

Ab initio calculations of proton and neutron scattering on ^{12}C

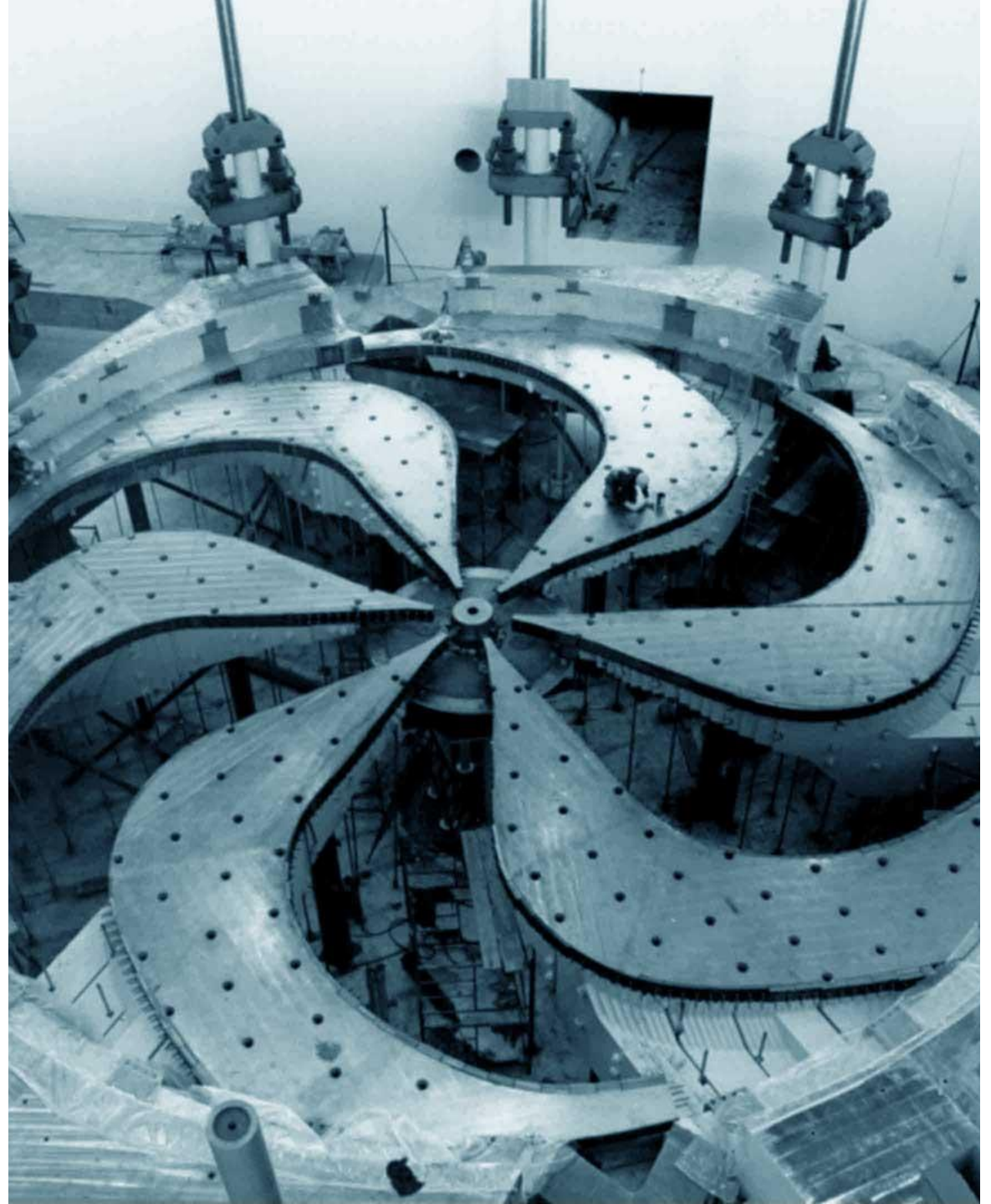
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Marshall Kodar

