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Quadrupole moment of the yrast superdeformed band in ^{192}Pb

A.N. Wilson [a,b,*], G.D. Dracoulis [a], P.M. Davidson [a], A.P. Byrne [a,b], R.M. Clark [c], P. Fallon [c], A. Görgen [c,1], G.J. Lane [a], A.O. Macchiavelli [c], D. Ward [c]

[a] *Department of Nuclear Physics, Research School of Physical Sciences and Engineering, Australian National University, Canberra ACT 0200, Australia*
[b] *Department of Physics, Faculty of Science, Australian National University, Canberra ACT 0200, Australia*
[c] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA*

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Abstract

The lifetimes of states with spins $26\hbar \geqslant I \geqslant 18\hbar$ in the yrast superdeformed band of ^{192}Pb have been measured using the Doppler shift attenuation method. The results are consistent with a constant quadrupole moment $\langle Q_0 \rangle = 19.6^{+0.5}_{-0.4}(\text{stat}) \pm 2.0(\text{sys})$ eb. This result is comparable with the values obtained for SD bands in Pb isotopes with $N \geqslant 112$, but could also be consistent with the smaller quadrupole moment measured in ^{193}Pb. Reasons for the apparently lower deformation of SD ^{193}Pb (compared to its heavier neighbours) are considered in the light of total Routhian surface calculations, and the question of whether a similarly reduced deformation should be expected in ^{192}Pb is addressed.

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* Corresponding author.
E-mail address: anna.wilson@anu.edu.au (A.N. Wilson).
[1] Present address: CEA Saclay, DAPNIA/SPhN, Bat. 703, l'Orme des Merisiers, F-91191 Gif-sur-Yvette, France.

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1. Introduction

1.1. Motivation for lifetime measurements in superdeformed nuclei

The first evidence for an island of superdeformation around mass number $A \approx 190$ came with the observation of a superdeformed band in ^{191}Hg by Moore et al. [1] in 1989. Since then, 83 superdeformed rotational bands have been observed in this mass region in 25 isotopes of Au, Hg, Tl, Pb, Bi and Po [2]. It is well established that the superdeformed minimum in this region is associated with the presence of $N = 6$ ($i_{13/2}$) proton and $N = 7$ ($j_{15/2}$) neutron intruder orbitals, which are close to the Fermi surface at large deformations. However, the precise order of the orbitals close to the Fermi surface, and whether or not the number of *occupied* intruder orbitals polarizes the nuclear shape, is not known.

Unfortunately, the experimental evidence needed to determine the microscopic structure of SD bands has been very limited, mainly because of the difficulty of connecting the SD bands into the normal level scheme. Direct linking transitions between SD and ND states, which allow absolute excitation energies, spins and parities to be established, have been observed in only a handful of cases [3–7] in this mass region. With the exception of an excited band in ^{194}Hg [4], all of the SD bands for which excitation energies have been measured are the yrast bands in even–even nuclei, and are therefore associated with the superdeformed "vacuum" state. The superdeformed states in nuclei with $A \approx 190$ occur at sufficiently low spins that the SD nuclei are strongly affected by pairing correlations, and so the SD vacuum is not simply described in a single-particle picture. Thus even where this detailed information is available, little light has been shed on the underlying nuclear structure.

Uniquely in this mass region, it has been possible to obtain strong evidence for a particular configuration assignment in those cases where g-factors can be extracted for signature partner bands [8–11]. However, such information is limited to those cases where both in- and inter-band transitions are observed: that is, to odd-A nuclei where the valence nucleon occupies a relatively high-K orbital.

One other way in which information has been gleaned about the underlying single-particle configurations is through the measurement of the lifetimes of the in-band superdeformed transitions. With the construction of the high-efficiency γ-ray detector arrays Gammasphere and Euroball, it has been possible to perform comparative measurements, in which several SD bands are populated via reactions on a single target, and their lifetimes measured using the Doppler shift attenuation method (DSAM). Such experiments allow the lifetimes of states with comparable properties to be measured with good relative precision, despite the large uncertainty (of the order of 10% [12]) in the stopping powers. As the intruder orbitals are primarily responsible for the formation of the superdeformed minimum, it might be expected that the higher the number of intruder orbitals occupied in a particular SD band, the larger the nuclear deformation. It was hoped that measurements of the quadrupole moments of SD bands across an isotopic chain, or of different SD bands