# Alpha particle formation and decay rates from Skyrme-HFB wave functions.

Daniel Ward[1], Gillis Carlsson, Sven Åberg

*Division of mathematical physics, Department of Physics, Lund University, S-221 00, Lund, Sweden.*

**Abstract.** Alpha decay is one of the most important decay modes determining the stability of heavy nuclei, and is a crucial observable in the search for new super-heavy nuclei. The gross features of alpha decay is fairly well described by semi-empirical models describing a particle tunneling through the Coulomb barrier of the daughter nucleus, but not treating explicitly the formation of the alpha particle [1]. To account for shell effects and describe decay rates to excited states the formation of the alpha particle from individual nucleons must also be taken into account.

Using a microscopic approach, where contrary to previous microscopic calculations [2][3], the mean field and pairing interaction is taken into account in a self-consistent way, we study the alpha decay formation probability in near spherical nuclei. The decaying and residual nucleus is described in the Hartree-Fock-Bogoliubov(HFB) approximation using effective Skyrme forces. A large spherical basis is used to ensure that the alpha particle formation amplitudes are converged. It is found that the decay probabilities depends strongly on the details of the pairing force, and to a smaller extent on the properties of the particle-hole mean field. The results are compared to experimental data for a range of known unstable nuclei [4], showing that trends due to quantum shell effects in the relative decay probabilities of neighboring nuclei are reproduced. Absolute rates are on the other hand too small, possibly indicating the need for a more accurate description of correlations in the nuclear surface.

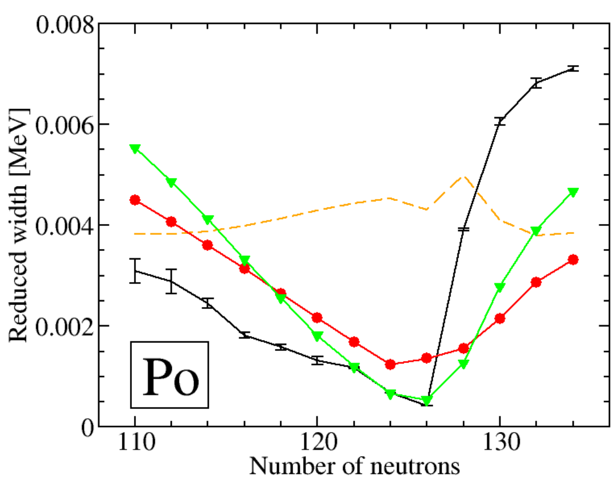


**Figure:** Alpha decay reduced widths, proportional to the alpha particle formation probability, for Po isotopes. The error bars show experimental widths extracted from data [4]. They have a distinct minimum at the 126 neutron shell closure. The dashed line shows results from a semi-empirical model [1] where the formation probabilities are fitted to a wide range of data. The circles and triangles show results from the normalized microscopic calculations. The circles show results using an effective pairing interaction without density dependence. For the triangles, the pairing is active only in the nuclear surface.

[1] *E-mail address:* daniel.ward@matfys.lth.se

**References**

[1] C. Qi, *et al*., Physical Review C 80, 044326 (2009)
[2] R. G. Lovas, *et al*., Physics Reports 294, 265-362 (1998)
[3] D. S. Delion, *Theory of Particle and Cluster Emission*, Lecture Notes in Physics 819, Springer (2010)
[4] Y. A. Akovali, Nuclear Data Sheets 84, 1 (1998)