Coulomb excitation of $^{78,80}Sr$ and deformation around N=Z=40

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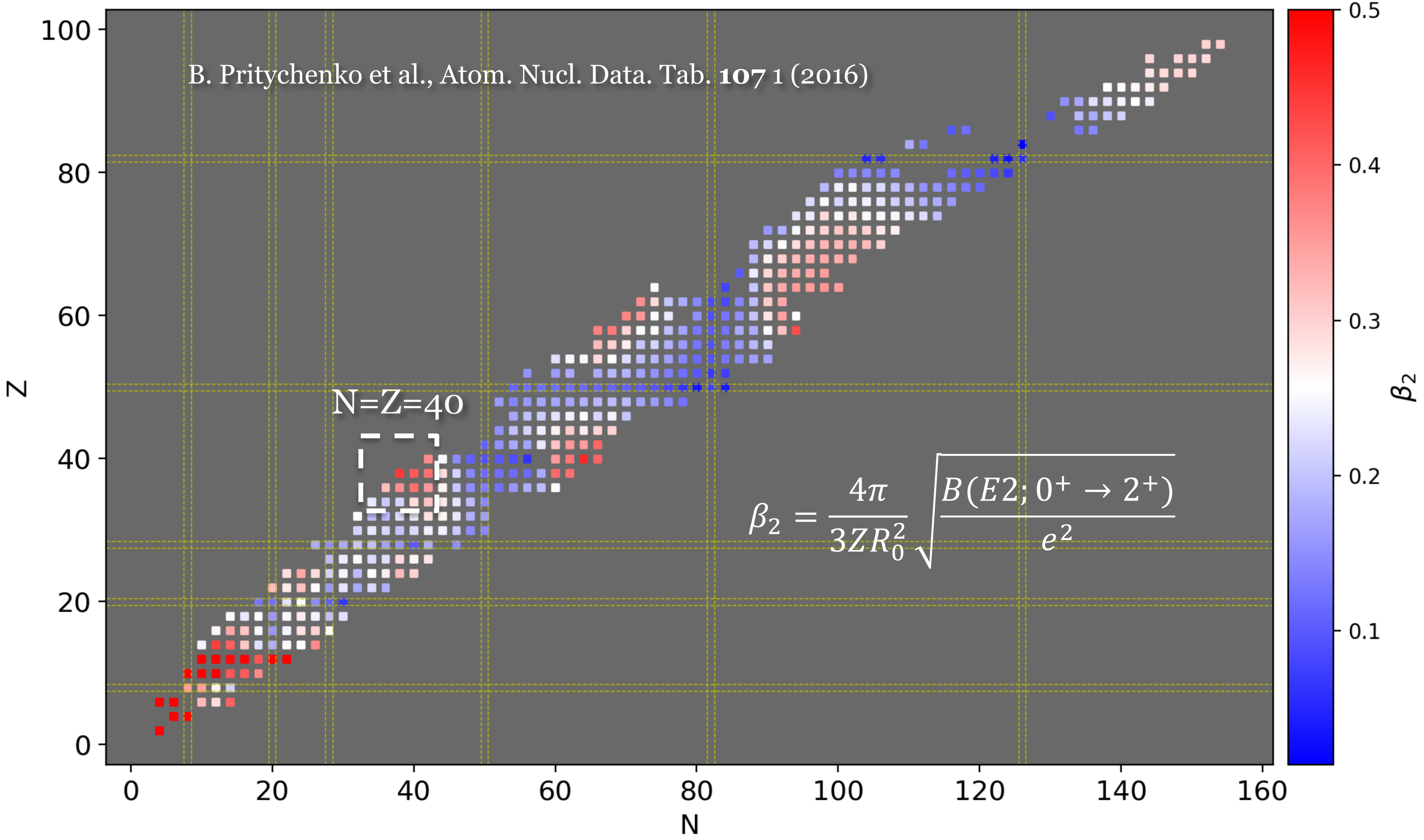
