TALENT Course 6: Theory for exploring nuclear reaction experiments
Outline project proposal

Project name: The use of the Berggren basis in coupled-channels calculations

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Project outline and aims: In the description of nuclear reactions, the Continuum Discretized Coupled-Channels method (CDCC) [1] takes into account the continuum for the projectile, by the use of bin wave functions. This approach is based on the Newton basis, where the real continuum is discretized by blocks to form a set of packets, which can be normalized and used as single particle basis states. The main limitation comes from one-body resonances near the threshold, because the density of states around them increases and so their correct description requires a high discretization of the continuum and/or a bigger number of bin states. A possible solution of this problem is the use of the Berggren basis [2], where the set of real continuum states is replaced by a set of complex continuum states along a contour in the complex energy plane [3], and a sum over all the resonances included in the region between the real energy axis and the complex contour. In this case the one-body resonances are explicitly taking into account, and the complex contour can be discretized with a standard method.

Methodology:

1. Identify where the introduction of the Berggren ensemble will changes the CDCC equations.
2. Define the boundary conditions for different kinds of problems.
3. Show how observables can be calculated with the help of the complex-scaling method [4].

References

[1] M. Kawai. Chapter II: Formalism of the method of coupled discretized continuum channels. *Prog. Theor. Phys. Suppl.* ***89****, 11 (1986).*

[2] T. Berggren. On the use of resonant states in eigenfunction expansions of scattering and reaction amplitudes. *Nucl. Phys. A* ***109****, 265 (1968).*

[3] N. Michel, W. Nazarewicz, M. Płoszajczak, and T. Vertse. Shell model in the complex energy plane. *J. Phys. G : Nucl. Part. Phys.* ***36****, 013101 (2009).*

[4] N. Michel, W. Nazarewicz, M. Płoszajczak, and J. Okołowicz. Gamow shell-model description of weakly bound nuclei and unbound nuclear states. *Phys. Rev. C* ***67****, 054311 (2003).*