Electric monopole transitions in nuclei

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Electric monopole, E0 transitions are unique to nuclei; they are not observed in any other manifestations of matter. The reason for this ‘‘isolated’’ manifestation is because photons have spin one, and nuclei are well isolated from their environment by atomic electrons. Thus, electromagnetic decay by single-photon emission is forbidden for a transition between two states with spin zero [1]. However, decay is possible through the interaction between the nucleus and its atomic electrons: the so-called internal conversion process. While the formation region of higher multipole order transitions (E1, M1, E2, etc.) is dominantly outside the nucleus, the formation region of E0 transitions, involving a different set of nuclear matrix elements, takes place inside the nuclear volume. Decay is also possible through the creation of electron–positron pairs (if the decay energy exceeds the mass of the pair, i.e., $\Delta E > 1.022$ MeV). This is the so-called internal pair formation (IPF).

States with spin zero in nuclei are of particular interest. This has always been true but has acquired enhanced significance in the last twenty years. The reason is that they are a sensitive indicator of nuclear structure. In particular, at low energy, excited states with spin zero and positive parity, 0^+ states are associated with either changes in pair-correlated structure or changes in deformation (shape) relative to the ground state of the nucleus. The largest E0 transition strengths are consistent with changes in deformation: thus, we consider them a compelling spectroscopic fingerprint of shape coexistence in nuclei. The issue of shape coexistence in nuclei has progressively become an ever more fundamental one over the past fifty years: it may be said, along with the domination of nuclear structure by deformed shapes, to have become a leading indicator of the fundamental defining characteristics of atomic nuclei.

In this talk recent results from studies on ^{12}C [2,3], ^{24}Mg [4] and ^{40}Ca [5] will be used to examine selected nuclear structure questions where the observation and characterisation of E0 transitions were crucial.

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