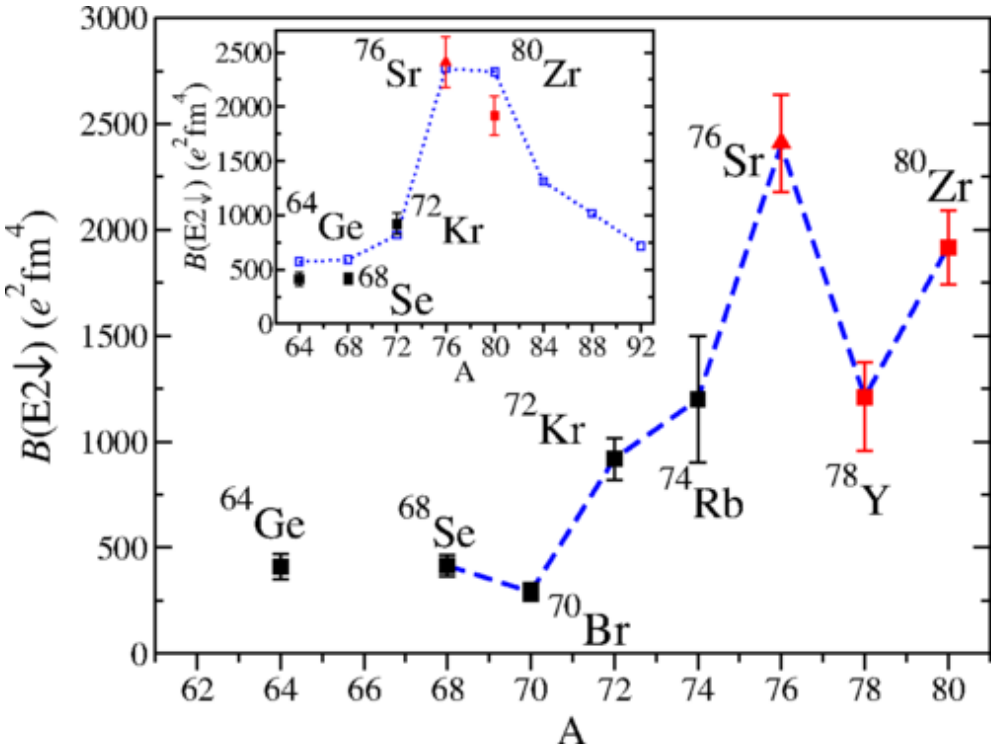
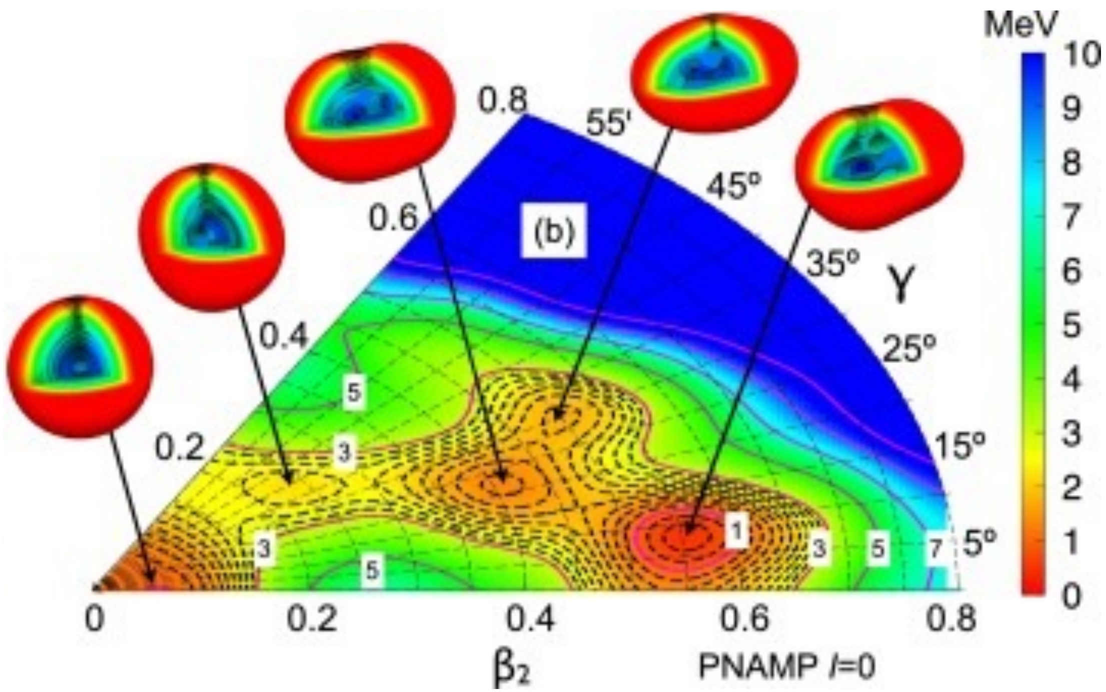
Quadrupole deformation: A global perspective



