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Alpha decay and nuclear structure of odd nuclei

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Recent experiments [1] have made a first exploration of the low-energy spectroscopy of super heavy elements around Z=115. One uses alpha-gamma-coincidence measurements to probe the low lying states. This calls for a theoretical understanding of the alpha decay and structure in particular of odd nuclei.
In the alpha decay of an odd nucleus the resulting daughter nucleus can often be left in an exited state, which subsequently decays electromagnetically. The most probable state to alpha decay into is the one where the odd particle occupies the same orbital as in the mother nucleus – such decays are called favored. Hindered decays, where the orbital of the odd particle changes, are generally less probable. As a first approximation one can employ rule-of-thumb estimates to determine how hindered a certain alpha decay is [2]. The largest hindrance is associated with decays where the odd nucleon intrinsic spin changes direction, a spin flip, and where the parity of the mother and daughter are different.
To correctly asses which states are connected by alpha decay one needs to consider the interplay between the energy dependence of the alpha particle tunneling and the formation probability of the alpha particle given the different daughter and mother nucleus states. This requires a microscopic theoretical description.
In previous work [3, 4] we considered alpha decay of even near-spherical nuclei using a microscopic Skyrme-HFB approach. From the wave functions obtained in the self-consistent mean field calculations we calculated the alpha-particle formation amplitudes. The resulting decay rates reasonably reproduce data, especially shell and pairing effects not captured by simpler models. In the current work we extend the approach to near-spherical odd-A nuclei. By considering different quasi-particle excitations of the daughter nucleus we obtain the partial alpha-decay rates for different possible decay branches of the mother nucleus. Comparing the obtained decay rates with experimental data we see a good agreement for the relative rates of different favored and hindered decay branches. The hindrance observed in experiment varies from nucleus to nucleus. In the calculations both the overall hindrance, and the variation in the decay rates for different nuclei are reproduced.

References

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