Extrapolated Masses towards drip lines from the regularity of the AMC12 Mass surfaces

B. Pfeiffer[1,2], Shreesha Rao D. S.[3], K. Venkataramaniah[2,3],* U. Czok[1], and C. Scheidenberger[1,2]
[1] *II. Physikalisches Institut, Justus-Liebig-Universität Gießen, Gießen, GERMANY*
[2] *GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, GERMANY and*
[3] *Department of Physics, Sri Sathya Sai Institute of Higher Learning, Prasanthinilayam, INDIA*

Introduction

The new atomic mass compilation AMC12 [1] provides a variety of potential uses. One such important application is to predict dependable estimates of unknown, poorly known or questionable masses and extrapolation toward the drip lines and also to test the theoretical models. Such an attempt has been made in this work. The procedures by which we get the extrapolated values encompass a subjective component in the form of individual judgments. So we want to study the possibilities of avoiding the personal judgment by applying objective techniques for extrapolation. Despite the complexity of nuclear interactions some simple trends in the mass surfaces can be used to obtain unknown masses. Estimation of the unknown masses of nuclei relies mostly on observing the regularities in derivatives mentioned below. We consider four different mass sheets [2].

S_{2p} as a function of proton number
S_{2n} as a function of neutron number
$Q_{\beta\beta}$ as a function of mass number
Q_{β} as a function of mass number

The two-neutron separation energy. S_{2n}(Z, A) can be computed from the ground state nuclear masses M(Z, A) and M(Z, A-2) and neutron mass. The evolution of S_{2n}, as a function of neutron number shows the well-known regularities [3]. For a given proton number, S_{2n} decreases smoothly as the neutron number increases. This characteristic can be clearly seen in nuclear systematic representation of the experimental values of S_{2n} along the isotopic chains. The curves of various isotopic chains are roughly parallel to each other.

Evaluation and Analyses :

It was perceived that to follow the trend we have to consider point to point extrapolation by looking at the trends very closely. A small deviation in the graph, which is in MeV, for the extrapolated value will lead to large deviation in the mass value. Thus to obtain the extrapolated S_{2n} value for a nuclide, we used the trend in the sheet by using the existing derivatives of the other nuclide, by finding the slopes of the line joining the S_{2n} value for next three Nuclide. It is observed that in order to follow the trend of the next nuclide more closely it was necessary to have more weightage for the slope of the immediate next element than the others. So the slope M was found as M = 0.5 m_1 + 0.3m_2 + 0.2m_3, where m_1, m_2 and m_3 are slopes of the next three lines. The intercept for the extrapolated value was obtained by substituting the slope, M into the already known S_{2n} value for the nuclide of interest. Using the intercept and slope M, the extrapolated S_{2n} are calculated for all nuclides of AMC12 as shown in the Figure I and all the corresponding unknown atomic mass values are derived. Table I shows a representative data set for 18 new nuclides. These are compared with the theoretical predictions of Nayak et al. [4].

It can be seen that the method using weighted slope to compute S_{2n} values can be said to be the best possible method for dependable estimates of unknown, poorly known or questionable masses. A similar work using S_{2p}, $Q_{\beta\beta}$ and Q_{β} extrapolations is in progress.

*Electronic address: vrkamisetti@gmail.com

Figure 1 : Extrapolated S_{2n} for N= 0 to 25

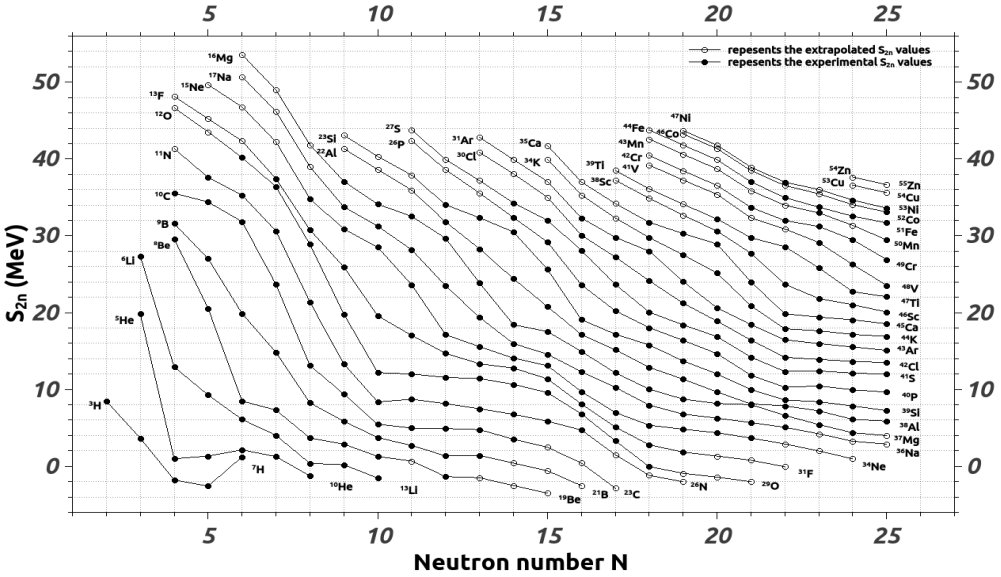

Table I : Comparison of extrapolated masses with theory.

Nuclide	Extrapolated S_{2n} (MeV)	Extrapolated Mass (amu)	Error in Mass (amu)	Theoretical Mass (amu) [4]	Percentage Deviation (%)
$^{24}_{7}N_{17}$	1.512786	24.050106	0.001520	24.050736	-0.003
$^{25}_{7}N_{18}$	-1.190820	25.057988	0.002640	25.056415	0.006
$^{26}_{7}N_{19}$	-2.023589	26.069608	0.003918	–	–
$^{27}_{8}O_{19}$	-0.922253	27.047780	0.000759	27.049372	-0.006
$^{28}_{8}O_{20}$	-1.416974	28.056201	0.001441	28.057660	-0.005
$^{29}_{8}O_{21}$	-2.013904	29.067272	0.003947	–	–
$^{29}_{9}F_{20}$	1.326876	29.042415	0.000793	29.042083	0.001
$^{30}_{9}F_{21}$	0.778282	30.051834	0.002001	30.052400	-0.002
$^{31}_{9}F_{22}$	-0.070635	31.059821	0.004803	31.058412	0.005
$^{32}_{10}Ne_{22}$	2.897627	32.038969	0.002481	32.039023	0.000
$^{33}_{10}Ne_{23}$	1.985182	33.048299	0.004641	33.048653	-0.001
$^{34}_{10}Ne_{24}$	0.960445	34.055268	0.006712	34.056146	-0.003
$^{34}_{11}Na_{23}$	4.224074	34.033015	0.000842	34.034643	-0.005
$^{35}_{11}Na_{24}$	3.253085	35.039198	0.001611	35.040075	-0.003
$^{36}_{11}Na_{25}$	2.880255	36.047253	0.003108	36.049673	-0.007
$^{37}_{12}Mg_{25}$	3.993995	37.029832	0.001184	37.031165	-0.004
$^{38}_{12}Mg_{26}$	3.402310	38.035557	0.002236	38.037638	-0.005
$^{39}_{12}Mg_{27}$	2.632207	39.044336	0.004279	39.047204	-0.007

References

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