The N=Z=40 region: deformation and shape coexistence



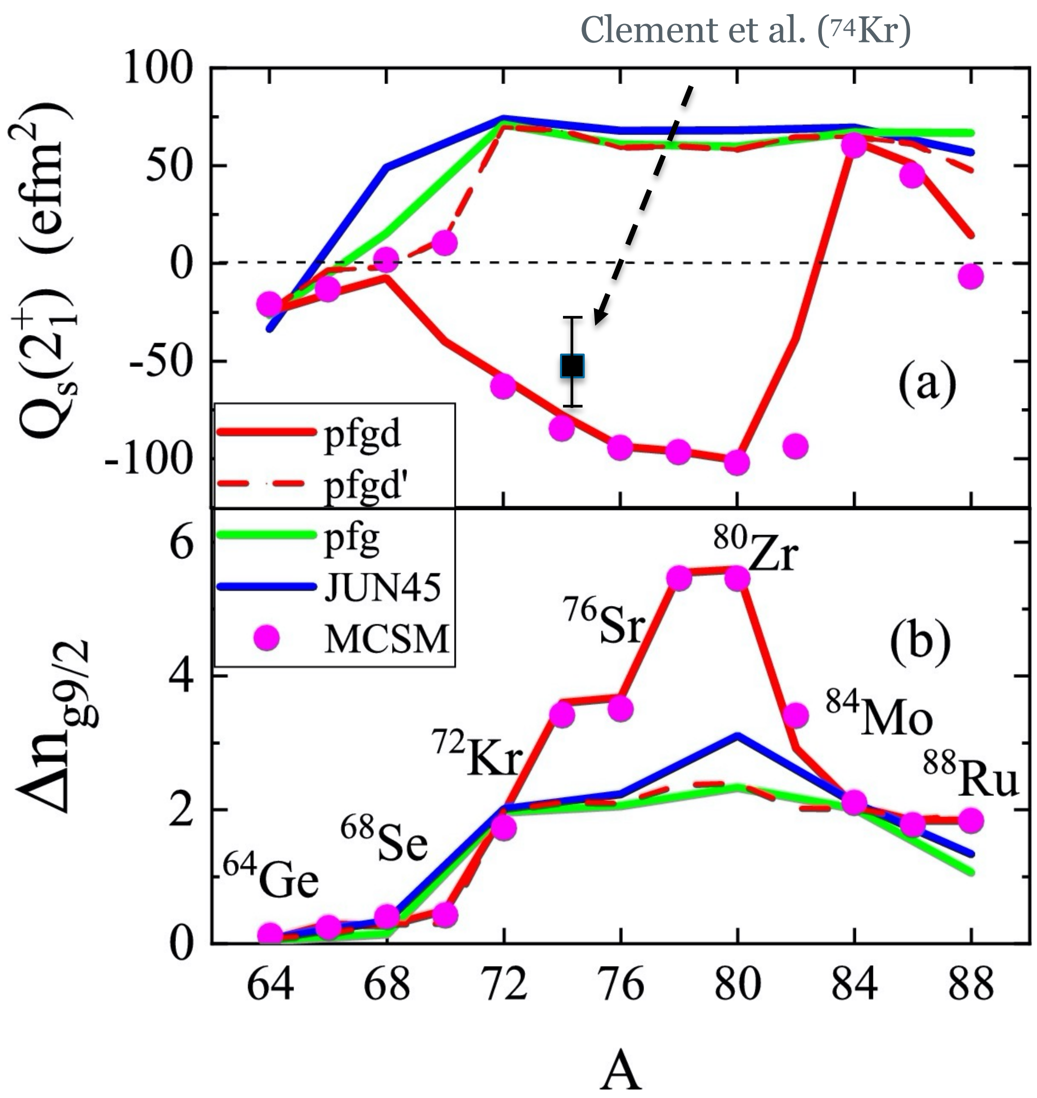
R. D. O. Llewellyn et al., PRL **124** 152501 (2020)



