



# Towards Precision Calculations of Hypernuclei

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Progress in Ab Initio Nuclear Theory, TRIUMF, 2023

# Hypernuclei in Ab Initio Calculations

YN @ LO

YN @ NLO

YN @ N<sup>2</sup>LO

SRG  
—————  
induced YNN

J-NCSM

(IT-)NCSM

NLEFT  
NSHH  
AFDMC  
GEM  
FY  
⋮

many-body  
uncertainty

interaction  
uncertainty

# Hyperon-Nucleon Interaction

YN @ LO

5 LECs

*Polinder et. al. 2006*

- 36 YN scattering data for S-waves
- practically no data for P-waves
- ${}^3_{\Lambda}\text{H}$  as additional constraint

YN @ NLO

23 (10) LECs

*Haidenbauer et. al. 2019*

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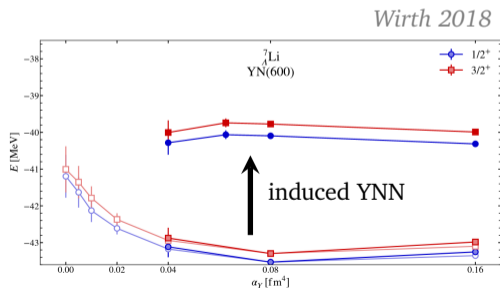
*Haidenbauer et. al. 2023*

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**higher orders are  
poorly constrained!**

SRG  
—  
induced YNN

- speed up convergence of many-body method
- inclusion of induced YNN forces



# Many-Body Method

- matrix eigenvalue problem

$$\sum_j \langle \Phi_i | H | \Phi_j \rangle \langle \Phi_j | \Psi_n \rangle = E_n \langle \Phi_i | \Psi_n \rangle \quad \forall i$$

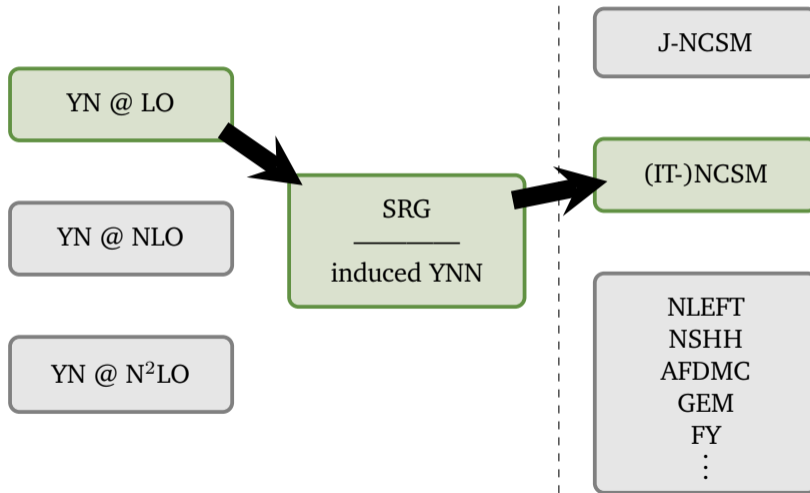
- include strangeness  $S$  in single-particle basis

$$|n(ls)jm_j, S t m_t\rangle$$

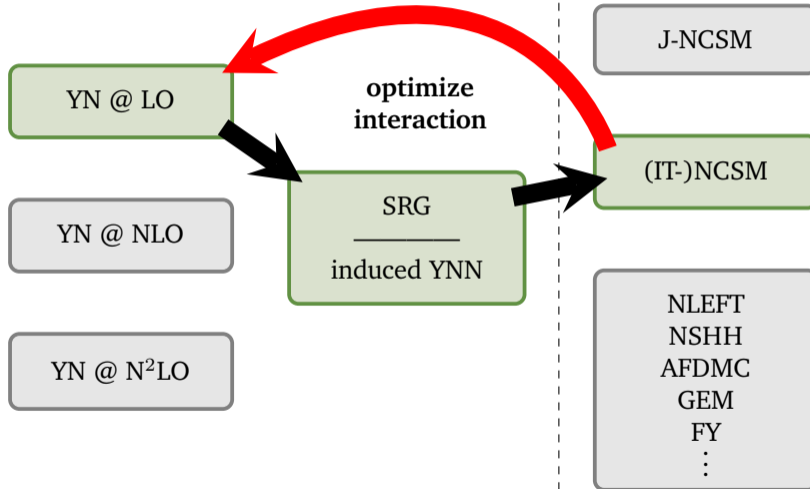
- constituents:  $n, p, \Lambda, \Sigma^-, \Sigma^0, \Sigma^+$

