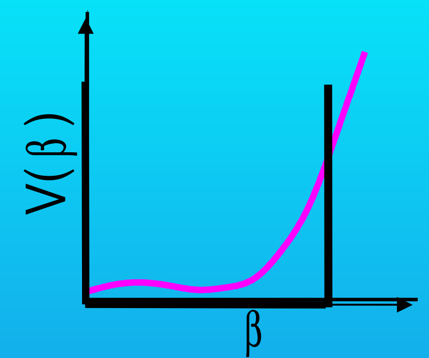
Investigation of critical point symmetries in neutron rich nuclei

D. Tonev, G. de Angelis, P. Petkov, N. Goutev, M.S. Yavahchova, A. Dewald, I. Deloncle, D. Bazzacco, S. Brant, E. Farnea, A. Gadea, C. He, S. Lenzi, S. Lunardi, R. Menegazzo, B. Melon, D. Mengoni, A. Nannini, D. R. Napoli, H. Penttila, A Pipidis, F. Recchia, E. Sahin, C.A. Ur, J.Valiente Dobon, and Q. Zhong

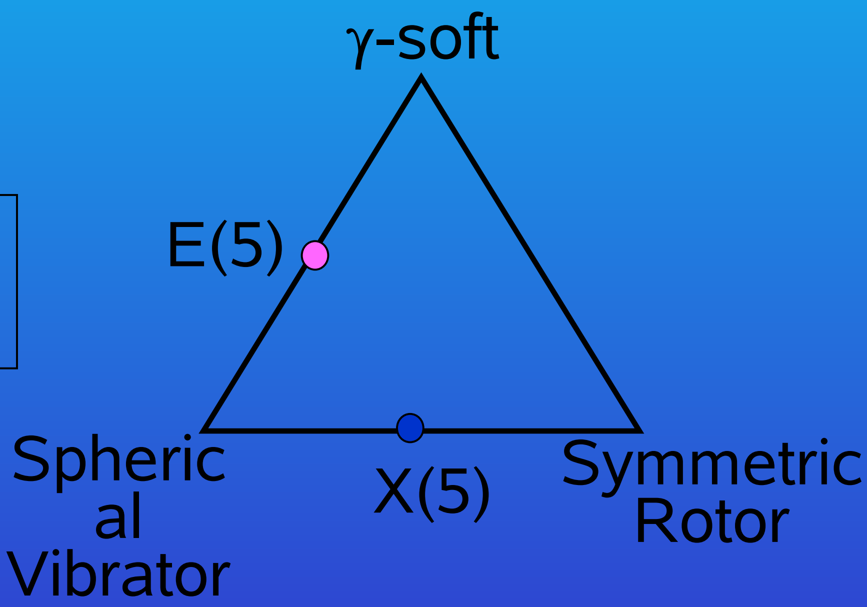
Institute for Nuclear Physics and Nuclear Energy, BAS, Bulgaria
INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy
INFN and Dipartamento di Fisica, Universita di Padova, Italy
IKP, Cologne University, Germany
INFN and Dipartimento di Fisica, Universita di Firenze, Italy
Department of Physics, University of Zagreb, Zagreb, Croatia
University of Jyvaskyla, Finland,
Department o Nuclear Physics, CIAE, Beijing, P.R. China

Critical Point Symmetries

- Approximate potential at phase transition with infinite square well
- Solve Bohr Hamiltonian with square well potential
- Result is analytic solution in terms of zeros of special Bessel functions
- Predictions for energies and electromagnetic transition probabilities



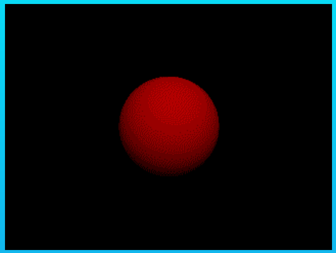
Two solutions depending on γ degree of freedom

