Doubly Magic N = Z Nuclei near the rp-Process Path Unravelled in Deformed Space

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In rapid-proton-capture *rp*-process in x-ray bursters, $N = Z$ nuclei above $Z = 32$ play an important role in producing a part of x-ray flux. Measurements of masses in the region of $Z = 34$–40 have shown that $N = Z$ nuclei act as waiting-points in the chain of *rp*-process, thus delaying it. These nuclei give rise to a large-energy x-ray flux and produce peaks in abundances in the *rp*-process [1]. Structure of these nuclei is understood poorly. Experimental isotope shifts [2] show that the proton drip-line $N = Z$ nucleus ^{72}Kr is compact against the conventional wisdom.

RMF theory was the first successful theory to describe the anomalous kink in isotope shifts in Pb nuclei [3], that led to the modification of the spin-orbit potential in density dependent Skyrme functionals [4]. Within the framework of the RMF theory, we have investigated the isotope shifts in Kr nuclei near the *rp*-process path employing the deformed relativistic Hartree Bogoliubov (DRHB) approach. Using the RMF Lagrangian model NL-SV1 [5], we show that the contraction in the charge radius of ^{72}Kr is produced by the double shell closure at $N = Z = 36$ in the deformed single-particle space. On investigating the shell structure of other $N = Z$ *rp*-process nuclei, we find that the waiting-point nuclei ^{68}Se, ^{72}Kr, ^{76}Sr and ^{80}Zr exhibit shell closures both in proton and neutron numbers in the deformed space. This lends a double magicity to these nuclides. The major *rp*-process waiting-point nuclei thus possess a magic character similar to that exhibited by major *r*-process waiting-point nuclei in the neutron-rich region.

The double magicity supports the waiting-point character of these nuclei with consequences on the *rp*-process x-ray flux, beta-decay rates and *rp*-process abundances. Experimental evidence in support of this will be discussed.

References

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