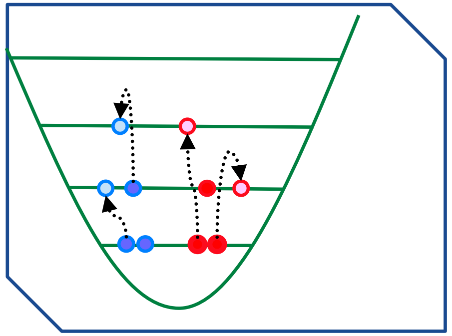
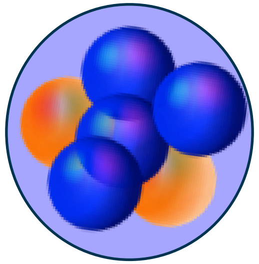
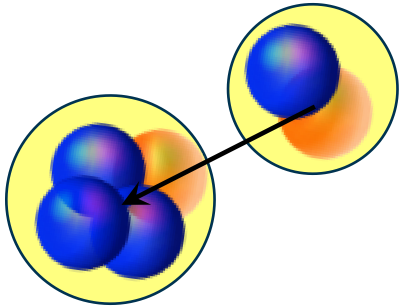
Guillaume Hupin, CNRS IJClab

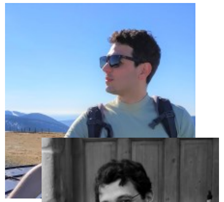


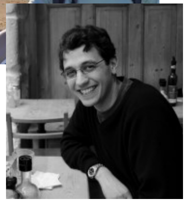


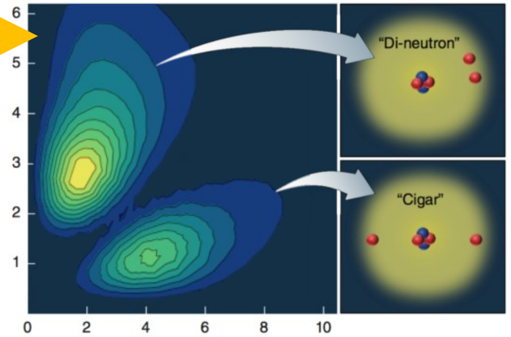
My expertise

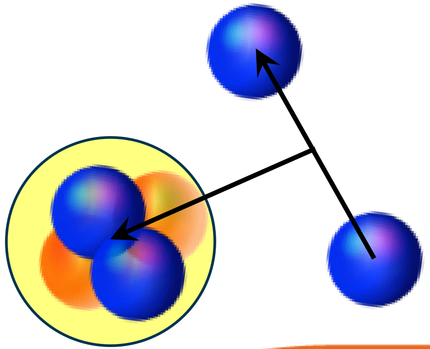


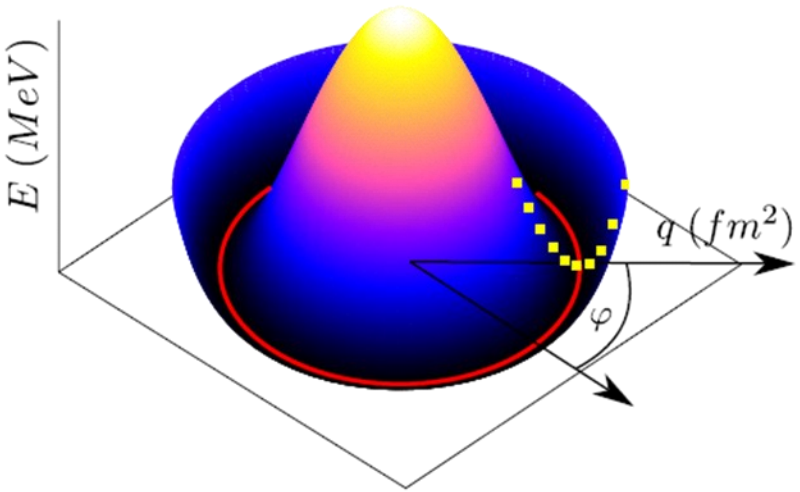
- Degree in engineering and physics (condensed matter&radiation)
- My Phd in nuclear theory at GANIL, CAen
- 1st postdoc at LLNL with S. Quaglioni in ab initio reaction
- 2nd Postdoc at CEA on nuclear structure
- Gantt chart discovery
- PhD students

