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First direct measurement of the intrinsic dipole moment in pear-shaped thorium isotopes

It is now well established that atomic nuclei composed of certain combinations of protons and neutrons can adopt reflection-asymmetric, or octupole-deformed, shapes at low excitation energy. These nuclei show promise in the search for a permanent atomic electric dipole moment, the existence of which has implications for physics beyond the Standard Model. Theoretical studies have suggested that certain isotopes of thorium may have the largest octupole deformation. However, due to experimental challenges, the extent of the octupole collectivity in the low-energy states in these thorium nuclei has not yet been demonstrated. This paper reports measurements of the lifetimes of low-energy states in ^{228}Th ($Z = 90$) undertaken using the mirror symmetric centroid difference method and a natural thorium source. Lifetime measurements of the low-lying $J^{\pi} = 1^{-}$ and 3^{-} states, which are the first for a thorium isotope, have allowed the $B(E1)$ rates and the intrinsic dipole moment to be determined. The results are in agreement with those of previous theoretical calculations allowing the extent of the octupole deformation of ^{228}Th to be estimated. This study indicates that the nuclei ^{229}Th and ^{229}Pa ($Z = 91$) may be good candidates for the search for a permanent atomic electric dipole moment. The potential to extend such source measurements at iThemba Labs will be discussed.

Primary author: Dr O'DONNELL, David (University of the West of Scotland)

Co-authors: Dr CHISHTI, Muhammad Rauf (University of Surrey); Mr BATTAGLIA, Giorgio (University of Strathclyde); Dr BOWRY, Michael (University of the West of Scotland); Prof. JAROSZYNSKI, Dino (University of Strathclyde); Dr NARA SINGH, Bondili Sreenivasa (University of the West of Scotland); Prof. SCHECK, Marcus (University of the West of Scotland); Dr SPAGNOLETTI, Pietro (University of the West of Scotland); Prof. SMITH, John F (University of the West of Scotland)

Presenter: Dr O'DONNELL, David (University of the West of Scotland)

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