T. R. Rodriguez & J. Luis Egido, PLB **705** 255 (2011)

Driven by multiple strongly-deformed shell gaps and *compounded* by the proximity of the line of N=Z

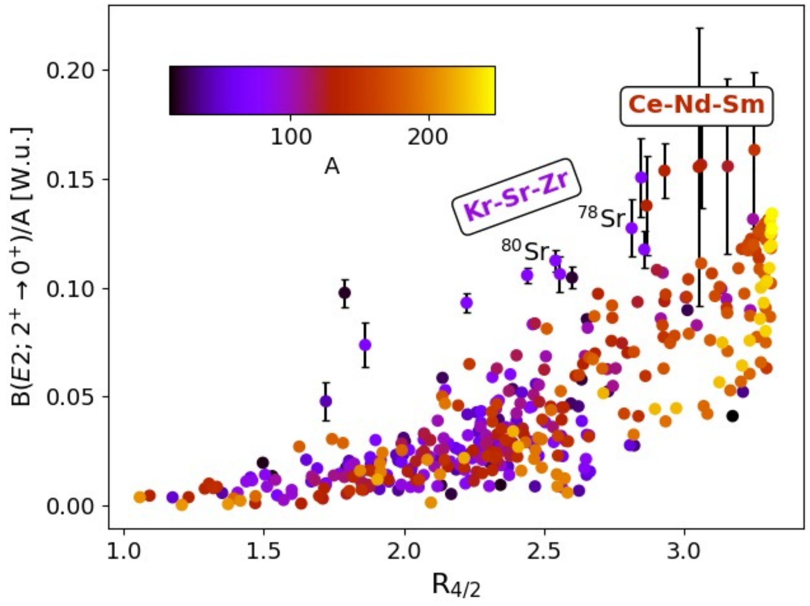
Microscopic drivers: quasi-SU(3) partners



Kaneko et al. [PLB **817** 136286 (2021)] find that interplay between $2d_{5/2}$ + $1g_{9/2}$ drives deformation

Inclusion of $2d_{5/2}$ takes systems from modestly oblate to strongly prolate: large, negative $Q_s(2+)$

Isotopes are clear outliers in systematics: can be *partly* explained in quasi-SU(3) model, but e.g. R_{42} < 3.3 is not reproduced. Might other effects play a role?



