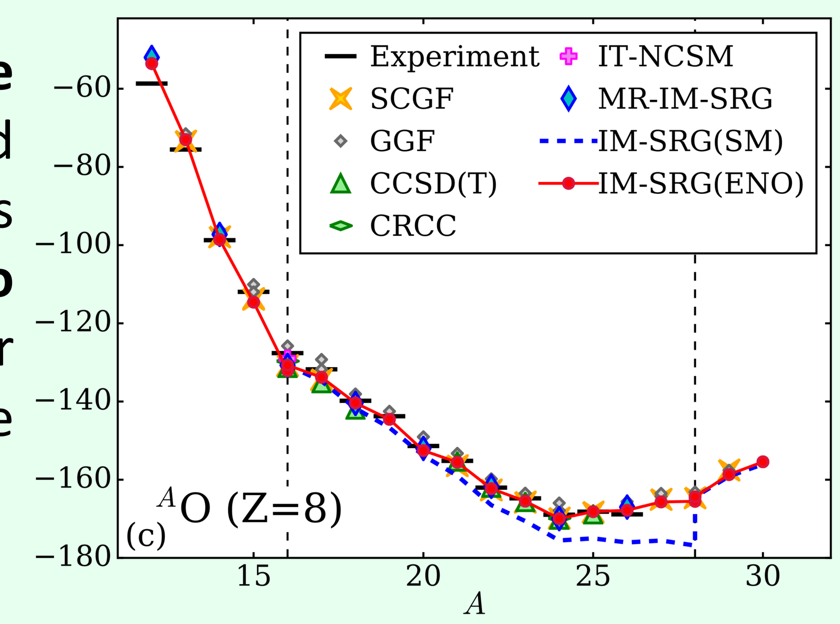
IMSRG-Enhanced Many-Body Methods

IMSRG treats **dynamic** correlations, **complementary many-body method** ((No-Core or Active Space Configuration Interaction, Generator Coordinate Method, …) the **static** correlations.

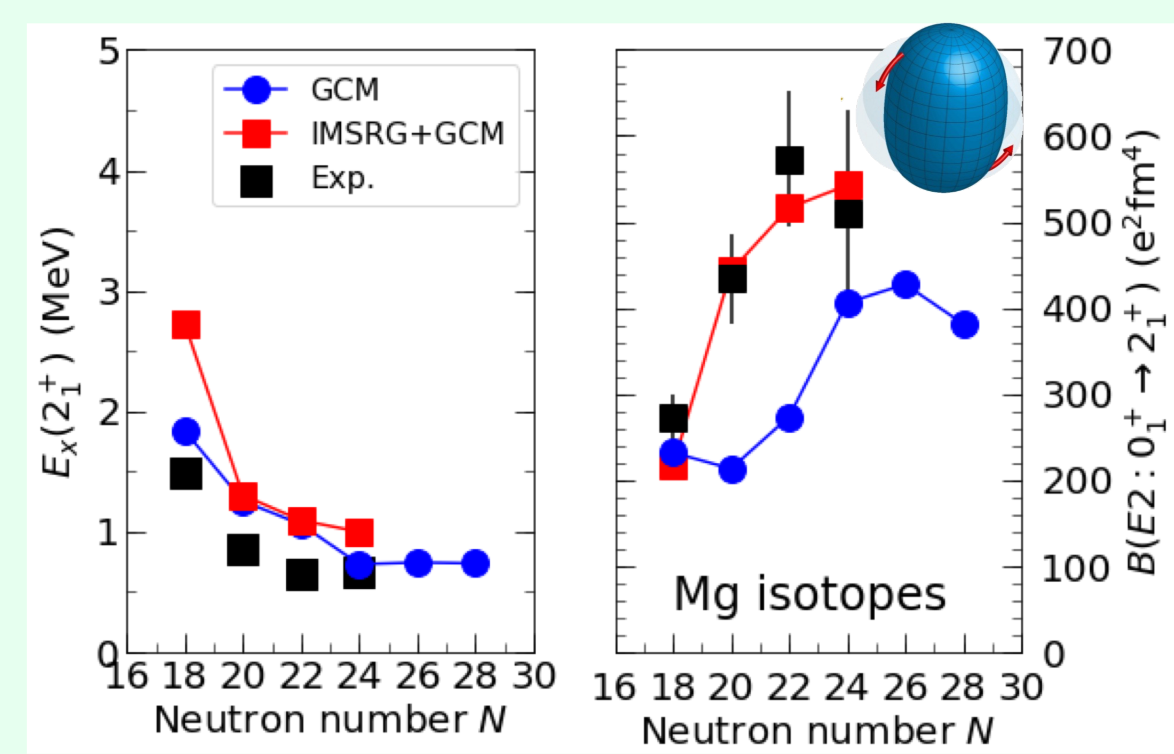
I. Reach of *Ab Initio* Methods



Starting from the **same Hamiltonian**, IMSRG and other many-body methods yield **consistent ab initio results** across the nuclear chart – e.g. for ground-state energies of oxygen isotopes [PRL 118, 032502].