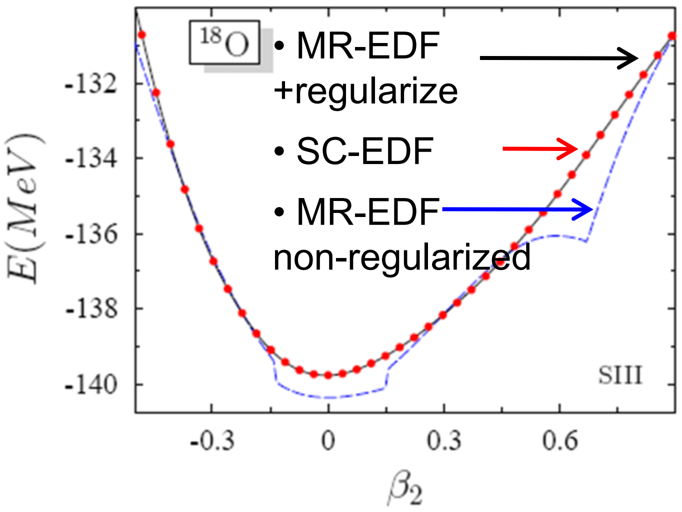


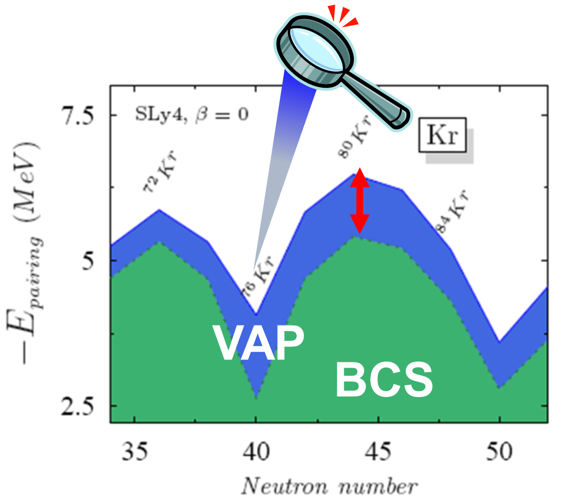


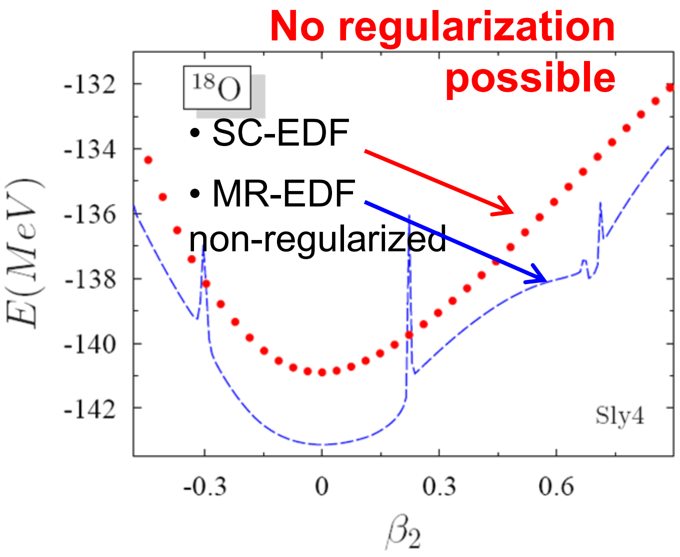


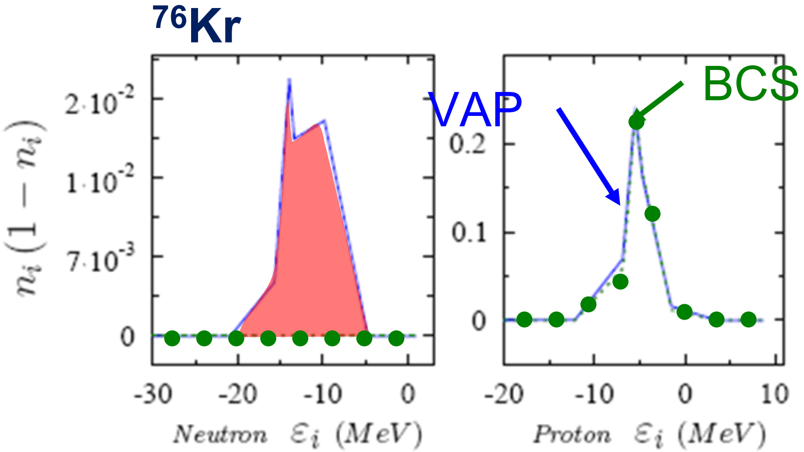




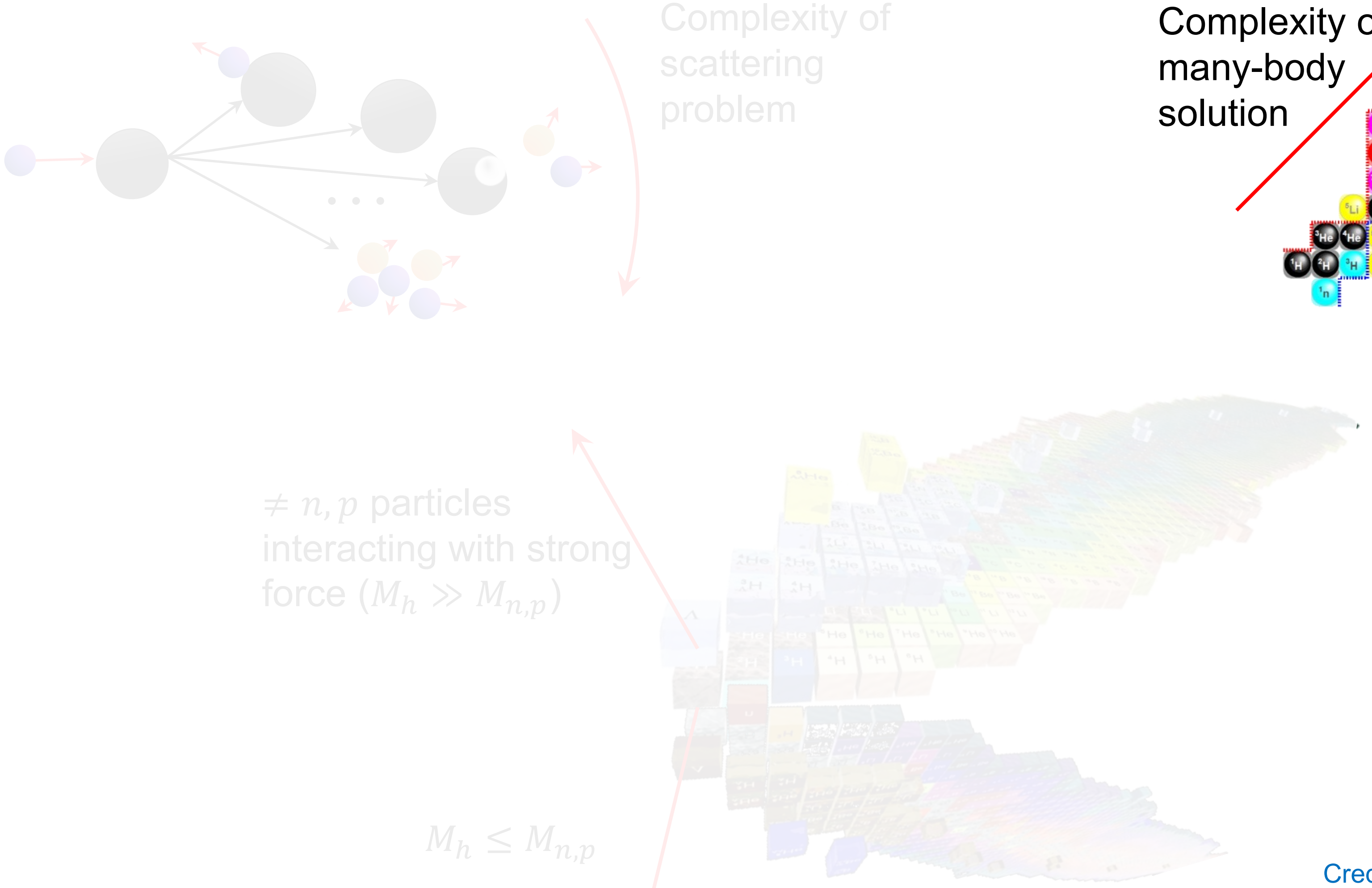


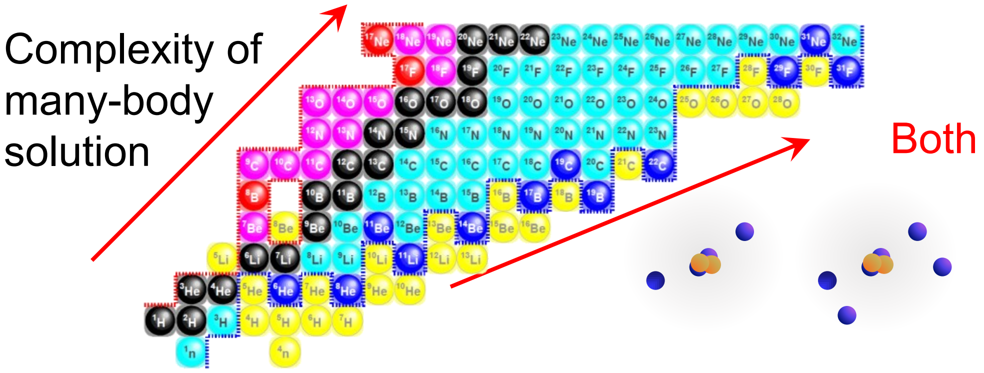






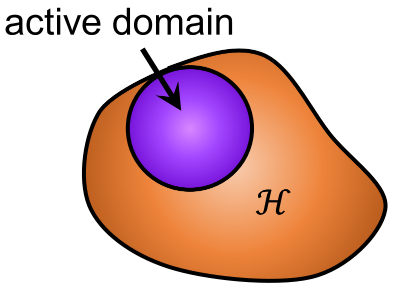
- I was already able to plot a Mexican hat ! (not in python🤔)
- Most of these acronyms do not exist anymore…
