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

Project name: Deformed barrier penetration in a coupled channels description

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Project outline and aims:
Describe fusion and particle decay using a local potential model in the coupled channels framework. The effects of intrinsic nuclear deformation of the fragments will be explicitly taken in into account. For fusion, inelastic excitations of the fragments will be modeled using a collective rotational model.

The aim of the project is to review the necessary formalism of the coupled channels framework and implement a numerical solver for the corresponding coupled differential equations. The numerical code will allow different boundary conditions to be able to do both particle decay and simple fusion calculations. The in principle exact treatment of penetration through a deformed Coulomb barrier for particle decay can be used in alpha decay calculations, where it can be used instead of the conventional approximate method of Fröman [1].

Methodology:
The coupled channels differential equations will be numerically integrated on a radial grid using the Numerov algorithm. The intrinsic deformation will cause couplings between different channels. The coupling matrix elements will be obtained from a multi-pole expansion of the nuclear and coulomb potentials.

The code will be written in Fortran 90, where possible published libraries such as `BLAS` and `LAPACK` will be used.

The code will be benchmarked against existing coupled channels codes, such as `ccfull`. For alpha decay, the angular distribution of alpha particles from oriented decaying nuclei will be compared to experiment and previous calculations e.g. [2, 3].

References

[1] P.O. Fröman. Alpha decay of deformed nuclei. *Matematisk-fysiske Skrifter. Det Kongelige Danske Videnskabernes Selskab*, 1 no. 3, 1957.

[2] Tore Berggren and Peter Olanders. Alpha decay from deformed nuclei: (i). formalism and application to ground-state decays. *Nuclear Physics A*, 473(2):189 – 220, 1987.

[3] D. S. Delion, A. Insolia, and R. J. Liotta. Microscopic description of the anisotropy in alpha decay. *Phys. Rev. C*, 49:3024–3028, Jun 1994.