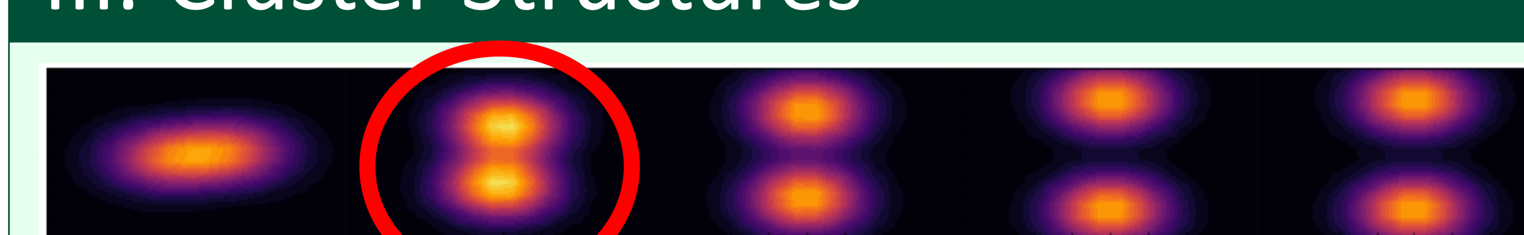


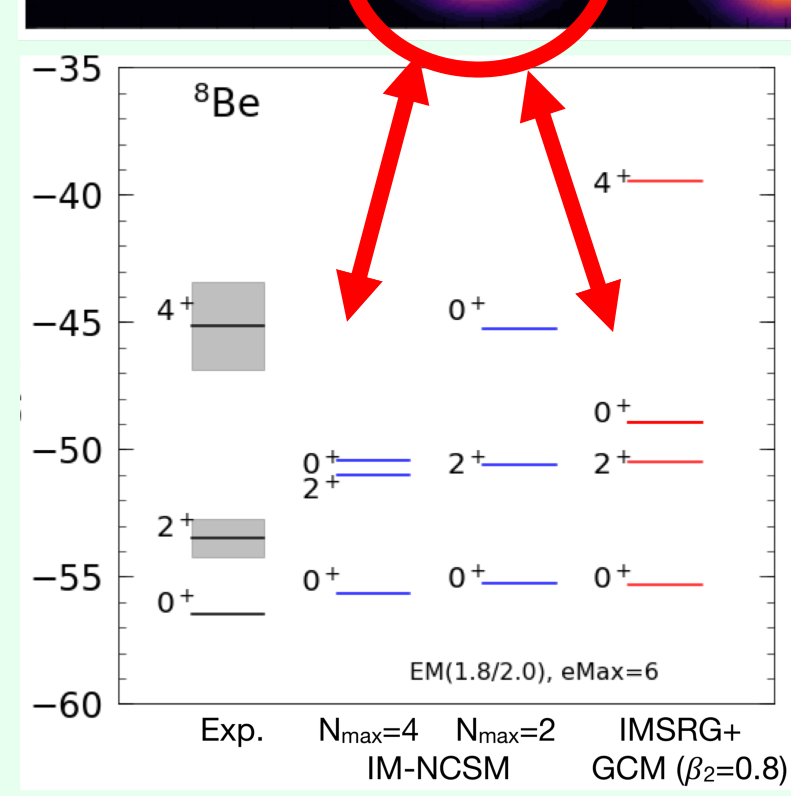
II. Axially Deformed Nuclei



The **IMSRG+GCM** successfully captures **dynamic** (through IMSRG) and **static correlation** (through GCM) in deformed nuclei like the magnesium isotopes, enabling improved simultaneous description of excitations and transition rates.

III. Cluster Structures





With **IMSRG-enhanced methods**, we can tackle complex nuclear structure features like clustering.

IMSRG+GCM and IM-NCSM – which use very different expansion schemes - draw a **consistent picture** of cluster structures in nuclei like ^{8}Be.

H. Hergert et al., Phys. Rept. **621**, 165
H. Hergert, Phys. Scripta **92**, 023007
S. R. Stroberg et al., arXiv: 1902.06154
J. M. Yao et al., PRC **98**, 054311

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