Systematics study of octupole bands in rotating even-even nuclei to reveal rigid or soft octupole shape

Project: MSc level
Supervisor: Elena Lawrie
Start date: 2023

Project Aim / Scope:
This MSc project proposes a systematic investigation of the pairs of alternating-parity bands in all even-even nuclei with octupole correlations using a Coriolis-interaction analysis. This is a new idea that allows to extract information on the softness/rigidity of the octupole shape in a parameter-free approach. The results will be compared with those from previous studies [1,2], where an alternative technique, using an alignment analysis, was used.

Abstract:
Most nuclei with octupole deformation are also quadrupole deformed, which allows them to rotate around an axis perpendicular to their symmetry axis. Such nuclei typically show a pair of bands with positive and negative parity, observed at similar excitation energy. In even-even nuclei such pairs comprising the ground-state and the 3^- octupole bands are well known in many nuclei, for instance in the heavy nuclei in the A = 240 mass region. While such pairs indicate the presence of octupole correlations, it is not easy to determine whether the nuclear shape possess stable octupole deformation (rigid octupole shape) or is soft, thus the nucleus undergoes octupole vibrations. In order to extract information on the rigidity of the nuclear shape often an analysis based on the experimentally extracted alignments is used. This analysis assumes that the octupole vibration of the nucleus can be described with an octupole phonon, which is (at least partially) aligned along the rotational axis. Therefore, an aligned angular momentum with considerable magnitude (eg of up to $3\hbar$) is observed. This alignment analysis includes three input parameters, the projection of the total angular momentum on the symmetry axis, K, and two Harris parameters describing a reference rotor. This makes the results input-dependent.
We propose to use a new type of approach, e.g. the Coriolis-interaction analysis, in order to extract information on the rigidity/softness of nuclei with octupole deformation.

This is a new idea as such an analysis had not been used for octupole bands yet. The advantage of this approach is that it is parameter-free. Our results will be compared with those obtained with the alignment analysis [1,2]. Available experimental data, listed in the NNDC data base [3], will be used.

Relevant References:

[1] P.A. Butler et al., J. Phys. G: Nucl. Part. Phys. 43 (2016) 073002
[2] P.A. Butler, et al., Nature Communications, (2019) 10:2473
[3] National Nuclear Data Center, https://www.nndc.bnl.gov/