NUCLEAR SHELL EFFECTS NEAR THE DRIP LINES

C. Samanta[a),b)], S. Adhikari[a)]
[a)] *Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Kolkata 700064, India*
[b)] *Physics Department, Virginia Commonwealth University, Richmond, VA 23284-2000*

Recently, with the advent of more precise mass measurement techniques, many old nuclear masses have been revised and, new mass data of several nuclei away from the stability line have been available [1]. This provides the opportunity to re-evaluate the shell effects in nuclei whose experimental mass data are now available. In the past, Bethe-Weizsäcker mass formula (BW) was used to present the shell effect in nuclei and it can be found in many text books [2, 3]. As BW has no shell effect incorporated, direct comparison with the measured masses delineates the shell effect in nuclei. However, later on it was pointed out that BW is severely inadequate in the low mass region and a modified Bethe-Weizsäcker mass formula (BWM) was prescribed in which the asymmetry and the pairing terms are different from the BW[4]. According to BWM, the binding energy of a nucleus (A, Z) is defined as,

$$BE(A,Z) = 15.777\,A - 18.34\,A^{2/3} - 0.71\,Z(Z-1)\,A^{-1/3} - 23.21(1+e^{-A/17})^{-1}\,(A-2Z)^2\,A^{-1} + (1 - e^{-A/30})\,\delta$$

where, the pairing energy term $\delta = +12A^{-1/2}$ for even N-even Z nuclei, $-12A^{-1/2}$ for odd Z-odd N nuclei and 0 for odd A nuclei. Compared to BW, the BWM gives a better description of the binding energy versus neutron number (N) curves from Li to Bi [4]. Like BW, the BWM also has no shell effect incorporated and, it is valid for nuclei with almost no deformation and without magicity. As no Wigner term is incorporated in BW or, BWM, both under predict the binding energies of N=Z nuclei. Thus a comparison of the binding energies computed from the mass data and BWM (or, BW) clearly delineates the shell effect in nuclei. Earlier an improved liquid drop mass formula (ILDM) was suggested as an improvement of the Bethe-Weizsäcker mass formula [5]. But, the BWM is found to give a better fit to the light nuclei compared to ILDM. The shell effects at magic neutron numbers N= 8, 20, 28, 50, 82 and 126 and, magic proton numbers Z= 8, 20, 28, 50 and 82 are found to vary rapidly approaching the drip lines. The shell effect increases when approaches another magic number. Thus, shell effects are not always negligible near the drip lines. A comparison with the predictions of the ILDM will also be presented.

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