- So many nucleons at that time !



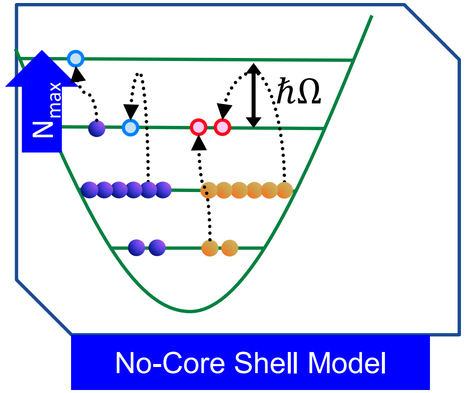


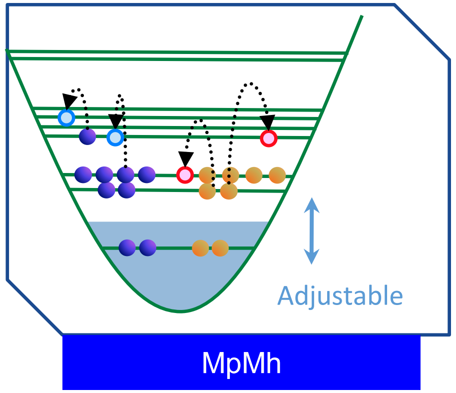
- 😐 Nuclear theory is **data driven**.
- ☹ The lack of accuracy of *ab initio* structure methods impedes the development of reactions modeling.

Credits H. Lenske



- Variational;
- Orthonormal basis;
- Controllable parameters ($N_{\max}$, $E1_{\max}$ etc…);
- UV/IR convergence.

