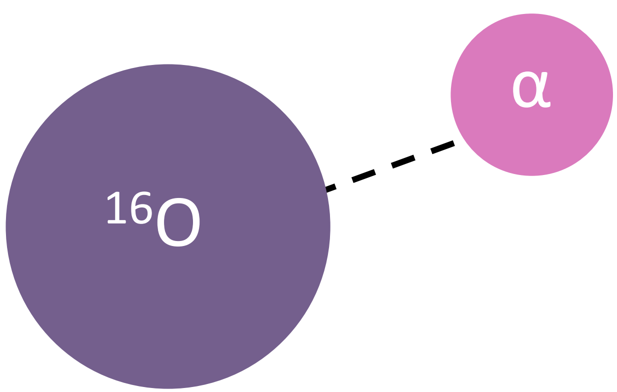
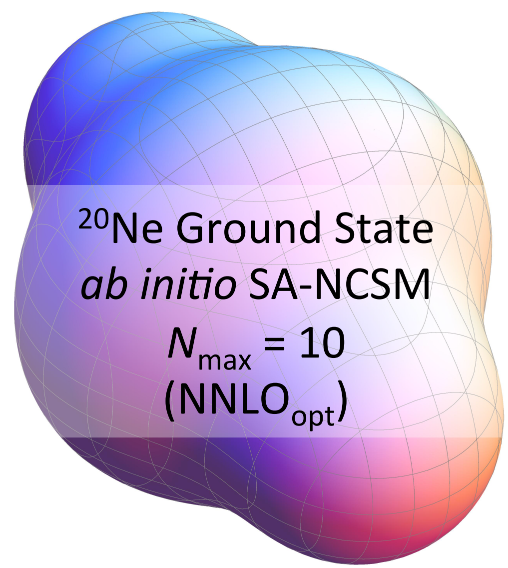
Better Living Through Symmetry:

Probing alpha-clustering in ^{20}Ne

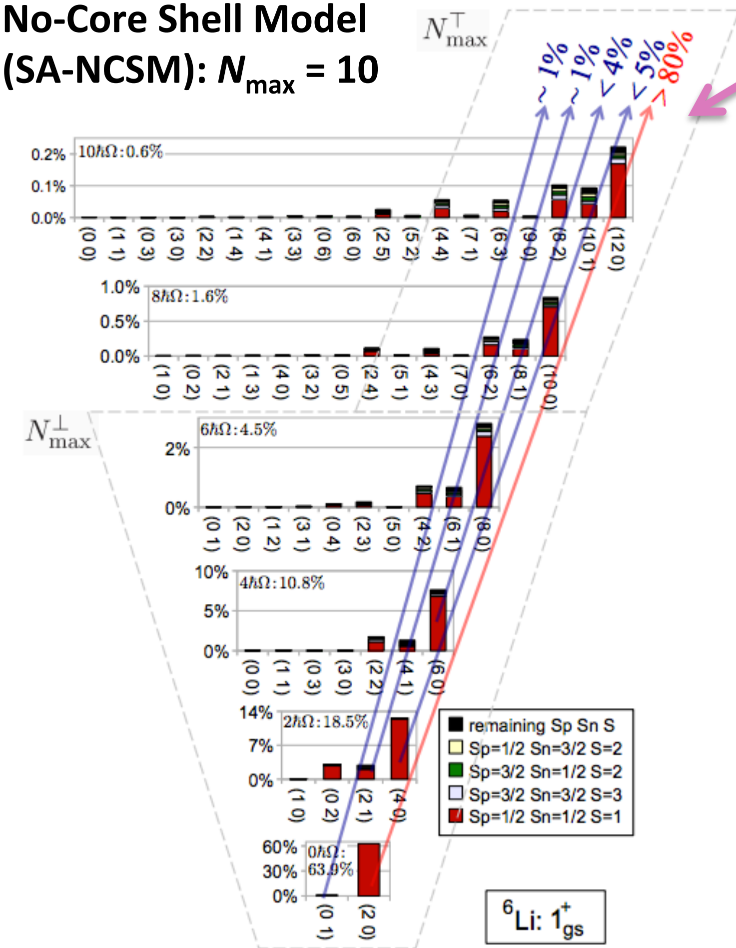
A. Dreyfuss
Department of Physics and Astronomy
Louisiana State University
Baton Rouge, LA





Why Symplectic?