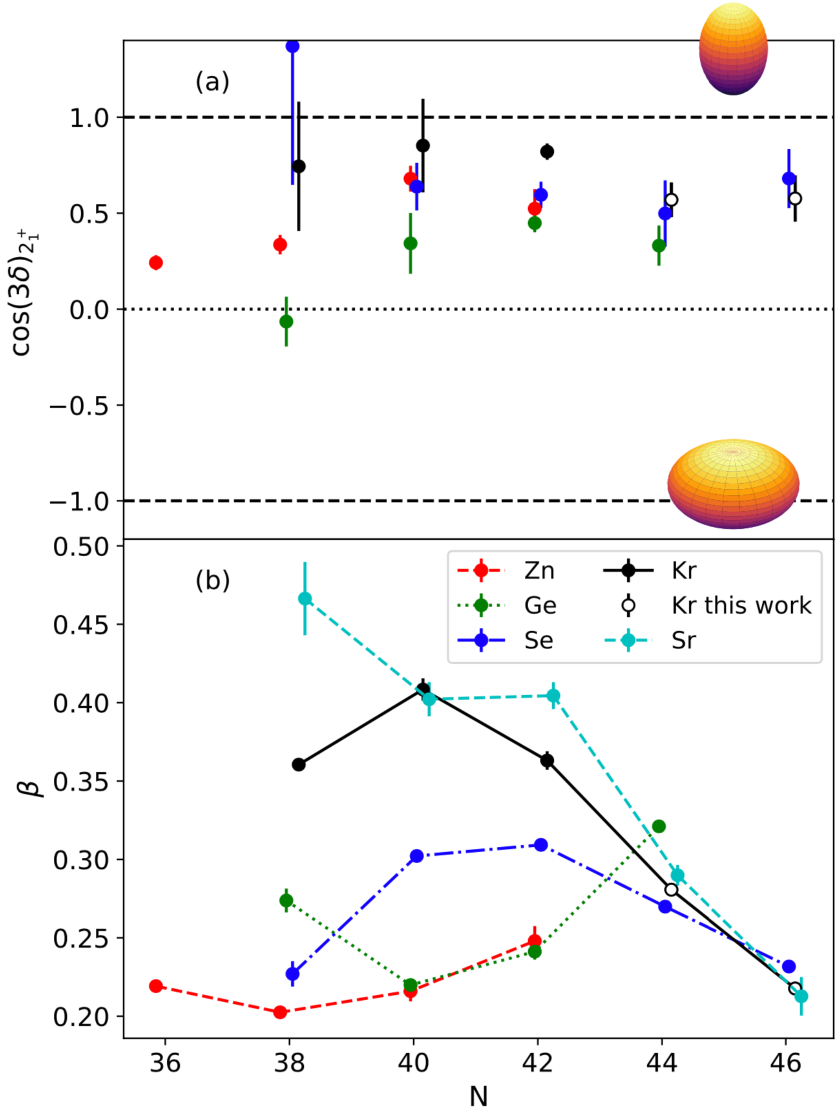
Neutron deficient Sr: maximal quadrupole deformation

Approximate solution from Kumar-Cline sum rules:

$$\cos(3\gamma) = -\frac{Q_s(2_1^+)}{\frac{2}{7}\sqrt{\frac{16\pi}{5}B(E2;0_1^+ \rightarrow 2_1^+)}}$$

Empirical determination of $\cos(3\gamma)$: evolution towards near-axial, strongly prolate systems in Sr [PRC **104** 044313 (2021)]

Unclear (due to uncertainties) how well ^{74,76}Kr supports this picture [Clement *et al.*, PRC **75** 054313 (2007)]