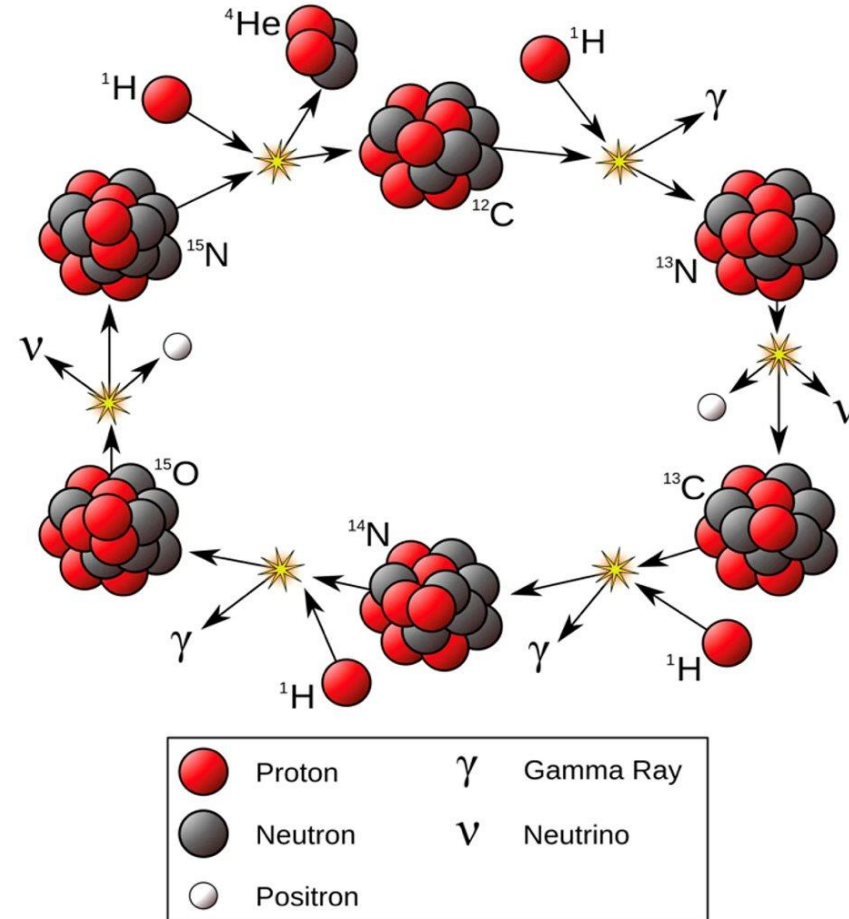
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Motivation

- The $A = 13$ reactions $^{12}\text{C}(p,\gamma)^{13}\text{N}$ and $^{12}\text{C}(n,\gamma)^{13}\text{C}$ are important processes in astrophysics
- $^{12}\text{C}(p,\gamma)^{13}\text{N}$ is the first step in the CNO cycle in stars
- Modelling these reactions helps our understanding of stellar fusion



No-Core Shell Model with Continuum (NCSMC)

