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Nuclear Radius Parameter-An Indicator of Nuclear Shell Closure

Content :

This paper presents behavior of nuclear radius parameter (r0) of alpha-daughter nuclei with parent neutron and proton numbers. Preston's spin–independent equations [1] of alpha-decay radioactivity were used to calculate the nuclear radius parameter (r0) of 184 even–even nuclides from up-to-date experimental alpha-decay data.

Variation of r0 parameters with parent neutron number for different nuclides demonstrates that r0 parameters exhibit a minimum at N=126 (a major shell closure) and increase thereafter, decreasing again toward the next minor shell closure [2]. Additionally, there is a shallow minimum at N=152, which indicates a minor shell closure, consistent with the recent mapping of N=152 shell effects [2].

On the basis of present study, we suggest that the isotonic chains with N=104, 106 and 112 exhibit a minima at Z=82, which indicates the role of Z=82 proton shell closure, consistent with the shell model predictions of Wauters et al.[3]. However, the shell effects at Z=82 disappear for the isotonic chains with N=102, 108 and 110 as suggested by Buck et al. [4,5] and Brown [6]. Thus, further calculations are required to address the issue pertaining to Z=82 proton shell closure.

We have also investigated the behavior of deformed actinides from Th to Cf. These nuclei are found to exhibit interesting behavior near N=126. The Th, U and Pu isotopes display two minima, which keep shifting by two neutrons to the right. These minima lie at N=134 and 140 for Th, at N=136 and 142 for U, at N=138 and 144, for Pu, and at N=146 for Fm isotopes. Thereafter, Pu and Cm have a minimum at N=150, and Fm and Cf at N=152. It is, therefore, clear that the much talked about N=152 minimum [2] is also a transient minimum. This behavior of "shifting minima" for these heavy nuclides is interesting and, as yet, has not been discussed in the literature. The evaluated r0 parameters in our work can further be used to deduce r0 parameters of odd-A and odd-odd nuclides, and hence to extract alpha-decay hindrance factors for elucidating important nuclear structure information of such nuclei.

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