Resolving deformation around N=Z=40: Coulomb excitation of ^{78,80}Sr

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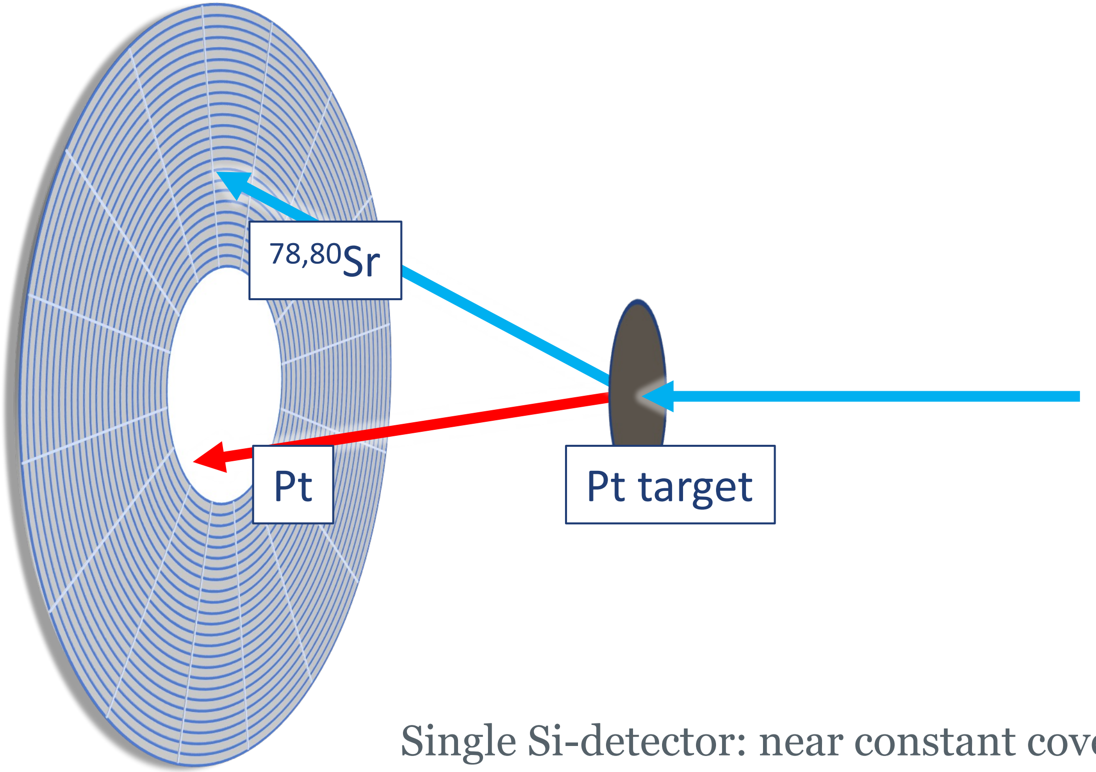
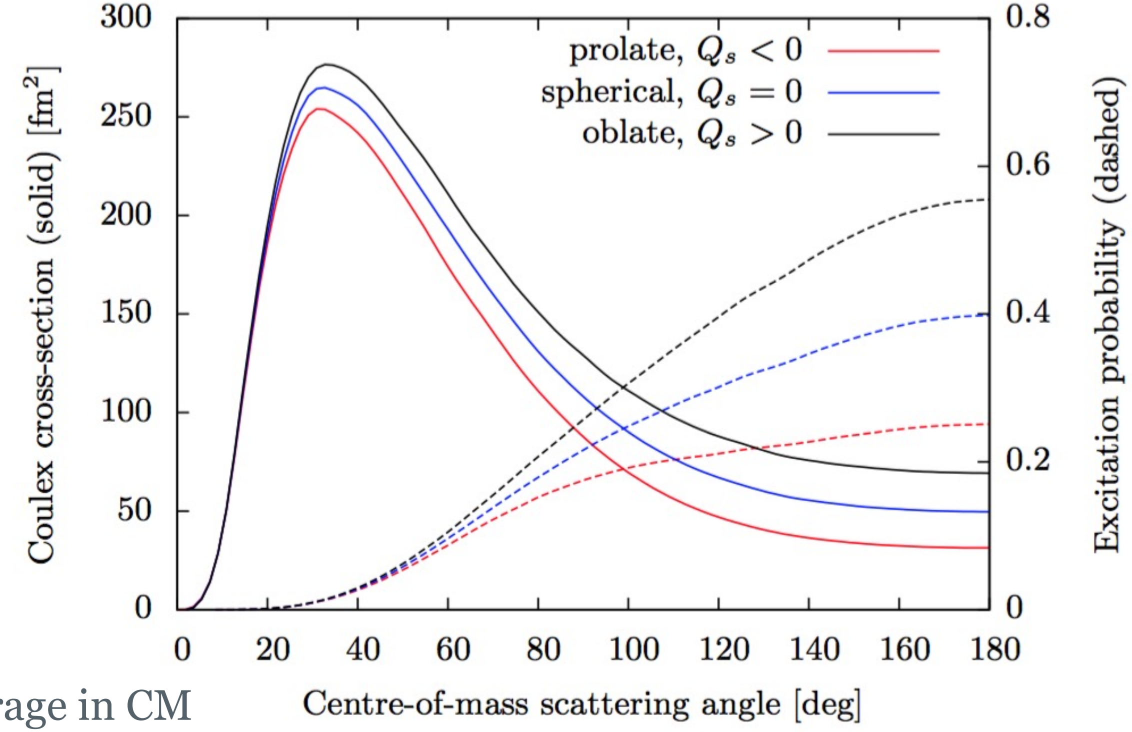
Predictions of $Q_s(2^+)$ from *pfgd* shell model calculations *must* be confronted with experimental data