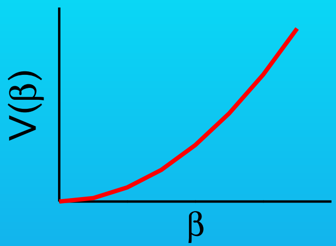


F. Iachello, Phys. Rev. Lett. 85, 3580 (2000); 87, 052502 (2001).

Summary of Structural Benchmarks

Spherical Vibrator

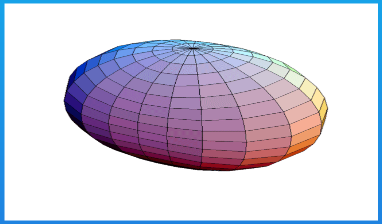


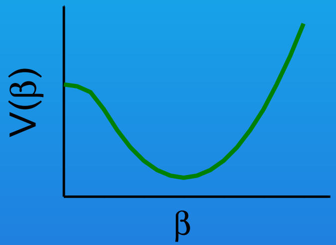


$$E=\hbar\,\omega(N+5/2)$$

$$R_{4/2}=2.0$$

Axially Symmetric Deformed Rotor



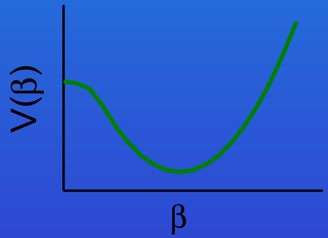


$$E_{rot}=\frac{\hbar^2}{2I}J(J+1)$$

