^{219}At - Comments on evaluation of decay data by A. L. Nichols

Evaluated: September 2010

Evaluation Procedure

Limitation of Relative Statistical Weight Method (LWM) was applied to average numbers throughout the evaluation. The uncertainty assigned to the average value was always greater than or equal to the smallest uncertainty of the values used to calculate the average.

Decay Scheme

Very little of substance can be gleaned from the literature concerning the decay characteristics of ^{219}At (2001Br31). Although no γ or β^- emissions have been observed, an alpha group at 6.27 MeV was assigned to ^{219}At by Hyde and Ghiorso (1953Hy83). A simple decay scheme has been constructed with little confidence from this early study. Alpha and β^- feeding directly to the ground states of daughter ^{215}Bi and ^{219}Rn were assumed, but these processes were neither observed satisfactorily nor quantified experimentally. Spin and parity of $7/2^-$ were tentatively assigned to the ground state of ^{219}At to align with $5/2^+$ identified with the ground state of daughter ^{219}Rn (2001Br31), in order to define the proposed single beta-particle emission as first forbidden non-unique. Further spectral studies are required to assemble and quantify the decay scheme of ^{219}At with much greater confidence.

Nuclear Data

Part of the (4n + 3) naturally-occurring decay chain, and of relevance in quantifying the environmental impact of ^{235}U and resulting decay-chain products. Specific radionuclides in this decay chain are noteworthy because of their distinctive decay characteristics (e.g. alpha decay of ^{215}Po, ^{211}Bi and ^{211}Po).

Half-life

The recommended half-life is the weighted mean of only two measurements (1953Hy83 and 1989Bu09).

Reference	Half-life (sec)
1953Hy83	54 (6)
1989Bu09	57 (4)
Recommended value	56 (4)*

* Uncertainty adjusted upwards from ± 3 to ± 4 in line with the most precise value of this limited data set.

Q values

Q^- of 1566 (3) keV and Q_α of 6324 (15) keV were adopted from the evaluated tabulations of Audi *et al.* (2003Au03, 2009AuZZ).

Alpha particle

Energy

The alpha-particle branch of ~ 97 % was assumed to populate the ground state of ^{215}Bi directly. Both the energy and uncertainty of this proposed alpha-particle emission were calculated to be 6208 (15) keV from the evaluated Q-value of 6324 (15) keV (2003Au03, 2009AuZZ).

Emission Probability

The alpha-particle emission probability was calculated from a quoted α/β^- ratio of approximately 30, as determined from measurements of the ^{219}At/^{219}Rn peak ratio (1953Hy83). An ill-defined alpha branch of ~ 97 % can be derived from this ratio without an assigned uncertainty.

Alpha-particle emission probability per 100 disintegrations of ^{219}At, and hindrance factor

E_α(keV)	P_α	HF
	Recommended value	
6208 (15)	~ 97	~ 1.07

An unweighted mean value of 1.547 (9) was adopted for the radius parameter r_0(^{215}Bi) as derived from the equivalent data for neighbouring nuclei (1998Ak04), and used in the calculation of the α-hindrance factor (HF):

$$r_0(^{215}\mathrm{Bi}) = [r_0(^{214}\mathrm{Pb}) + r_0(^{216}\mathrm{Po})] / 2$$

$$= [1.5379\ (7) + 1.5555\ (2)] / 2 = 1.547\ (9)$$

Beta particle

Energy

The beta-particle branch of ~ 3 % was assumed to populate the ground state of ^{219}Rn directly. Therefore, the recommended energy and uncertainty of this single beta-particle transition was adopted from the evaluated Q-value of 1566 (3) keV (2003Au03, 2009AuZZ).

Emission Probability

The beta-particle emission probability was calculated from a quoted α/β^- ratio of approximately 30, as determined from measurements of the ^{219}At/^{219}Rn peak ratio (1953Hy83). A single, ill-defined, first forbidden non-unique transition is proposed directly to the ground state of ^{219}Rn, with an emission probability of ~ 3 % and no assigned uncertainty.

Beta-particle emission probability per 100 disintegrations of ^{219}At, transition type and log *ft*

E_β(keV)	P_β	transition type	log *ft*
	Recommended value		
1566 (3)	~ 3	(1st forbidden non-unique)	~ 6.2

Data Consistency

An effective Q-value of 6181 (15) keV has been adopted from the atomic mass evaluation of Audi *et al*. (2003Au03, 2009AuZZ) while in the course of formulating the decay scheme of ^{219}At. This value has subsequently been compared with the Q-value calculated by summing the contributions of the individual emissions to the ^{219}At alpha- and beta-decay processes:

$$\text{calculated Q-value} = \sum (E_i \times P_i) = 6181\ (15)\ \text{keV}$$

Percentage deviation from the effective Q-value of Audi *et al*. is (0.0 ± 0.3) %, which supports the derivation of a highly consistent decay scheme.

References

1953Hy83 E.K. HYDE, A. GHIORSO, The Alpha-branching of AcK and the Presence of Astatine in Nature, Phys. Rev. 90 (1953) 267-270. [Half-life, E_α, α and β^- decay, α/β^- ratio]

1989Bu09 D.G. BURKE, H. FOLGER, H. GABELMANN, E. HAGEBØ, P. HILL, P. HOFF, O. JONSSON, N. KAFFRELL, W. KURCEWICZ, G. LØVHØIDEN, K. NYBØ, G. NYMAN, H. RAVN, K. RIISAGER, J. ROGOWSKI, K. STEFFENSEN, T.F. THORSTEINSEN, and the ISOLDE Collaboration, New Neutron-rich Isotopes of Astatine and Bismuth, Z. Phys. – Atomic Nuclei 333 (1989) 131-135. [Half-life]

1998Ak04 Y.A. AKOVALI, Review of Alpha-decay Data from Doubly-even Nuclei, Nucl. Data Sheets 84 (1998) 1-114. [alpha decay, r_0 parameters]

2001Br31 E. BROWNE, Nuclear Data Sheets for A = 215, 219, 223, 227, 231, Nucl. Data Sheets 93 (2001) 763-1061. [Nuclear structure, level energies]

2003Au03 G. AUDI, A.H. WAPSTRA, C. THIBAULT, The AME2003 Atomic Mass Evaluation (II). Tables, Graphs and References, Nucl. Phys. A729 (2003) 337-676. [Q-value]

2009AuZZ G. AUDI, W. MENG, D. LUNNEY, B. PFEIFFER, Atomic Mass Evaluation 2009, Atomic Mass Data Centre, Centre de Spectrométrie Nucléaire et de Spectrométrie de Mass (CSNSM), Orsay, France, private communication, 2009. [Q-value]