Shape effects and beta decay: what can we learn from TAS experiments

A. Algora

IFIC (CSIC-Univ. Valencia), Valencia, Spain

INTRODUCTION

Nuclear shapes and in particular nuclear deformation plays a key role in our understanding of nuclear structure. From the historical point of view it is interesting to see its evolution and how the concept become so necessary for our understanding of nuclear states. Actually it dates back to the 1950s when the interpretation of a large amount of accumulated nuclear data related to multipole moments, Coulomb excitation, large B(E2)-s, etc, leaded to the introduction of deformation and collectivity. An overview can be obtained from Aage N. Bohr's Nobel talk [1]. Since the 1950s, nuclear shape becomes a concept and an important tool for testing nuclear models.

But experimentally how do we deduce nuclear shapes? There are several ways and methods. We can obtain information on the deformation by means of measurements of nuclear electric quadrupole moments, which provide a direct measurement of the departure from sphericity. We can also determine the nuclear radii by scattering experiments and deduce the corresponding nuclear shape. The probes can be hadrons or charged particles and depending on that we can obtain information on the Coulomb radius or the mass radius. We can probe the shape by Muonic atoms or laser spectroscopy methods, which again can provide information on the departure from sphericity. The interpretation of nuclear spectroscopic data is also a source of shape information. From level lifetimes, B(E2)-s, etc., deformation can be deduced. More difficult is to obtain information on the sign of the deformation. One possibility is to obtain the sign of deformation from in-band multipole mixing ratios (from angular distributions). E0 transitions are also a "traditional" source of information, mainly related to shape changes and shape mixing. It is important to remember that shape is always model dependent in nuclear structure.

BETA DECAY and DEFORMATION

Beta decay can be a source of spectroscopic information, from which shape can be deduced. But there is also another alternative, based in the pioneering work of I. Hamamoto [2], and later followed by studies of P. Sarriguren *et al.* [3], Petrovici *et al.* [4] and references therein, which is related to the dependency of the beta strength distribution in the daughter depending on the assumed shape of the parent nucleus. This method can be used when theoretical calculations predict different strength distributions for the possible shapes of the decaying ground state (prolate, spherical, oblate). The procedure can be of particular interest since in some cases it can provide information on the shape for decaying 0^+ ground states.

DEFORMATION and THE TAS TECHNIQUE

The feasibility of this procedure depends on the precision of the experimental determination of the strength distribution. For these measurements total absorption is the most appropriate technique. This technique is based on the detection of the gamma cascades that follow the beta decay instead of detecting the individual gamma rays as we do in conventional Ge or high-resolution gamma spectroscopy. With the use of a highly efficient device, in essence a calorimeter placed around the source, efficiency close to 100 % for detecting gamma cascades can be achieved and then the so-called Pandemonium effect can be avoided.

This method has been applied successfully for example in the A~80 region, which is characterized by drastic shape changes and shape coexistence. In Nácher *et al.* [5], we confirmed that ^{76}Sr is one of the most deformed prolate N=Z nucleus in nature, and in Poirier *et al.* [6], we showed that ^{74}Kr is mixed in its ground state with this alternative technique. More recently we have extended these studies to the Pb region, where the beta decay of ^{188,190,192}Pb has been studied using the *Lucrecia* TAS spectrometer at CERN. Our preliminary results show, that even though the agreement between theory and experiment is not so spectacular compared with the A~80 region, the method can provide an alternative way for shape determination in the heavier domains [7]. We plan to continue this line of research for Hg, Po isotopes for which theoretical calculations are already available [8].

The future EURISOL facility, with beams of higher intensity for isotopes of interest for this application, can provide new opportunities for the study of nuclear shape effects using the total absorption technique.

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