Strong Rules for Proton Radioactivity

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Background

Conditions for strong assignment

Proposed rule

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Background

A given nucleus with a proton radioactivity

A measured value of half-life $T_{1/2}$, and proton Q-value Qp

$\Delta T_{1/2}$ should be smaller than 50%

ΔQp should be smaller than 10 keV

$0.5\ MeV < Qp < 2\ MeV$

$1\ \mu s < T_{1/2} < 10s$

Ground state or low-lying isomers

Conditions for strong assignment

1) Odd-Z and even-N nucleus (even-even daughter)

2) Certainty that the decay populates the ground state of the daughter nucleus (0+)

$J\pi(\text{parent}) = J\pi(\text{proton})$

3) Nearly-spherical shape, that is, Z or/and N closed to magic numbers.

For $51 <= Z <= 63$, $J\pi(\text{proton}) = 7/2+$ or $5/2+$

For $65 <= Z <= 81$, $J\pi(\text{proton}) = 11/2-$, $3/2+$ or $1/2+$

based on systematics / Shell Model

Conditions for strong assignment

4) Availability of experimental proton emission half-life

Measured value of proton branching ratio, or measured half-life considerably smaller than expected alpha and EC+B+ half-lives.

5) Calculated proton emission half-lives:

Obtained by solving the Schrödinger equation for the proton plus daughter nucleus system, for a variety of physically possible proton Jπ values

$T_{1/2}$(proton): Strongly dependent function of Jπ(proton)

Conditions for strong assignment

6) Comparison

Assignment can be made if there is one set of Jπ values so that:

$$0.1 < T_{1/2}(\text{calc}) / T_{1/2}(\text{exp}) < 1$$

While for the remaining ones:

$$T_{1/2}(\text{calc}) / T_{1/2}(\text{exp}) << 1, \text{ or}$$

$$T_{1/2}(\text{calc}) / T_{1/2}(\text{exp}) >> 1$$

Proposed rule

The spin and parity of a level exhibiting proton radioactivity and belonging to a nearly spherical odd-Z, even-N nucleus can be taken equal to a particular set of Jπ values of the emitted proton if a) the transition reaches the ground state of the daughter nucleus, b) the proton Jπ values are physically possible, that is supported by systematic studies / Shell Model calculations, c) the calculated proton radioactivity half-life for those Jπ values is smaller than the experimental value, and d) calculated proton radioactivity half-lives for the other physically possible Jπ values are far larger or smaller than the experimental value.