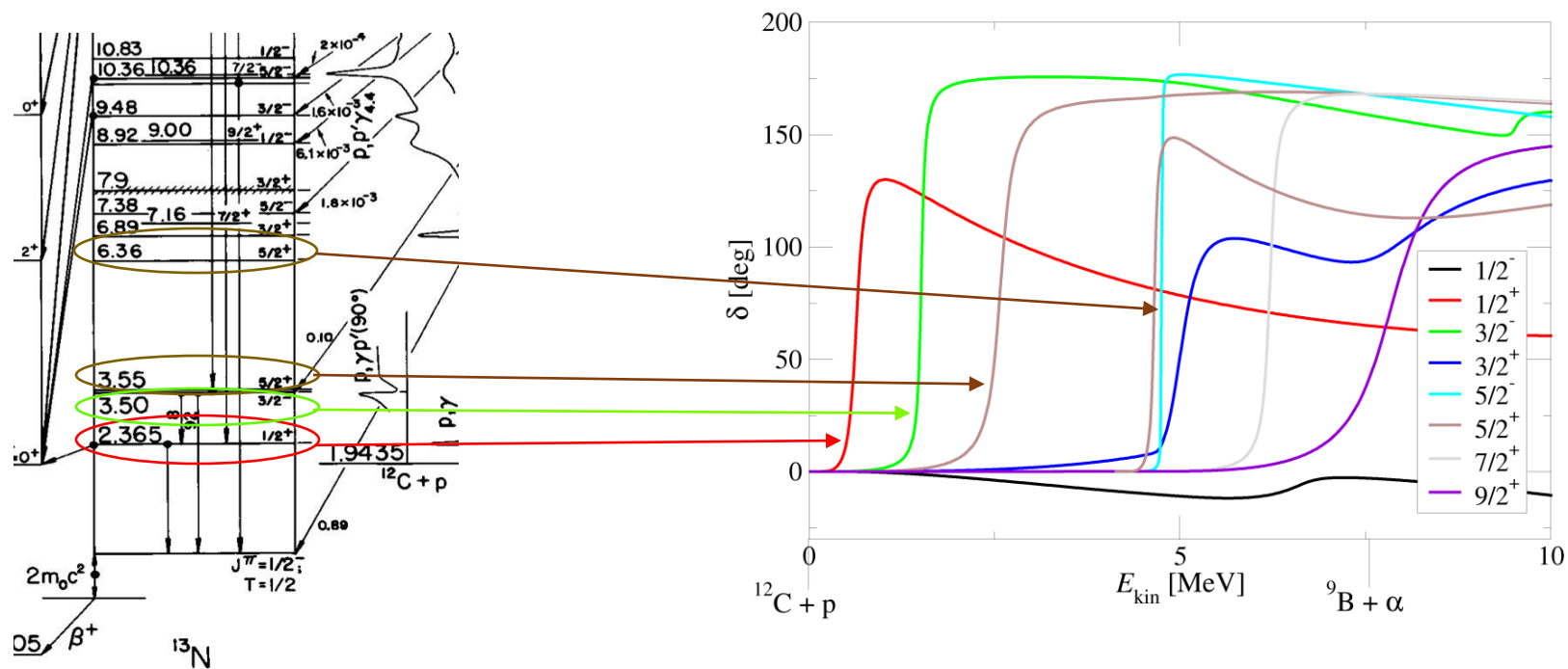
- Combines two nuclear models – No Core Shell Model (NCSM) and Resonating Group Method (NCSM/RGM)
- NCSM used to describe behaviour of nucleons close together, NCSM/RGM describes long-range interactions (scattering)

$$\Psi^{(A)} = \sum_{\lambda} c_{\lambda} \left| \begin{array}{c} (A) \\ \text{NCSM} \\ \lambda \end{array} \right\rangle + \sum_{\nu} \int d\vec{r} \gamma_{\nu}(\vec{r}) \hat{A}_{\nu} \left| \begin{array}{c} (A-a) \quad (a) \\ \text{NCSM/RGM} \\ \nu \end{array} \right\rangle$$