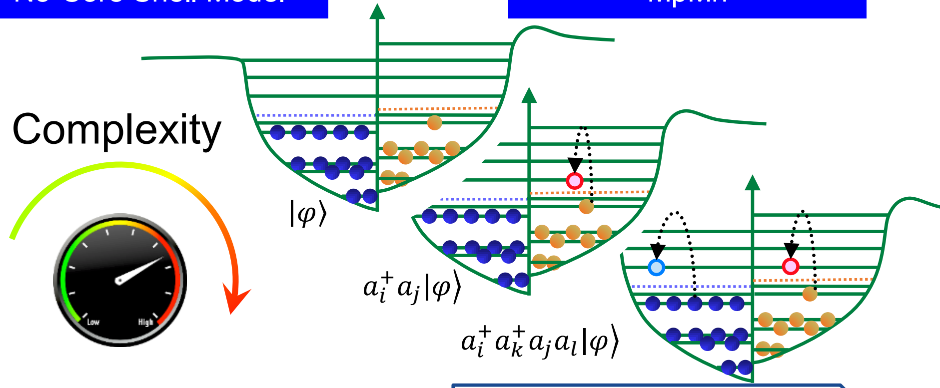




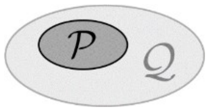
Superposition of Slater determinants:

$$|\Psi^A\rangle = \sum_{\alpha} c_\alpha \Phi_\alpha^{\varphi}(\vec{r}_1, \ldots, \vec{r}_A) = A_0 \left|\Phi_{0p0h}^{0}\right\rangle + \sum_{\alpha'} A_{\alpha'} \left|\Phi_{1p1h}^{\alpha'}\right\rangle + \cdots$$

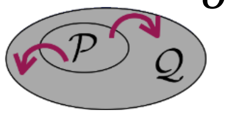
NCSM
IM-SH
MpMh



Optimization of mixing coefficients, one-body Hilbert space:



$$\delta\mathcal{E}[\Psi]_{/\{A_\alpha^*\}} = 0 \Longrightarrow \sum_{\beta} A_\beta \langle \Phi_\alpha | \hat{H} | \Phi_\beta \rangle = E A_\alpha$$



$$\delta\mathcal{E}[\Psi]_{/\{\varphi_\alpha^*\}} = \langle \Psi | [\hat{H}, \hat{T}] | \Psi \rangle = 0 \Longleftrightarrow [\hat{h}(\rho), \hat{\rho}] = \hat{G}(\sigma)$$

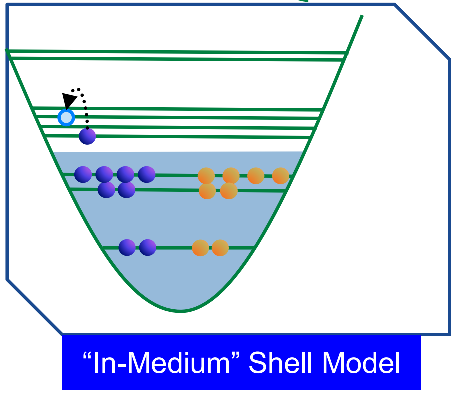
Generalized Brillouin (GB) equation

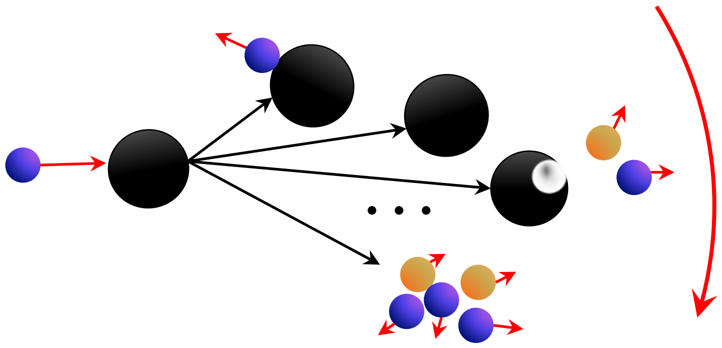
Collaborators

N. Pillet (CEA)
N. Smirnova (IP2IB)

Collaborator

P. Arthuis





Complexity of scattering problem

Complexity of many-body solution

$\neq n, p$ particles interacting with strong force ($M_h \gg M_{n,p}$)

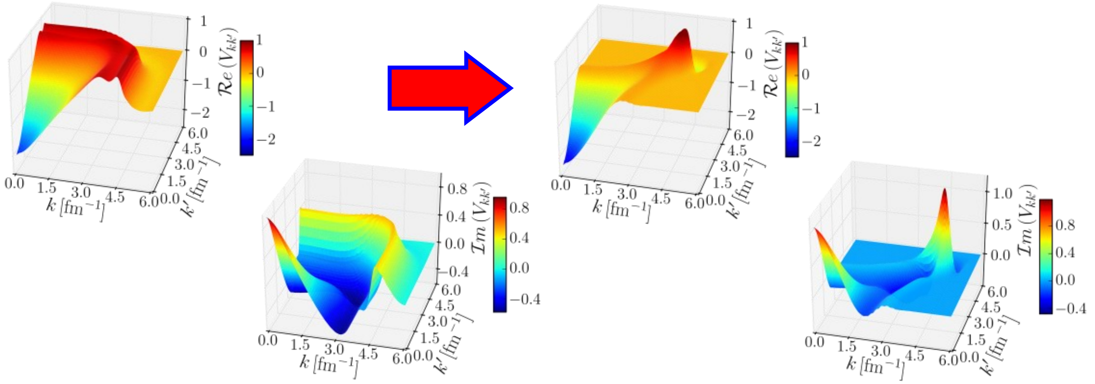
$M_h \leq M_{n,p}$

- 😐 Nuclear theory is **data driven**.
- ☹ Few-body techniques scale **very bad** with the number of constituents in the continuum.