(IT-)NCSM

# Hypernuclei in Ab Initio Calculations



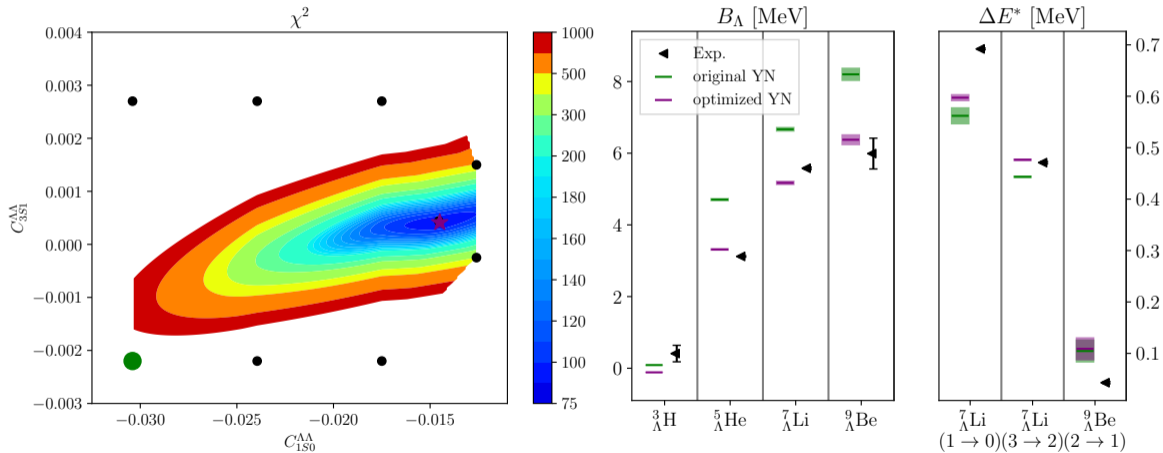
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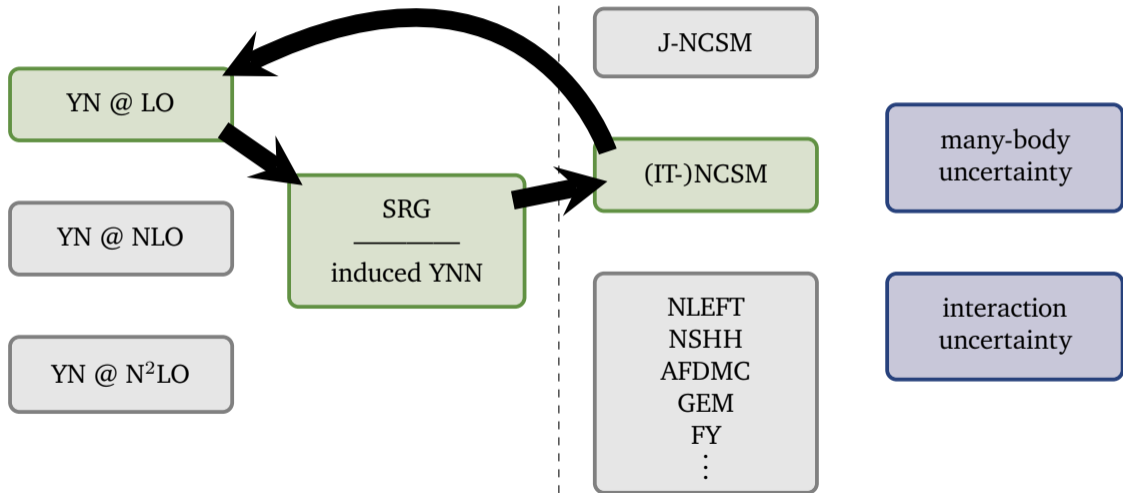
- use hypernuclear structure observables as additional constraints