Results: Eigenphase Shifts

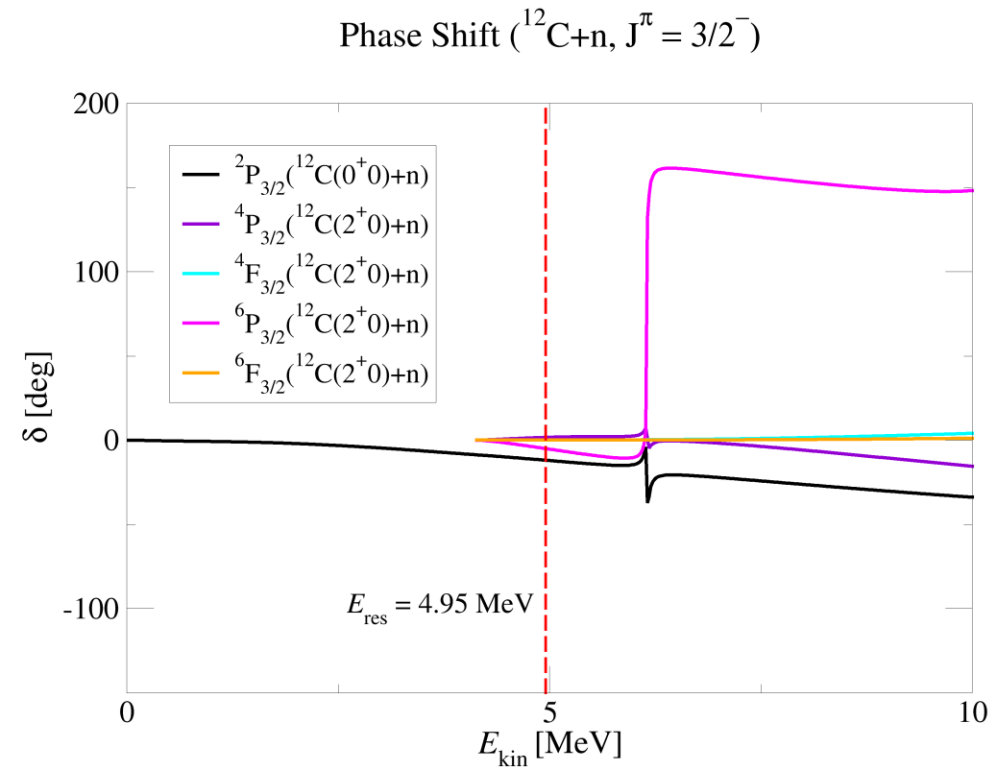
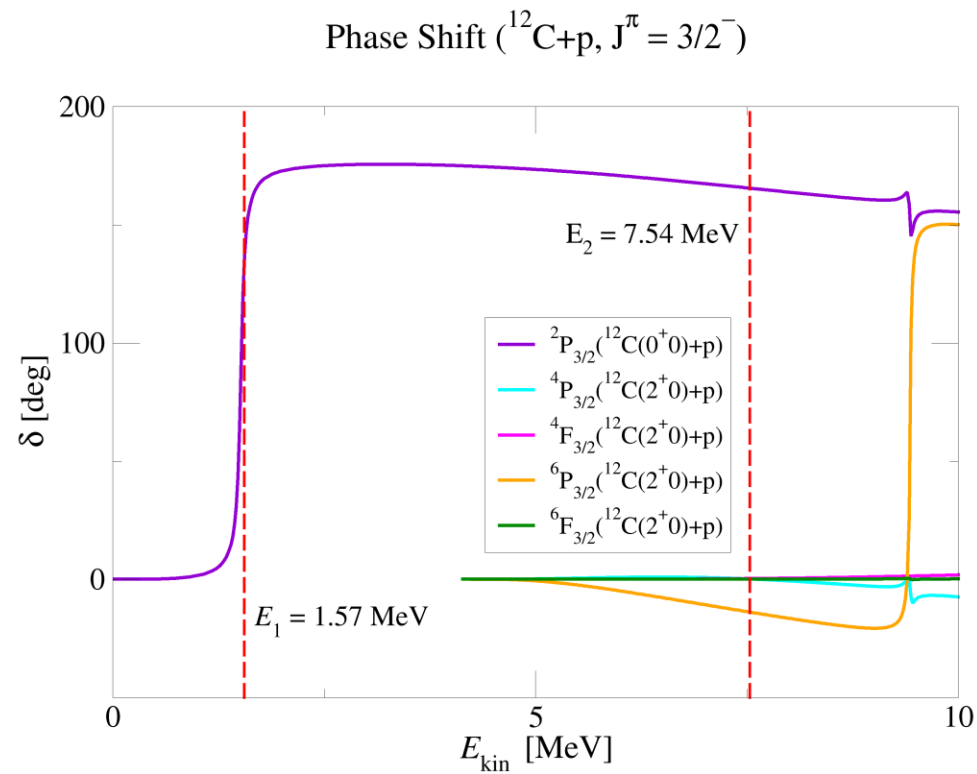
- Eigenphase shifts of scattering wavefunction for the $^{12}\text{C}+p$ system
- For given J^π , sharp increases in eigenphase shift correspond to known energy levels

Eigenphase Shift ($^{12}\text{C}+p$)