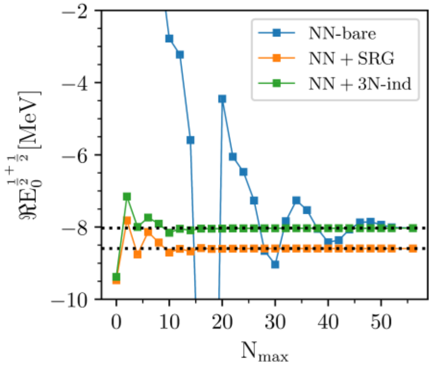
Credits H. Lenske

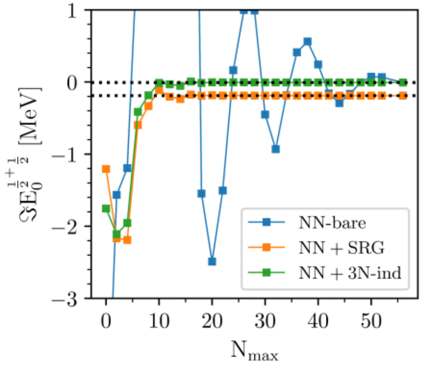
Collaborators

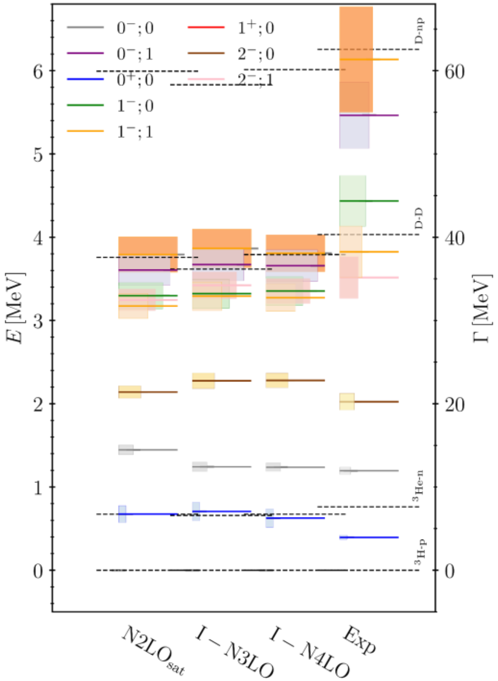
O. Yaghi (PhD)



- Game changer







Collaborators

R. Lazauskas (CNRS)
T. Frederico (ITA)
M. Gattobigio (UCA)
J. Carbonell (Gif)
ANR FCUBES

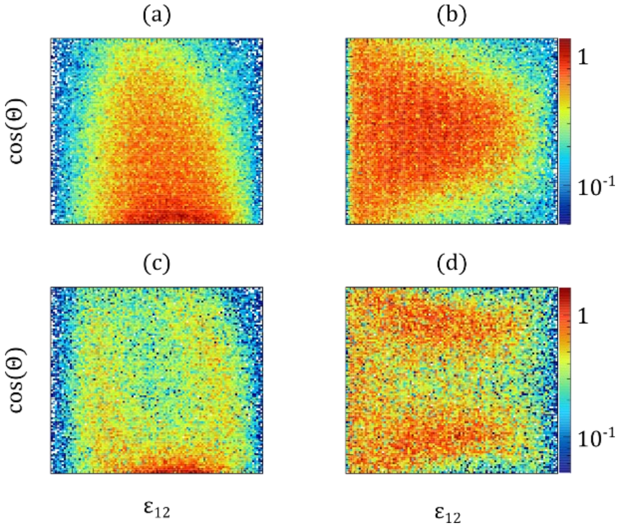
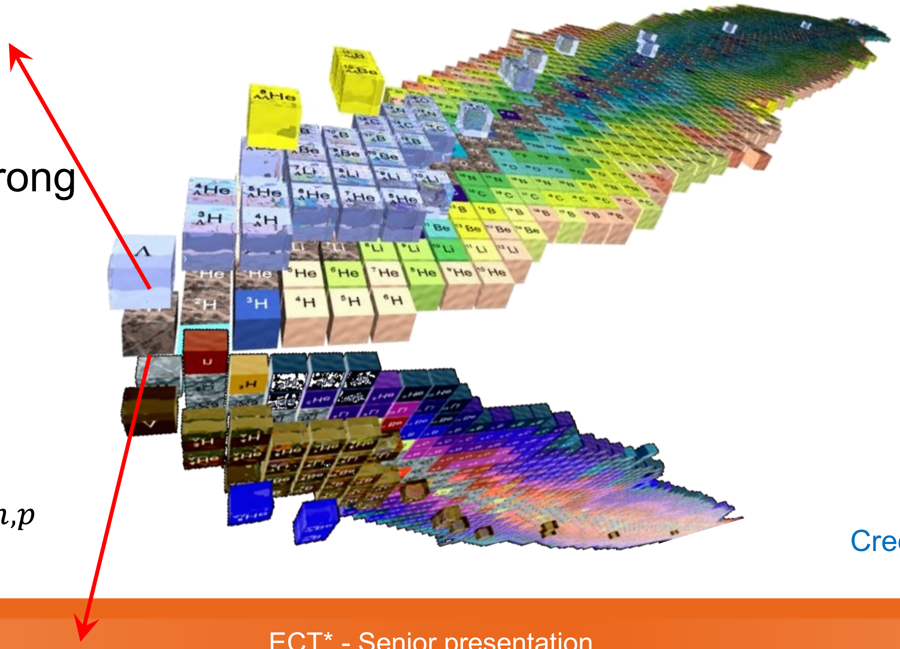


Figure 3: ^{6}He probability distribution as a function of cos (θ) vs ε_{12}. The distributions are plotted for the Jacobi coordinate Y and T, left and right respectively; (top) total kinetic energies between 1MeV and 3MeV, (bottom) from 3MeV to 6MeV.