$$R_{4/2}=3.33$$

$$\gamma = 0$$

Deformed γ – soft structure

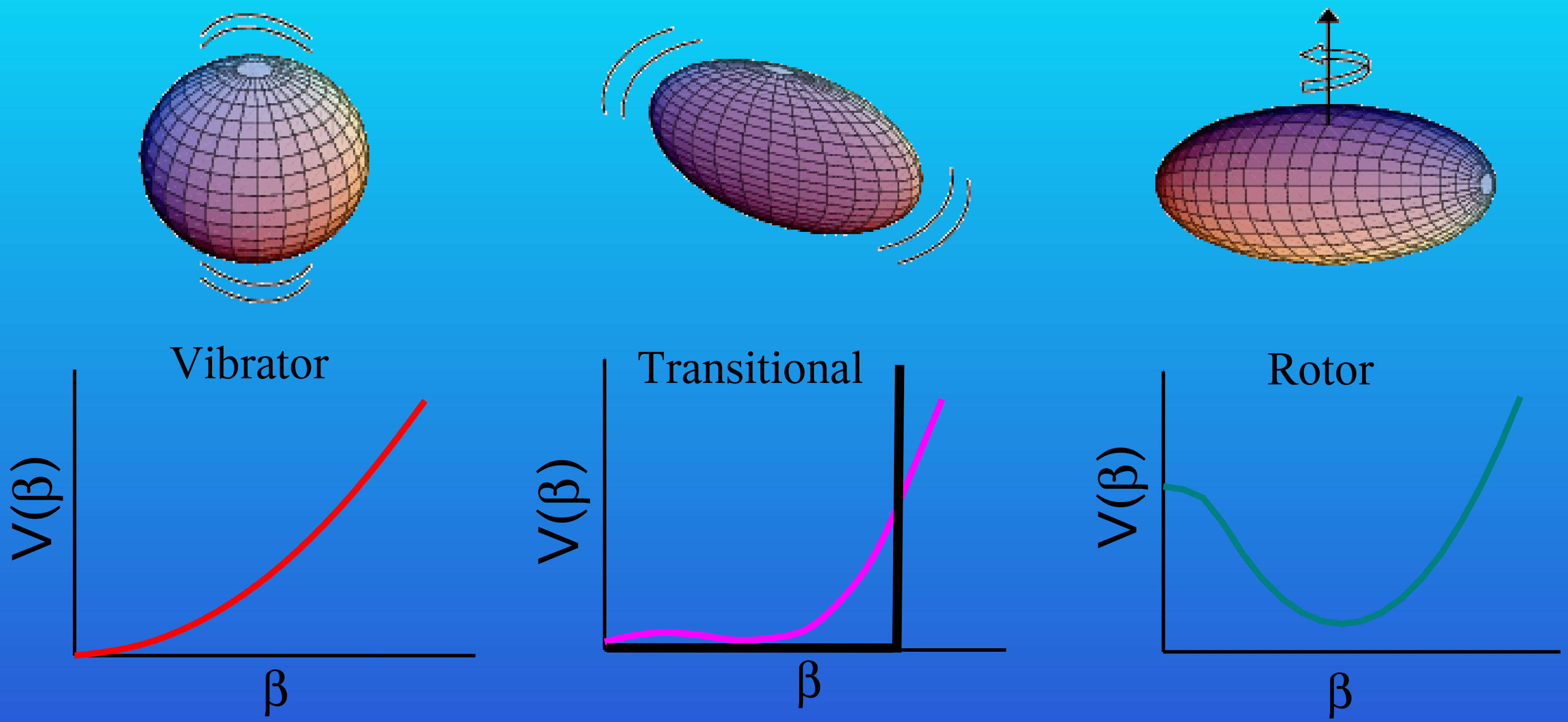


$$E(\tau)=\frac{\hbar^2}{2I}\tau(\tau+3)$$

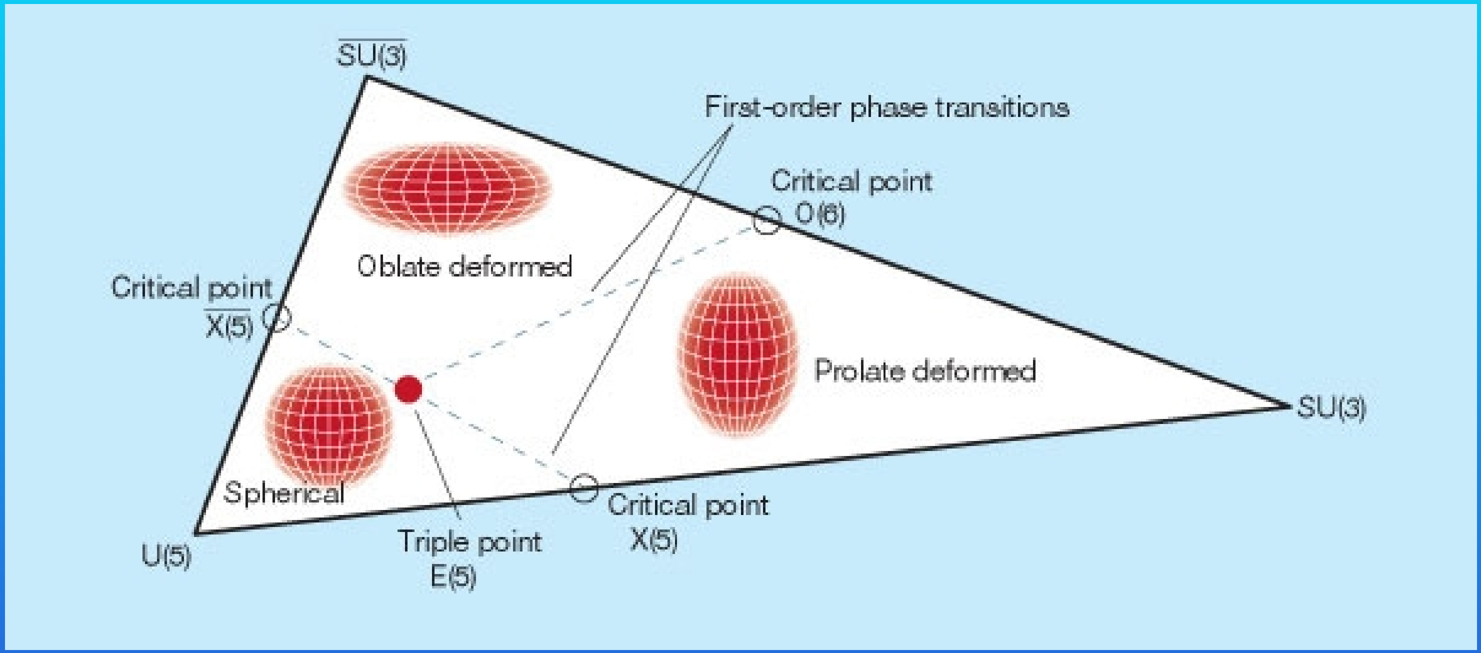
$$R_{4/2}=2.5$$

Potential completely flat in γ degree of freedom

Evolution of Nuclear Shapes



Extended Casten triangle



R.F. Casten, Nature Physics vol. 2, Issue 12 (2006) 811.

