Neutron Shell Strengths at N = 152 and towards N = 162

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Determination of the shell strengths is an important feature to characterize the properties of superheavy elements and to test the power of theoretical predictions. Recently ground-state masses of several nobelium (Z=102) and lawrencium (Z=103) isotopes have been measured directly with high precision at SHIPTRAP [1, 2]. The results have been used to determine the strength of the N = 152 subshell for Z = 102 and Z = 103 [2]. The experimental data from [2] are compared in fig. 1 with the results from a microscopic - macroscopic approach [3] and a selfconsistent calculation using the SLy4 - force [4]. The latter has been used recently to calculate properties of neutron stars, e.g. the relation between mass and radius (see e.g. [7]). This circumstance demonstrates that properties of the nuclear force (or strong force, respectively) derived from the structure and stability of nuclei can be used to describe astrophysical phenomena or in general, phenomena where the strong force plays an essential role (e.g. quark-gluon plasma). Vice versa, information on the strong force obtained from 'such other' studies will have a feedback on the description of nuclei. Superheavy nuclei are a specific, but of course not the only one, laboratory for such studies, as they exist only due to a delicate balance between the nuclear force and the Coulomb force.

Another source of information on shell strength in the transactinide region are the α - decay chains passing through ^{252,254}No. Based on the measured masses of these isotopes [1] the 2n- binding energies of the N-Z = 50 nuclei could be determined up to ^{266}Hs [5]. The results are compared with predicted values in fig. 2. It is seen that the 2n-binding energies obtained from the microscopic - macroscopic models [3, 6] describe the experimental trend, which shows a maximum value at N = 152, at least qualitatively, while the agreement between experimental and calculated values is somewhat better for [3] than for [6]. The selfconsistent calculation using the SkP force, however, does not show a local maximum at N = 152 and gives too low values for N$\leq$152. Towards higher neutron numbers all calculations show a steeper increase of the 2n - binding energies than measured. This may indicate that the N = 162 neutron shell might be weaker or stronger localized. To check this possibility it is necessary the estimate the 2n - binding energy of ^{270}Ds, which requires the identification of the so far unknown nuclide ^{268}Ds. Based on production cross-sections for ^{269,270,271}Ds measured previously at SHIP it can expected to be produced with $\sigma \approx$ 1-2 pb in the reaction ^{207}Pb(^{62}Ni,n)^{268}Ds.

This finding is in-line with the trend which is indicated by the spontaneous fission half-lives, which show a slower increase towards N = 162 than the values predicted in [8], which are based masses and shell effects from [3].

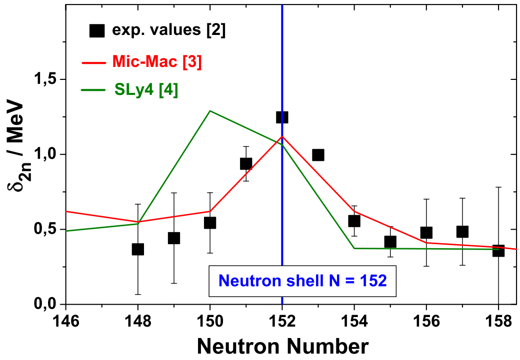

Figure 1: Experimental shell strength parameters of No isotopes in comparison with results from calculations.

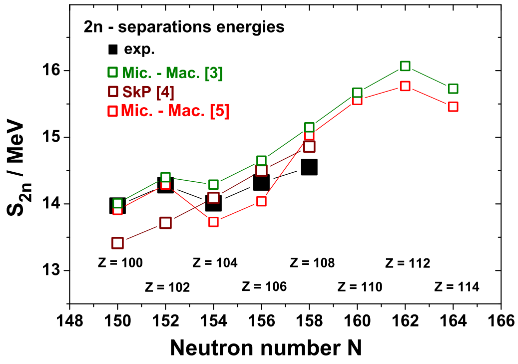

Figure 2: Experimental 2n - separation energies in comparison with results from calculations.

References

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