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High Multipolarity Tetrahedral Symmetry Shapes Predicted in Nuclei with Nucleon Numbers around Z=N=40

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There is an increasing interest in exotic symmetries predicted to occur in atomic nuclei, yet in the past traditionally associated with molecular structures. This tendency is witnessed by growing number of publications in this domain. Tetrahedral and octahedral symmetries can be considered among the most exotic since they are predicted to produce 4-fold degeneracies of the nucleonic levels in contrast to the standard 2-fold (Kramers) degeneracies.
Following Ref. [1], the presence of tetrahedral symmetry is expected to occur in groups of nuclei throughout the nuclear chart. In this project we examine systematically the exotic symmetry properties of Zirconium nuclei, since $Z = N = 40$ are predicted to be among the leading tetrahedral magic numbers. Our interest was strengthened by the experimental identification of the tetrahedral and octahedral symmetries published in Ref. [2].

It is well known that the molecular symmetry nuclear surfaces can be parametrised with the help of the standard spherical harmonics, $\{Y_{\lambda,\mu}\}$ with only a small sub-families of them contributing. In particular it can be shown, cf. e.g. Ref.[3], that tetrahedral symmetry shapes can be generated, up to two lowest orders by spherical harmonics with multipolarities $\lambda = 3$ and 7. We have systematically examined the tetrahedral symmetry shell effects around $Z = N = 40$ magic gaps discovering that, in contrast to the usual expectations, the strongest tetrahedral shell gaps are predicted as the effect of the 7^{th} order multipolarity. We will present the results performed using a realistic, phenomenological mean-field approach with the new parametrisation of the Hamiltonian tested for the absence of parametric correlations and thus expected to be stable.

To our knowledge, these are the first theory predictions using realistic mean-field Hamiltonians suggesting very low lying potential energy minima of the 7^{th} order multipolarity. We discuss in detail the experimental verification criteria.

In addition, the new internet service MeanField4Exp (https://meanfield4exp.ifj.edu.pl) allowing to confront the theoretical elementary structure properties of atomic nuclei with experiment and developed under the EURO-LABS Project, will be presented.

References

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