$\neq n, p$ particles
interacting with strong
force $(M_h \gg M_{n,p})$



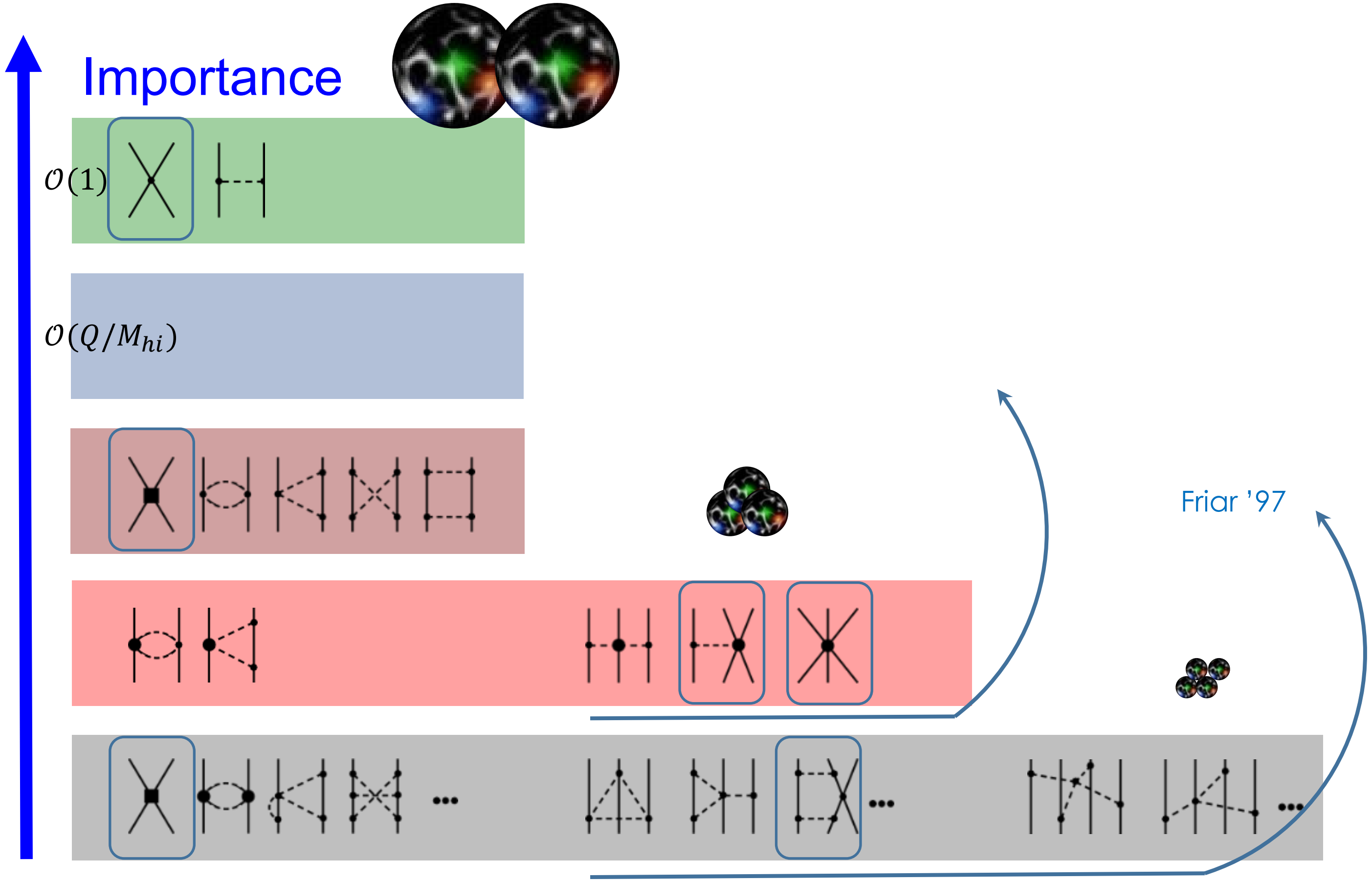
$M_h \leq M_{n,p}$

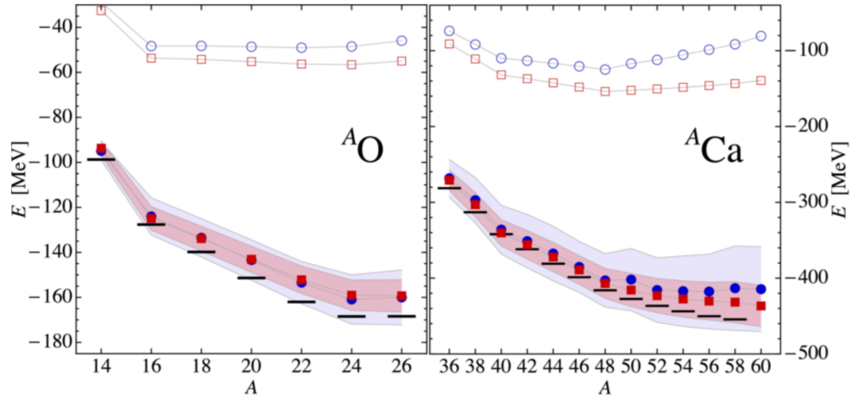
- 😐 Nuclear theory is **data driven**.
- ☹ Global optical models (NN or $N\bar{p}$ or $N\pi$ scattering) are not applicable to exotic systems.