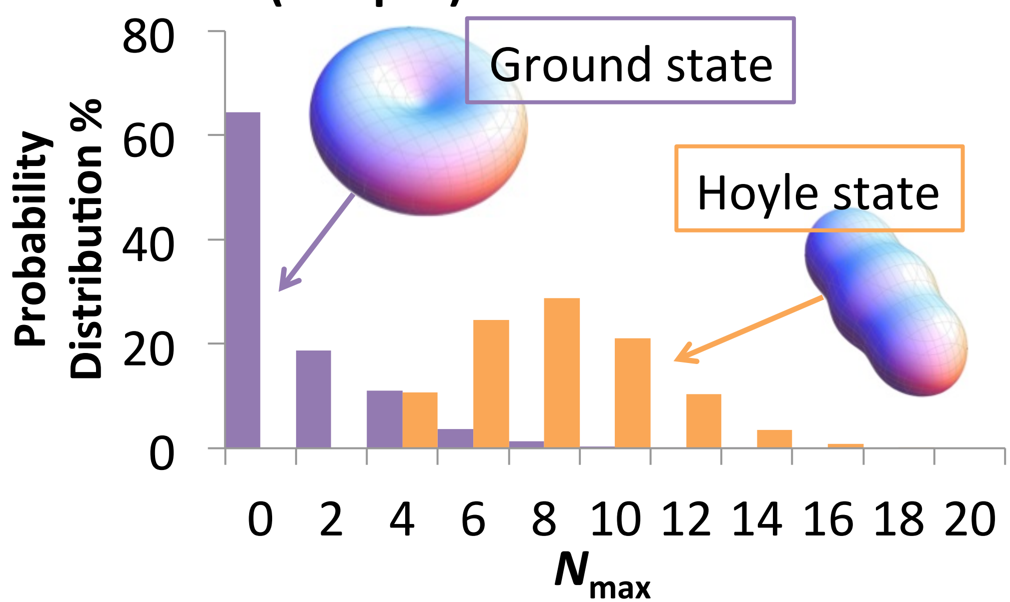
***Ab initio* Symmetry-Adapted No-Core Shell Model (SA-NCSM): N_{max} = 10**



Symplectic symmetry emerges from *ab initio* studies

Symplectic symmetry exposes cluster formation – e.g., in the Hoyle state of ^{12}C

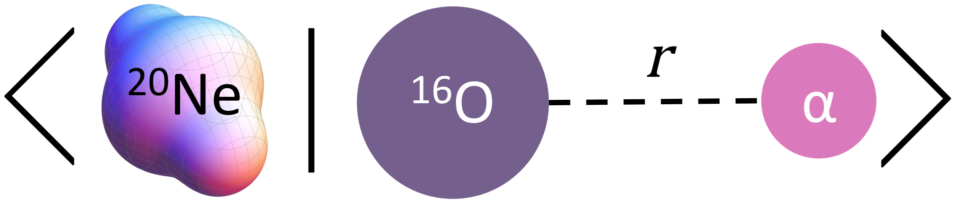
No-Core Symplectic Shell Model (NCSpM): ^{12}C



T. Dytrych, *et. al.* , Phys. Rev. Lett. 111, 252501 (2013).

Method

$$u_l(r) = \langle \psi_{^{20}\mathrm{Ne}} \mid \mathcal{A}\left\{A_c \times \alpha_c\right\} \mathrm{Y}_{l0}(\hat{a}) \frac{\delta(r-a)}{ra} \rangle$$