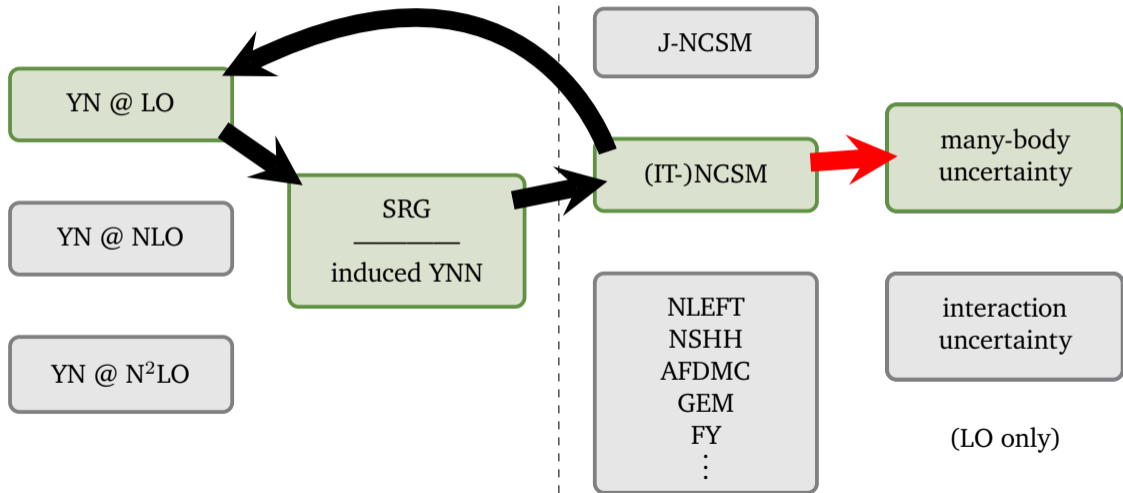
# Optimization Results



# Hypernuclei in Ab Initio Calculations

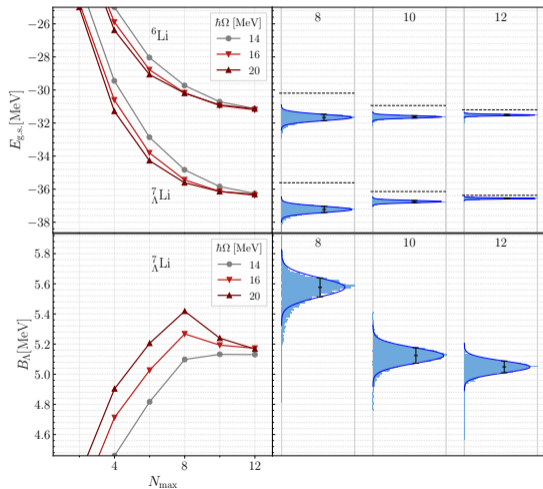


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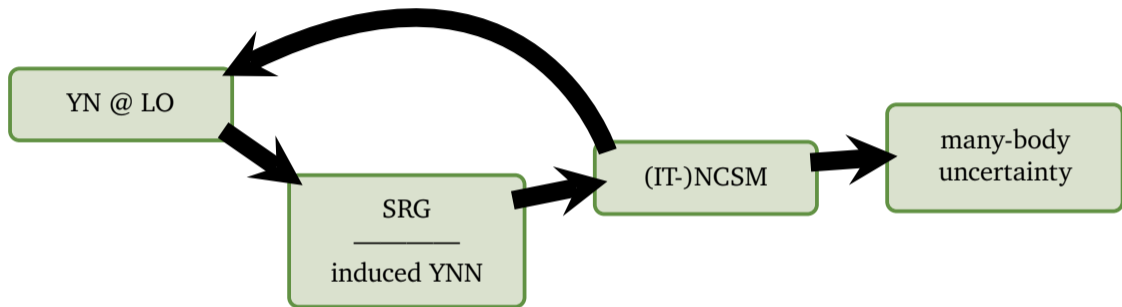


# Many-Body Uncertainty – Neural Networks

- machine learning tool provides prediction of converged energy with uncertainty
- convergence behavior of  $B_\Lambda$  is not constrained
- predict ground-state energies for hypernucleus and mother nucleus separately and subtract pointwise



## Hypernuclei in Ab Initio Calculations



- full pipeline for precise structure calculations of light hypernuclei
- significant improvement of the description of hyperon separation energies  $B_\Lambda$