Credits H. Lenske

Building block - Chiral EFTs

Weinberg '90'91'92 Ordóñez and vK '92 etc…

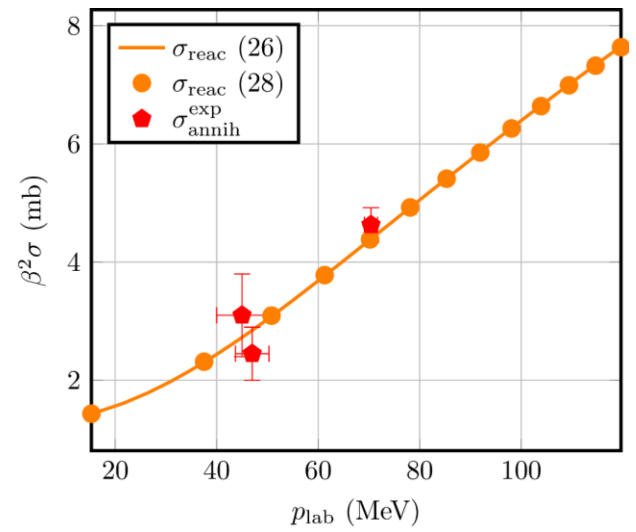




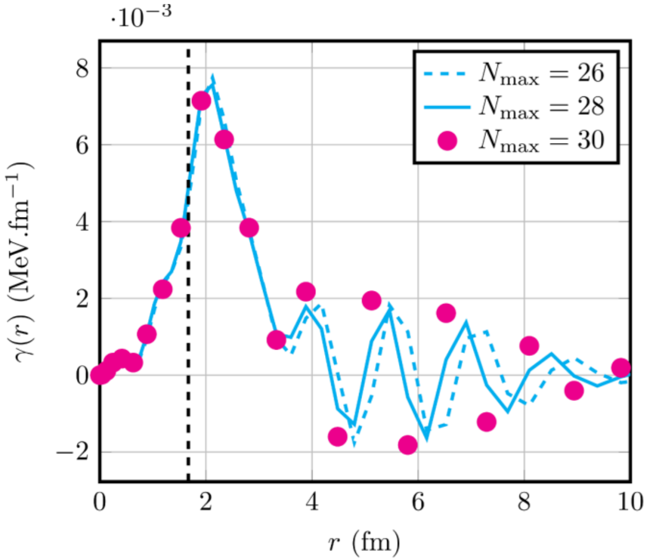
A. Tichai, *et. al.* Front. Phys. **8**, 164 (2020)

- ☺ **High quality** nuclear interactions (at N^{3}LO).
- 😐 **Various** fits and successes.
- ☹ Weinberg PC wrong: no **renormalizability**.
- ☺ Correct power counting: active research

1. Development of improved power counting ⟶ high-precision/high-orders.
2. Stability of p-shell nuclei.
3. How does chiral expansion perform under forthcoming LQCD data?



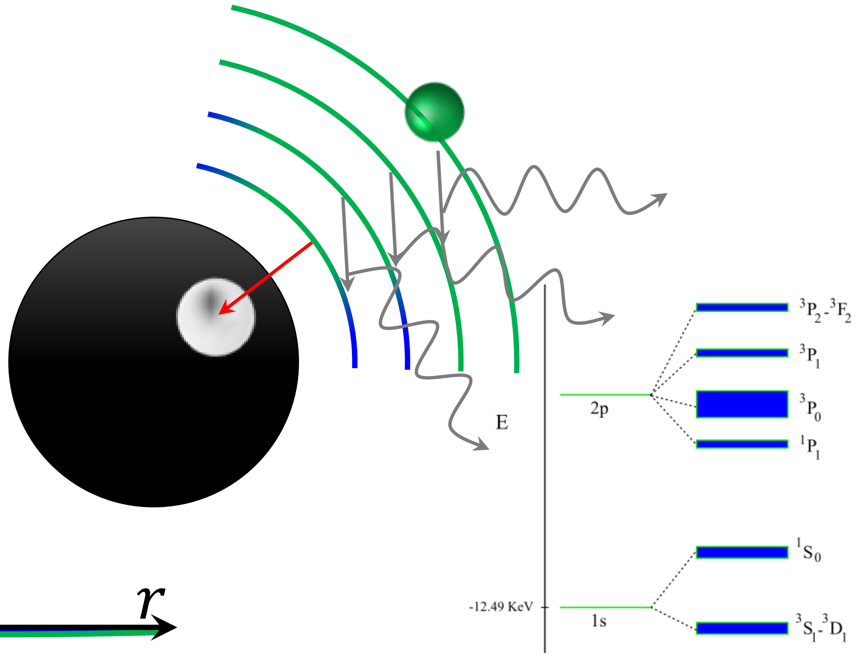
Annihilation cross-section of the $A = 4 + 1$ system N_{max}=28 compared to data.