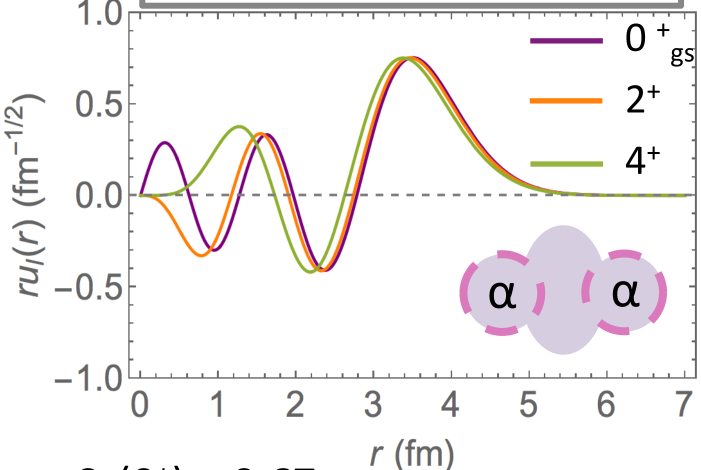
^{20}Ne eigenstates in symplectic basis: $|\psi_{^{20}\mathrm{Ne}}\rangle = \sum_Q c_Q |Q[\gamma(\lambda\mu)]\rangle$

Expand δ-function in orthonormal harmonic oscillator basis

$$u_l(r) = \sum_Q \binom{A}{A-a}^{1/2} R_{Q,l}(r)\ c_Q \langle Q[\gamma(\lambda\mu)] \mid \{\{(\lambda_c\mu_c) \times (0\ 0)\}^{(\lambda_c\mu_c)} \times (Q\ 0)\}_l^{(\lambda\mu)} \rangle$$

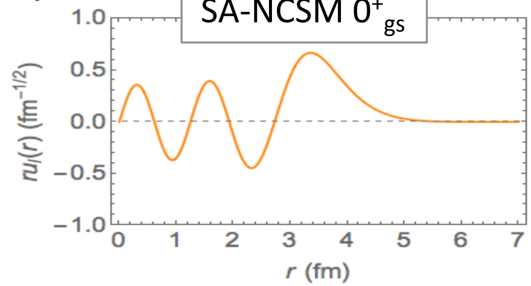
Spectroscopic Amplitudes and Factors

NCSpM: ground state rotational band

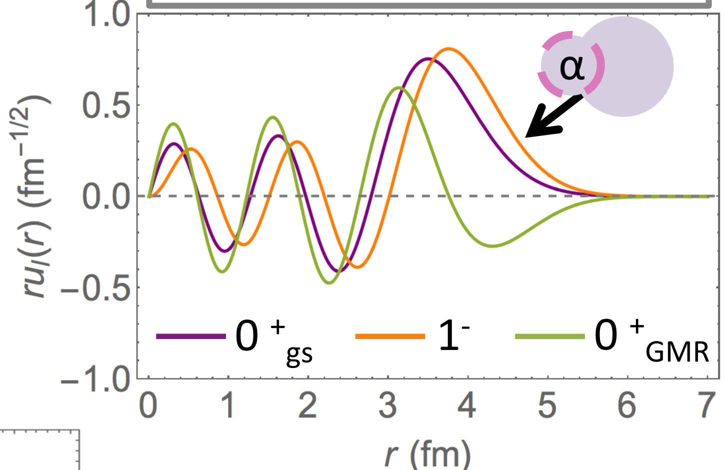


$S_\alpha(0^+) = 0.67$
$S_\alpha(2^+) = 0.67$
$S_\alpha(4^+) = 0.68$

ab initio SA-NCSM 0^+_{gs}



1^-, giant monopole resonance (GMR)



$S_\alpha(0^+_{GMR}) = 0.49$
$S_\alpha(1^+) = 0.74$

First steps toward combining *ab initio* SA-NCSM [SU(3) and Symplectic bases] with cluster RGM [Resonating Group Method] to describe both bound states and continuum

Thank You

References:

[1] D. Sääf and C. Forssén, *Phys. Rev. C* 89 (2014) 011303

[2] Y. Suzuki, *Nucl. Phys. A* 448 (1986) 395

[3] Y. Kanada En'yo, *Prog. Theor. Exp. Phys.* (2014) 103D03

[4] Y. Kanada En'yo, arXiv:1511.03862

Computing α-decay Widths

Spectroscopic Amplitude

$$\Gamma_L = 2P_L\gamma_L^2 \propto P_L S_\alpha$$

Penetrability for α