N=82 shell quenching below $^{132}_{50}Sn_{50}$

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The influence of nuclar structure on the r-process nucleosynthesis can best be studied within the "waiting-point" concept [1]. Within this framework, the successful reproduction of the global isotopic abundances ($N_{r,\odot}$) as well as remaining deficiencies have been interpreted by our group as signatures of nuclear structure near the neutron dripline [1]. Pronounced abundance troughs prior to the $N_{r,\odot}$ peaks at A≃130 and 195, respectively, have their origin in an overestimation of the N=82 and 126 shell strength in global mass models such as FRDM and ETFSI-1.

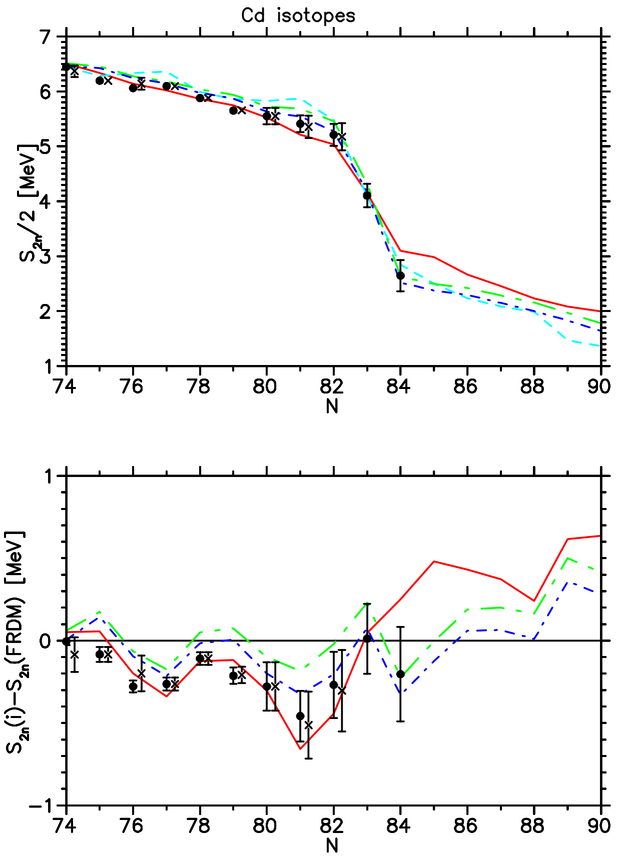

Figure 1: The two-neutron separation energies (S_{2n})across the shell gap at N=82 for Cd-isotopes (upper part) and the differences to the FRDM model (lower part). Experimental values: crosses from 1995 mass evaluation [3] and circles from 2003 evaluation [4]. Theoretical masses: FRDM: cyan, ETFSI-1: green, ETFSI-Q: blue, HFB-2: red

A weakening ("quenching") of spherical shells with increasing isospin, resulting in a gradual setting in of collectivity, is well established for the lower neutron-magic numbers and has been predicted by HFB calculations for the spherical shells at N=82 and 126 [2].
Signatures for a quenching of the shell strength can be derived from the difference of two-neutron separation energies (S_{2n}) across a magic neutron number. As an example, Fig. 1 displays the S_{2n} values for Cd isotopes. Experimental values from the 1995 mass evaluation of Audi et al. [3] (crosses) did not include Cd isotopes at or above N=82.
First detailed β- and γ-spectroscopic studies of the N=82 nuclide ^{130}Cd at CERN-ISOLDE yielded a surprisingly high Q_β value of 8.34 MeV, which is only in agreement with recent mass models that include the phenomenon of N=82 shell quenching [5].
Based on this result, the 2003 mass evaluation [4] could extrapolate to more neutron-rich isotopes with N≥82. As is indicated in Fig. 2, the shell strength is weakened relative to the maximum at the double-magic $^{132}_{50}Sn_{82}$ with increasing isospin, as requested by our group from astrophysical considerations since a long time [1].

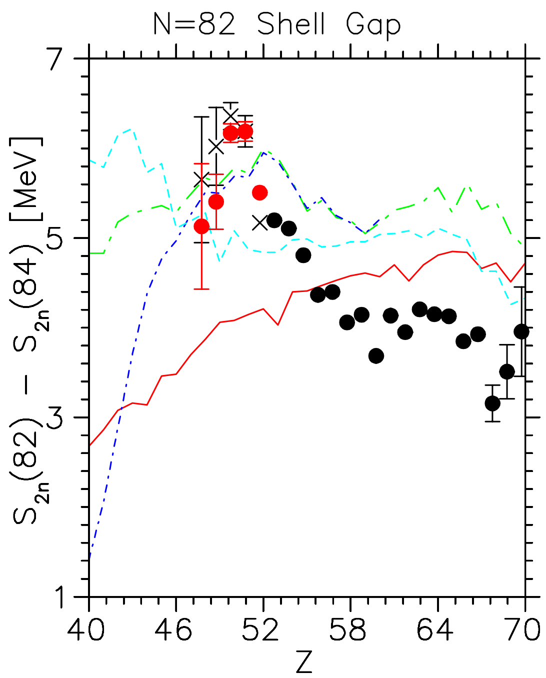

Figure 2: The N=82 shell gap as a function of Z. Experimental values from the 2003 mass evaluation [3] (black and red circles) are compared to the 1995 ones [4] (crosses and black circles). [The colour coding for the mass models is the same as in Fig. 1.]

Direct mass measurements at the FRS-ESR of the GSI will in future extend the range of experimental masses at N=82, as well as to more neutron-rich isotopes near N=126.

References

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