# Quadrupole Shape Phase Transitions in the $\gamma$-rigid Regime 

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#### Abstract

Quadrupole shape phase transitions are studied in the frame of the Bohr-Mottelson model [1,2] for which a sextic oscillator potential [3] in the $\beta$ variable is considered, while the $\gamma$ degree of freedom is frozen either to $0^{\circ}$ or $30^{\circ}[4,5]$. The corresponding solutions are called $\mathbf{X}(3)$-Sextic $\left(\gamma=0^{\circ}\right)$ [4] and $\mathbf{Z}(4)$-Sextic $\left(\gamma=30^{\circ}\right)$ [5] in connection with the previous ones $\mathbf{X}(3)$ [6] and $\mathrm{Z}(4)$ [7] for which an infinite square well potential is used. Both energy spectra and $E 2$ transitions are given in analytical form and up to some scale factors depend on a single free parameter. In particular situations when the $\beta^{2}$ or $\beta^{4}$ term vanishes, parameter free solutions are obtained. By varying the free parameter, for both $X(3)$-Sextic and $Z(4)$-Sextic, first order shape phase transitions occur from an approximately spherical shape to a well deformed one crossing a critical point where the potential is flat. The structure of the states in the critical points can offer answers concerning the unknown dynamical symmetries of $\mathrm{X}(5)$ [8] or Z(5) [9]. Regarding the applications to experimental data, the parameter free solutions can be used initially as reference points. Finally, the agreement between the theory and experiment is improved by fitting the free parameter, whose values are used to verify if a shape phase transition appears within an isotopic chain.


## References

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