Determination of $Q_s(2^+)$ experimentally *only* possible for ^{78,80}Sr through reorientation effect in Coulomb excitation



Annular Si detector

Single Si-detector: near constant coverage in CM



M. Zielinska et al. Eur. J. Phys. A **52** 99 (2016)

Additional information

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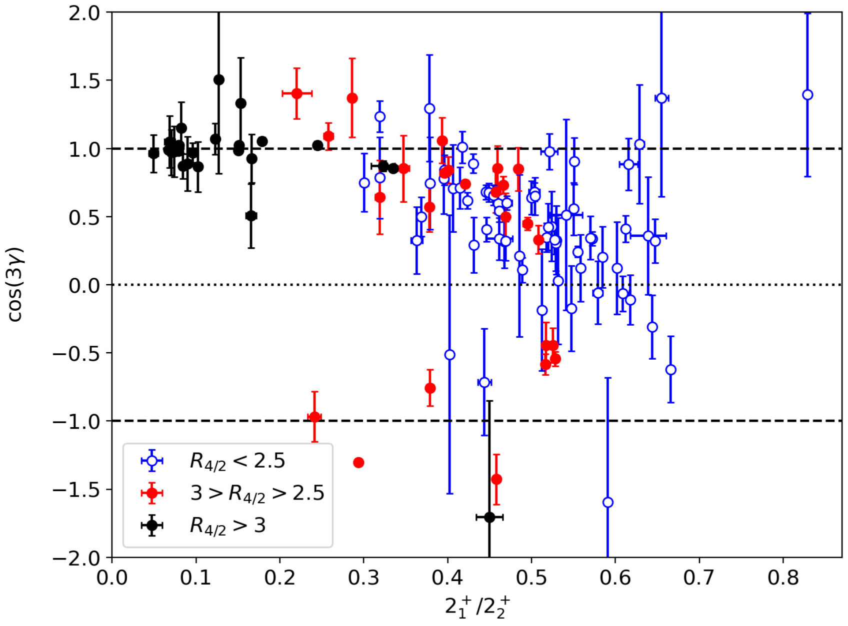
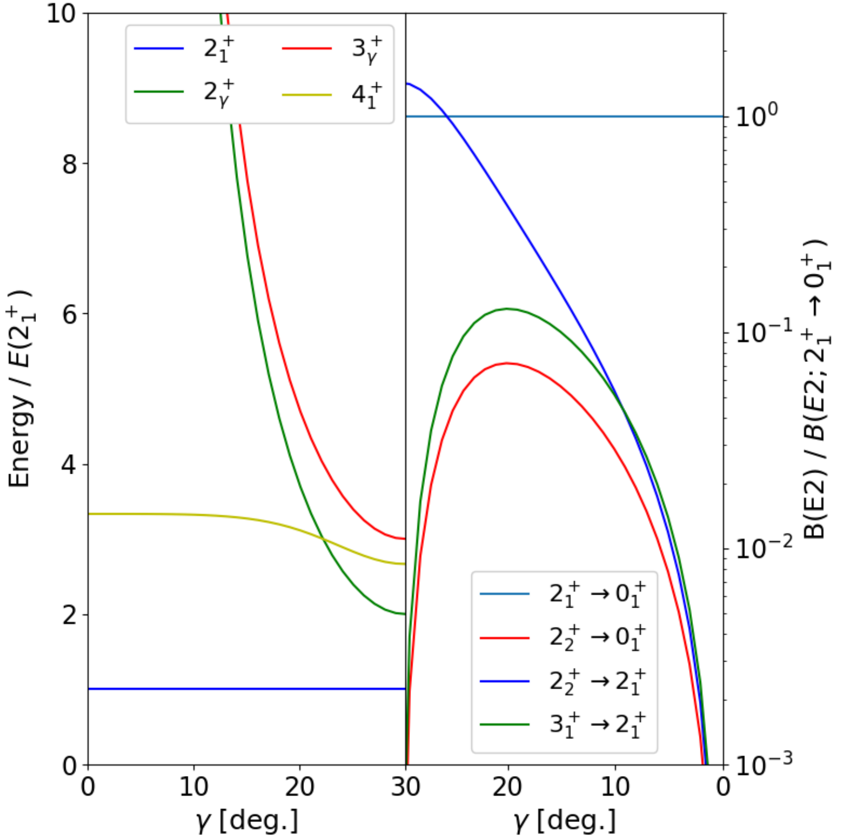


