Mass Excesses of very neutron rich Ga, Ge, As, Se and Br nuclei from Local extrapolations of AMC2012 Atomic Mass Data: a comparison with Global Mass Models

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Introduction

The GSI Helmholtzzentrum fur Schwerionen forschung in collaboration with the II. Physikalisches Institute of the Justus-Liebig-University in Gießen is contributing to this task by collecting and evaluating data on atomic masses. These activities lead in close international collaborations on the one hand to a follow-up of the 2003 Atomic Mass Table [1, 2] and the related NUBASE evaluation of nuclear properties such as $T_{1/2}$, spin-parity (I^{π}) as well as decay modes for ground and isomeric states [3], to the 2012 Atomic Mass Compilation [4].

Overall, our knowledge of the mass surface has been significantly improved in the last decade. This suggests the need for a more plausible way of extrapolations using the modified mass surface for the extrapolation of masses toward the drip lines. In recent years, our knowledge on atomic masses far from the valley of stability has been increased due to the advent of new measuring techniques. Application of these masses, e.g. for astrophysical calculations, requires data for even far more unstable isotopes which are generally derived from global mass models. In this report we investigate the possibility of local extrapolations.

In order to make estimates for unknown masses from trends in the mass surfaces for the Atomic Mass Evaluations, an interactive graphical program was developed [5,6]. This procedure encompasses a "subjective" component in form of individual judgments. In this report we want to study possibilities of avoiding the personal judgment by applying "objective" techniques preferably based on algorithms. Already back in 1954, Way and Wood [7] derived graphical presentations of nuclear decay data on the basis of the semi-empirical Bethe-Weizsacker mass formula [8]. In the absence of nuclear structure effects as magic numbers, the lines connecting nuclei with constant N or Z ought be "straight" lines. Under the assumption that the atomic masses are smoothly varying functions of N and Z (as the semi empirical mass formula) the lines can be extrapolated to unmeasured nuclei.

The very neutron-rich isotopes $^{88-90}$Ga and ^{94}As cannot be calculated with the directly from experimental values, but it is necessary to determine these very neutron-rich nuclei iteratively applying calculated values for lesser neutron-rich isotopes successively for the calculation of more neutron-rich ones. As a starting point, the mass excesses of ^{84}Ga and ^{86}Ge can be calculated from experimentally determined values alone. ^{85}Ga can then be derived applying these two calculated values and the three experimental values ^{84}Ge and ^{85,86}As. Continuing like this for increasing neutron-numbers the mass excess values of the extremely neutron-rich nuclides can be obtained.

The mass excess values calculated from the local extrapolations of S2n, S2p, $Q2\beta^{-}$, $Q4\beta^{-}$ derived from the AMC2012 [4] mass data are listed in Table 1 together with theoretical values from the mass models FRDM92 and HFB-21. Further values derived from the Garvey-Kelson relation are also presented [9]. Theoretical values from values derived from the HFB-21 [10] and FRDM [11] global mass models.

Table 1. Garvey-Kelson relation (G-K) [11]. HFB-21 (H) [10] and FRDM (F) [9] global mass models are added for comparison. Deviations from FRDM are also shown. [Mass excess values in [keV/C^2]]

Isotope	G-K	G-K -F	AMC2012[4]	A-F	HFB-21	H-F	FRDM
^{84}Ga	-44069	-521	-44100 (300)	-552	-43810	-262	-43548
^{85}Ga	-39908	-326	-39830(30)	-248	-39570	12	-39582
^{86}Ga	-33961	-578	-33581(600)	-198	-33540	-157	-33383
^{87}Ga	-29345	-398	-28836(1500)	-111	-29430	-483	-28947
^{88}Ga	-22850	-561	--	--	-22660	-371	-22289
^{89}Ga	-17908	-651	--	--	-18130	-873	-17257
^{90}Ga	-11102	-925	--	--	-10860	--683	-10177
^{86}Ge	-49626	-297	-49760(300)	-431	-49690	-361	-49329
^{87}Ge	-43832	-513	-43825(300)	-115	-43710	-391	-43319
^{88}Ge	-40021	-376	-39636(700)	-9	-39820	-175	-39645
^{89}Ge	-33526	-323	-33530(700)	-328	-33360	-158	-33202
^{90}Ge	-29037	35	-29490(700)	-418	-29240	-168	-29072
^{91}Ge	-22350	-162	--	--	-22400	-212	-22188
^{88}As	-50626	-737	-50488(30)	-599	-50320	-431	-49889
^{89}As	-46816	-436	-46555(150)	-175	-46860	-480	-46380
^{90}As	-40955	-189	-40940(400)	-174	-41120	-354	-40766
^{91}As	-36763	60	-37050(900)	-227	-37380	-557	-36823
^{92}As	-30739	25	-30740(1000)	24	-30990	-226	-30764
^{93}As	-26145	319	-26096(2000)	368	-27170	-706	-26464
^{94}As	-19683	651	-18430(4000)	1904	-20670	-426	-20334
^{91}Se	-50238	-329	-50225(250)	-316	-50100	-191	-49909
^{92}Se	-46734	2089	-46370(600)	453	-46850	1973	-46823
^{93}Se	-40951	-9	-40440(450)	502	-40860	82	-40942
^{94}Se	-37104	392	-36970(900)	526	-37400	96	-37496
^{95}Se	-30761	745	-29580(1000)	1926	-31250	256	-31506
^{94}Br	-47662	374	-47580(300)	456	-47530	506	-48036
^{95}Br	-43934	775	-43800(250)	909	-44500	209	-44709
^{96}Br	-38240	1665	-38620(800)	885	-38800	705	-39505

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