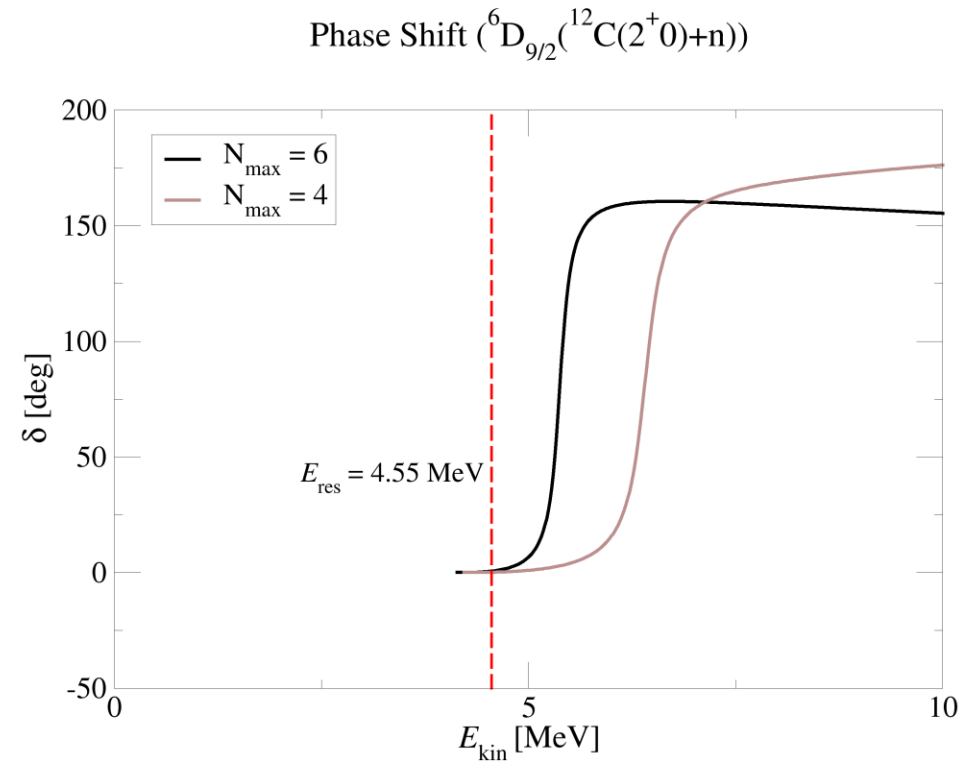
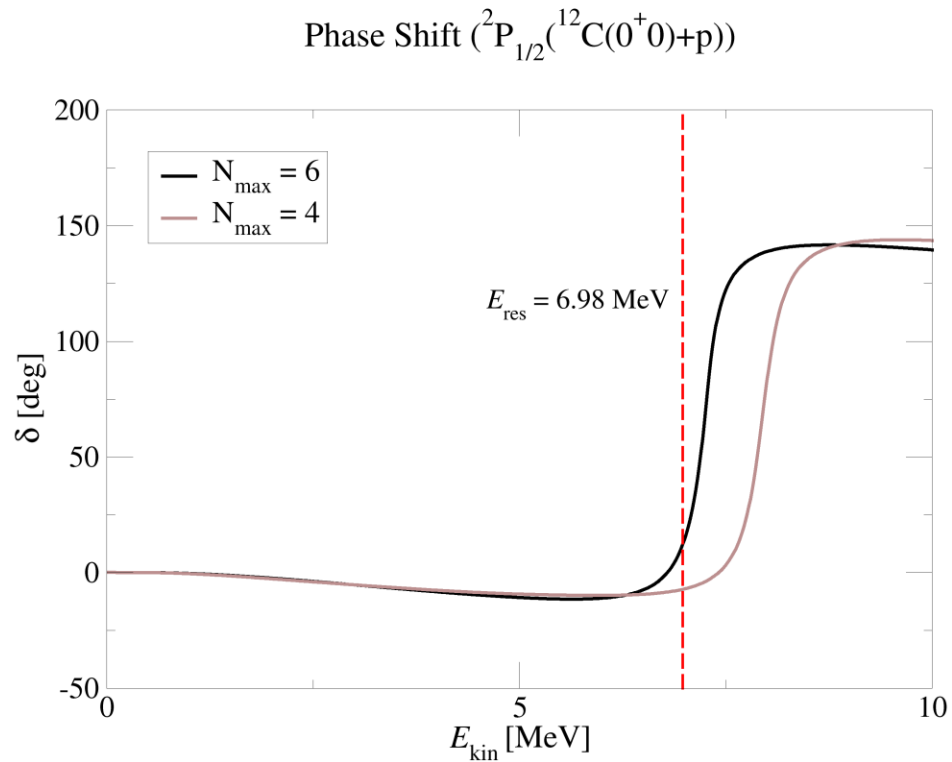
Results: Phase Shifts

- Phase shifts of scattering wavefunctions graphed for both proton and neutron cases
- Graphs show individual partial waves for a given J^π along with experimental resonance energies
- More accurate results for resonances at lower energies



Truncation of the Basis

- Both NCSM and RGM wavefunctions built using harmonic oscillator (HO) basis
- To make computation possible, must truncate basis to include maximum allowed excitations \mathbf{N}_{\max}
- Fairly accurate results at low \mathbf{N}_{\max} , higher \mathbf{N}_{\max} = more accurate results, longer computing time



Thank you!
Merci!
Danke!

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