Beta Transitions (β^-, β^+, and ε decays):

Y.A. Akovali, Oak Ridge National Laboratory
and
B. Singh, McMaster University
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Beta transitions are classified as allowed or forbidden.

(a) Allowed transitions occur between states with the same parity ($\pi_i \bullet \pi_f$ =+1) and with a spin difference of J_i - J_f =ΔJ=0 or ±1.

> The spins of the emitted beta and neutrino can couple to S=0 (called Fermi transitions) or to S=1 (called Gamow-Teller transitions). Transitions with ΔJ=±1 are pure Gamow-Teller decays, and pure Fermi transitions can only occur between J=0 nuclear states. All other ΔJ=0 transitions are mixed Fermi and Gamow-Teller decays.

(b) Forbidden transitions are further subdivided into their order of forbiddenness, the transitions becoming slower as the order increases. A general definition for an n–times forbidden beta transition is

$\Delta\pi=\pi_i \bullet \pi_f =(-1)^n$, ΔJ=n, n+1 (except first-forbidden which may have ΔJ=0)

ΔJ= n+1 transitions are called n^{th} forbidden-unique beta transitions

Therefore:

- first-forbidden transitions (n=1) occur between states with different parity ($\pi_i \bullet \pi_f$ =-1) and with a spin difference of ΔJ= 0, ±1, ±2; those with ΔJ= ±2 are specified as being first-forbidden unique;
- second-forbidden (n=2) beta transitions occur between states with same parity ($\pi_i \bullet \pi_f$ =+1) and ΔJ=±2, ±3; the ΔJ=±3 transitions being further specified as second-forbidden unique;
- for third-, fourth-forbidden, etc., transitions, n=3, 4, etc., respectively.

An allowed/forbidden beta transition may also be hindered or may be fast as a result of the nuclear structure of the initial and final states involved. See, for example, 1966Ko30 for a detailed discussion of the operators involved in various types of beta transitions. The selection rules for Nilsson states in deformed regions are tabulated in 1971El12. Violation of these selection rules could slow a beta transition. The beta transitions, therefore, may be hindered due to structures of the states involved. Definitions of some of the frequently used terms are given below:

- If a ΔJ=0 transition occurs between analog states (i.e. states having the same isospin and configuration), then the decay is very fast and is called "superallowed."
- Special cases of "allowed unhindered" (au) transitions in deformed region are discussed in section 33.
- "Isospin-forbidden" transitions refer to the decays between J=0 states of different isospin (*i. e.* non-analog states).
- "*l*-forbidden" transitions are those with Δ*l* > ΔJ, where Δ*l* is the change in *l* between the initial and final shell-model states.
- In deformed regions, if ΔK, the change in the K quantum number between the initial and final states, is larger than the spin change, ΔJ, the transition is called "K-forbidden."

A fast (strong) beta transition has a low *ft* value; forbidden transitions have larger *ft* values. Compilations of log *ft* values for known and well-established beta transitions appear, for example, in 1998Si17 and 1973Ra17.

The rules for various types of beta transitions are given below. Note that for nuclei at, or very near to, closed shells, values may be smaller. For example, in the mass region around Z=82, the upper limit of 5.9 given in #7 below could be 5.1.

#7 through #11 (No change)

See "b-Decay Rate Probabilities" on page vii.
Note that log $f^{1u}t$=log ft + 1.079

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