Characterising Nuclear Decay Schemes: Nuclear Structure to Radiological Standards

P.H.Regan

Department of Physics, University of Surrey, Guildford, GU2 7XH, UK &
National Physical Laboratory, Teddington, Middlesex, TW11 OLW, UK

ABSTRACT

Radioactive decays from the atomic nucleus have been studied for more than 100 years, since the discovery of radioactivity in uranium salts by Henri Becquerel in the late 19th century. There followed an explosion of scientific investigation aimed at the characterisation of decay products from nuclear excited and ground states with the aim of using the decay signatures associated with individual radioactive species to provide data towards for a universal understanding of nuclear structure. Included in such fundamental studies are the discussion of the evolution of the shape of the nuclear mass and charge distributions and how these vary from sphericity as a function of proton and neutron number. Nuclear systems can be excited into a range of non-spherical shapes, including prolate and oblate deformed. The first part of this talk will present some state of the art nuclear structure results pertaining to the nuclear shape evolution, including how this is established and quantified. Specific examples from neutron-rich Osmium isotopes [1] (which are predicted to switch suddenly between prolate and oblate shapes at neutron number N=116) and the neutron-rich Dysprosium isotope $^{170}Dy_{104}$ [2] (which represent the nuclear system with the largest proton-neutron valence product for stable elements) will be discussed. While these studies represent frontiers measurements in nuclear structure, the second part of the talk will include examples of how similar experimental and analysis methods used in this type of research can find direct impact in both environmental monitoring of radioactive waste materials [3] and radiopharmaceutical standardisations, which underpin radioisotope application in the medical arena [4].

REFERENCES:

[1] T. Daniel et al., *γ-ray spectroscopy of low-lying states and shape competition in ^{194}Os* Phys. Rev. C**95** (2017) 024328 https://doi.org/10.1103/PhysRevC.95.024328

[2] P.A. Söderström et al, *K-mixing in the doubly mid-shell nuclide ^{170}Dy and the role of vibrational degeneracy*, Physics Letters B**762** (2016) p404-408, https://doi.org/10.1016/j.physletb.2016.09.058

[3] N. Alazemi et al., *Soil radioactivity levels, radiological maps and risk assessment for the state of Kuwait*, Chemosphere, vol. **154** (2016) p55-62, https://doi.org/10.1016/j.chemosphere.2016.03.057

[4] S.M.Collins et al., Precise measurements of the absolute *γ*-ray emission probabilities of ^{223}Ra and decay progeny in equilibrium, Applied Radiation and Isotopes vol. **102** (2015) p15-28, https://doi.org/10.1016/j.apradiso.2015.04.008;
S.M. Collins et al., *Investigation of γ-γ coincidence counting using the National Nuclear Array (NANA) as a primary standard*, Applied Radiation and Isotopes vol. **134** (2018) p290-296, https://doi.org/10.1016/j.apradiso.2017.07.056;
P.H.Regan et al., *Radionuclide Metrology and Standards in Nuclear Physics*, Nuclear Physics News International September 2018, DOI:10.1080/10619127.2018.1495482)