(Tri)Axiality can also be probed through level energies

Low-lying 2nd 2^+ state ("γ band") indicates some triaxiality

In Coulomb excitation, clean population on 2nd 2^+ state anticipated (if physics allows)

More challenging: second 0^+ indicative of shape coexistence – likely requires strong mixing or *very* low-lying state



Beam challenges: Rb contamination

Neutron-deficient Group II elements (Sr) always struggle due to Group I (Rb) contamination

Need to suppress Rb contamination, options:

- LIST – suppress surface-ionized contaminants at the source
- Molecular beams – SrF^{+} extracted from the source and broken up in the EBIS
- Timed release – fast-released Rb is blocked, slow(er)-released Sr is transmitted

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For the purpose of this proposal we assume LIST. Molecular extraction efficiency isn't clear and timed release may not be suitable.

LIST will require running lasers on/off to subtract remaining background (also suppressing Kr)

TAC suggestion of pulsing the target and allowing ^{80}Rb to decay before extracting ^{80}Sr is an option, but significant advantages (common systematics, etc.) to running ^{78,80}Sr back-to-back

Anticipated yields

Based on SC yields, we anticipate yields of 5×10^5 and 3×10^3 pps for ^{80}Sr and ^{78}Sr, respectively

Large B(E2) and low E(2^+) values → good yields

Anticipate multiple 2^+ states in ^{80}Sr and the first- and second-excited states in ^{78}Sr

Low-background measurement: a high energy decay from a 2^{nd} 2^+ in ^{78}Sr would be observable (or limits can be placed)

		Counts / 5×10^5 pps / day					
^{80}Sr	2_1^+	4_1^+	0_2^+	2_2^+	2_3^+	6_1^+	8_1^+
	2.2×10^5	3.4×10^4	230	340	55	7900	730
		Counts / 3×10^3 pps / day					
^{78}Sr	2_1^+	4_1^+	2_2^+*				
	1.8×10^3	260	4				

Beam request

To allow for Rb and Kr subtraction, we require 1:1 signal to background running – ideally alternating supercycles to minimize variations

To achieve sufficient statistics for ^{78}Sr (e.g. >5x10^3 counts in $2^+ \rightarrow 0^+$) requires three days running in signal mode

To achieve sufficient statistics for ^{80}Sr requires one day in signal mode

We therefore request a total of **six days** for ^{78}Sr and **two days** for ^{80}Sr including both signal and background running

Beam energies at the safe limit (i.e. 4.26 MeV/u) will be used to maximize statistics

Summary

Low-energy Coulomb excitation measurements around N=Z=40 are the **only** way to resolve the different deformed configurations

Neutron-deficient Sr isotopes are exceptionally strongly deformed but the form of deformation remains unclear

The low background of sub-barrier Coulomb excitation also makes for a good environment for the study of low-lying, off-*yrast* 2^+ states – symptomatic of triaxiality

Good Sr yields combined with methods to suppress Rb contamination and subtract backgrounds make experiments feasible, with abundant lifetime data available to constrain Coulomb excitation analyses