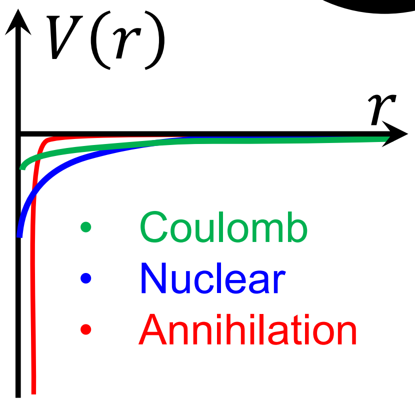


Annihilation density of the antiproton in the helium system.

Collaborators

A. Dehghani (PhD)
B. F. Wu (PD)

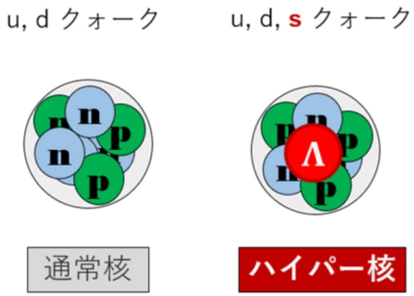




- We can do other “exotic” (not neutron) systems

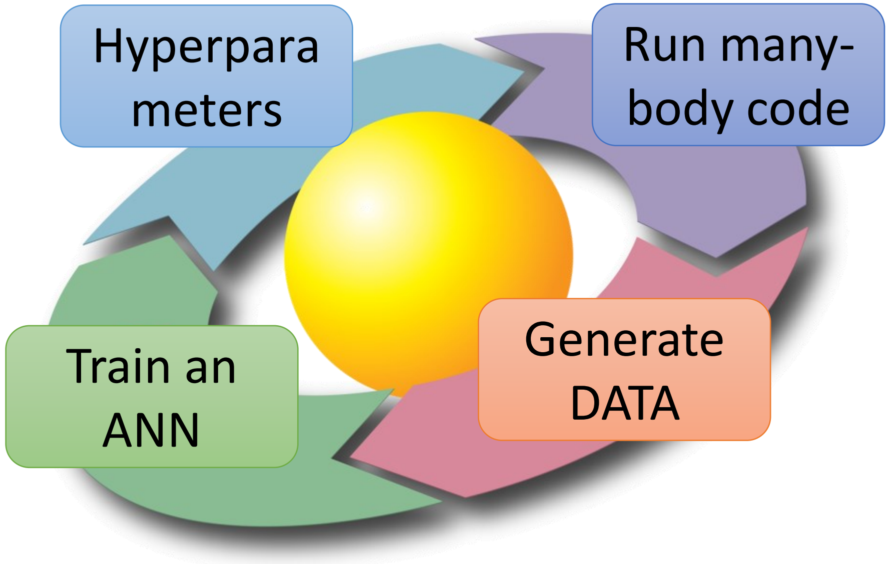
Collaborators

E. Hiyama
(RIKEN/UoTohoku)
Chair d’Alembert



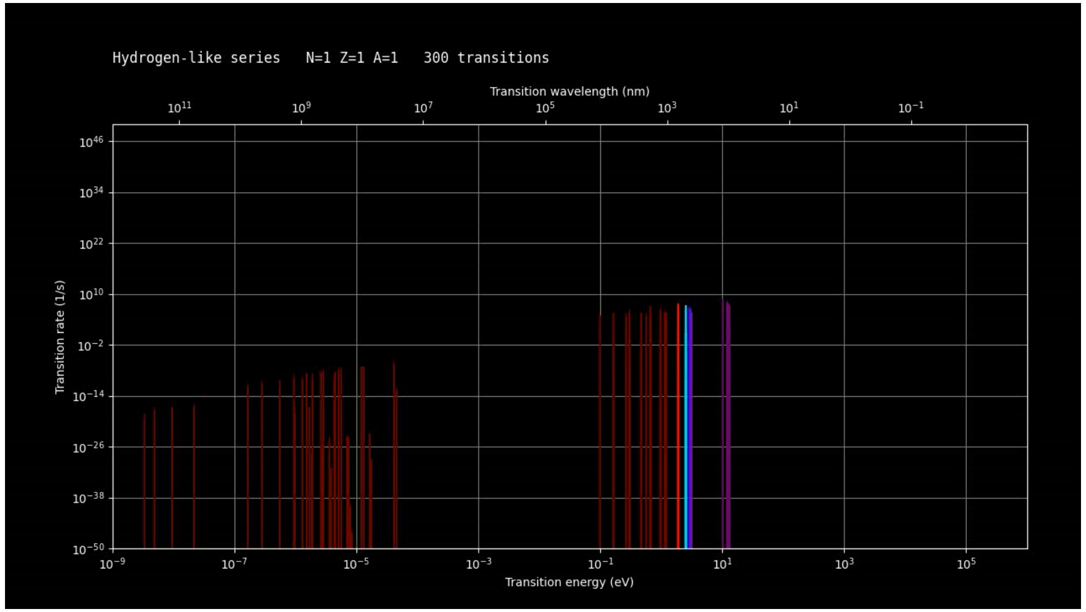
Collaborators

D. Becht (PhD)
P. Indelicato (LKB)
N. Pillet (CEA)



Dataset to train AI >> NIST repository

(BTW they got fired!)



Do the same for nuclear W.F. in CI, i.e. predict subspace of the Hilbert space to perform diagonalization