X(5) critical point-symmetry candidates

$A\sim150$, $N=90$

^{148}Ce, ^{150}Nd, ^{152}Sm, ^{154}Gd, ^{156}Dy

$A\sim180$

^{176}Os, ^{178}Os

$A\sim165$

^{162}Yb, ^{166}Hf

$A\sim120$

^{122}Ba, ^{126}Ba

$A\sim80$

^{76}Sr, ^{78}Sr, ^{80}Zr, ^{89}Sr

$A\sim100$

^{98}Sr

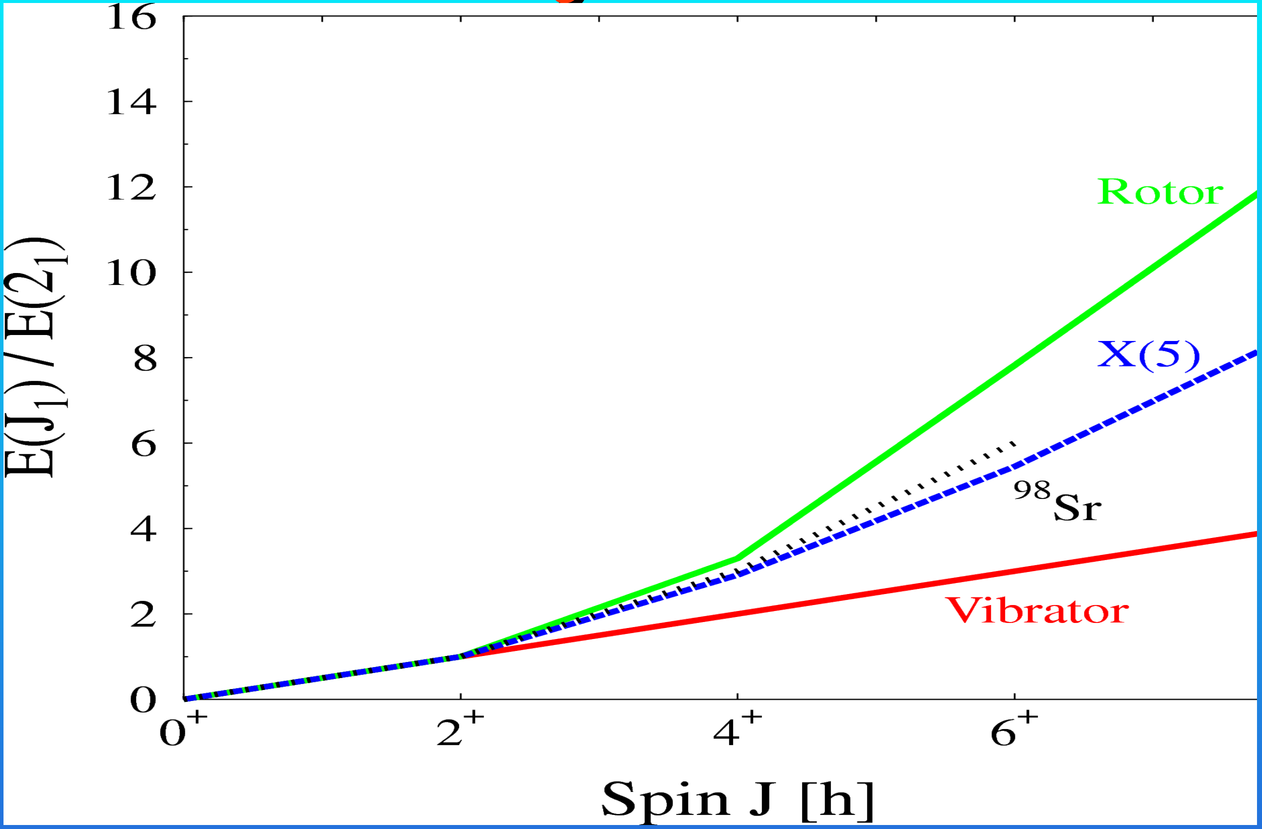
$A\sim130$

^{128}Ce, ^{130}Ce, ^{134}Sm

$A\sim105$

^{104}Mo, ^{106}Mo

Why ^{98}Sr?



Excitation energies have very close to X(5) behaviour

It is one of the first X(5) candidates in a neutron rich mass region.

Lifetime experiements:

We propose to populate excited states in 98Sr through Coulomb excitation

The efficiency for GALILEO array will be about 6% and that of TRACE detector about 50%. Assuming a ^{98}Sr beam intensity of about 1.2 x 10^{4} pps accelerated by SPES radioactive nuclear beam facility we will need about 7 days.

- Beam: ^{98}Sr at an energy of 350 MeV
- Target: 100 mg/cm^{2} gold for RDDS
- Position sensitive silicon detector TRACE will be utilized to detect the scattered beam particles.
- GALILEO gamma ray spectrometer
- Plunger device will used for determination of picosecond lifetimes.