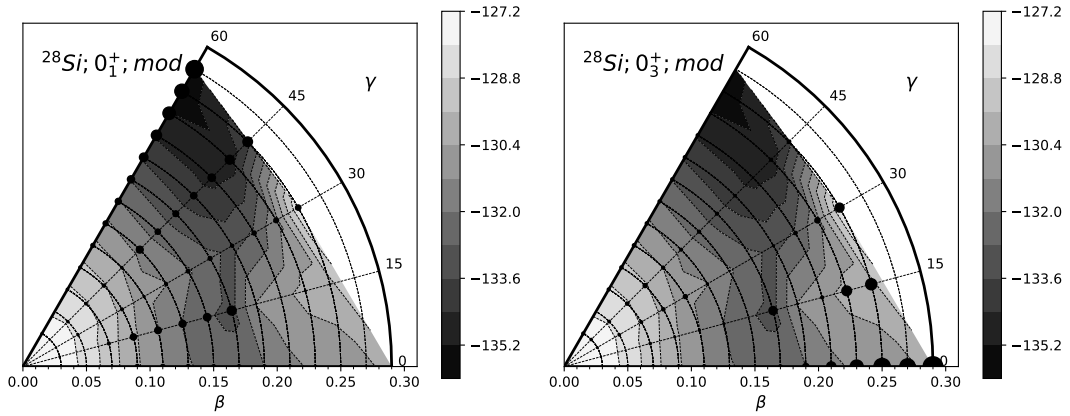
Shape coexistence and superdeformation in ^{28}Si

D. Frycz[1], J. Menendez[1], A. Rios[1], and A. M. Romero[1]
[1] *University of Barcelona, Barcelona, Spain*

We analyze the ^{28}Si nucleus using state-of-the-art numerical shell model calculations as well as the generator-coordinate method (GCM) with quadrupole constrained Hartree-Fock-Bogoliubov (HFB) wavefunctions. Experimentally, ^{28}Si presents shape coexistence between the oblate ground state and an excited prolate structure [1]. Although the standard USDB interaction reproduces well the oblate ground state and the vibrational bands, it fails at establishing a prolate band. A modification of the USDB interaction must be introduced to reproduce the experimental spectrum. Guided by Elliot's SU(3) scheme, we show that this is achieved by slightly lowering the gap between the nearly degenerate $0d_{5/2}$-$1s_{1/2}$ doublet and the $0d_{3/2}$ orbital. Our calculations suggest that the oblate ground state is mostly 0p-0h, whereas the prolate band consists mainly of 4p-4h excitations into the $0d_{3/2}$ orbital.

Additionally, we study whether ^{28}Si can exhibit a superdeformed structure at higher energies. In order to achieve such deformations, excitations from the sd to the pf shell must be taken into account. We find that most of the deformation contribution comes from the $0f_{7/2}$-$1p_{3/2}$ doublet and that the most favorable states are prolate 2p2h and 4p4h excitations into the pf shell. In contrast to previous studies [2], our numerical calculations suggest that this superdeformed state would mix with normal-deformed configurations, and therefore ^{28}Si would not present a superdeformed band. Overall, our study combines shell-model and beyond-mean-field HFB techniques to shed light on the rich coexistence of differently deformed states in ^{28}Si [3,4], challenging the established understanding of its nuclear structure.



(a) Oblate ground state.

(b) Prolate bandhead.

FIG. 1: Energy surfaces projected to J=0 for ^{28}Si. The size of the dots represents the weight of the HFB wavefunction in the considered state.

[1] L. Morris *et al.*, Physical Review C **104.5** (2021) 054323.
[2] Y. Taniguchi *et al.*, Physical Review C **80** (2009) 044316.
[3] Bachelor's thesis: http://hdl.handle.net/2445/188691
[4] D. Frycz, *et al.*, in preparation.