On the variation of ^{210}Po Half-Life at low temperature

S. Pierre, P. Cassette, M. Loidl, T. Branger, D. Lacour, I. Le Garrérès and S. Morelli

CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), F-91191 Gif-sur-Yvette, France.

Motivation

In 2006, *K.U. Ketter et al* predicted that in a metal cooled at 4 K, the half-life of ^{210}Po is shortened to 0.5 days. (K. U. Kettner *et al.*, (2006), J. Phys. G : Nucl. Part. Phys. **32** 489-495).
In 2007, *Raiola et al.* reported an increased activity for the α-decay for a ^{210}Po source embedded into a palladium matrix at low temperature (F. Raiola *et al.*, (2007), Eur. Phys. J. A **32**, 51-53).

If these claims are real, this would have a considerable impact in radionuclide metrology because the half-life of an isotope, could not be anymore considered of an intrinsic constant and must be temperature and matrix-dependent. Moreover, this would also open new perspectives in radioactive waste management.

Experimental approach

Cooling in liquid He at 4 K

A_i Activity before cooling →  → A_f Activity after cooling

Cooling time: *t*

Half-life calculation

T_{4K}: half-life of ^{210}Po at 4 K
A_i: activity at the beginning of the cooling process
A_f: activity at the end of the cooling process
t = cooling time

$$T_{4K} = -\frac{\ln(2)\cdot t}{\ln(A_f) - \ln(A_i)}$$

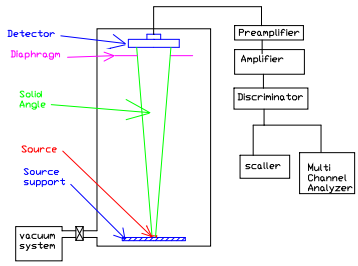
DSA chamber

Vacuum system

$$A = \frac{n}{t * G * I}$$

A: activity of the source
n: net counting rate
G: geometric factor
t: time of measurement
I: intensity of emission of the α line

Defined solid angle alpha measurement



Vacuum chamber equipped with a PIPS detector
Defined solid angle (DSA), stainless steel diaphragm
Distance diaphragm-source measured with a relative standard uncertainty of 0.02%.
Collimator radius measured with a relative standard uncertainty of 0.01 %.

G, geometric factor, calculated by an analytic program based on Curtis's method

Typical uncertainty budget

Uncertainty components	Relative standard uncertainty
Net counting statistics	2,6 10^{-4}
Spectrum extrapolation	1,4 10^{-4}
geometric factor	6,0 10^{-4}
backscattering	1,0 10^{-3}
dead time	1,0 10^{-3}
alpha scattering in the detector	1,0 10^{-5}
Temperature	6,0 10^{-5}
Reproducibility	1,0 10^{-3}
quadratic combination	**2 10^{-3}**

Source preparation

Source deposited on silver

Spontaneous deposit of ^{210}Po liquid source on a silver disk (Ø: 25 mm, e: 2 mm).
Disk placed in a PTFE cell filled with 4,10 ml of ^{210}Po in HCL 2M, (4,10 ± 0.12) kBq/g 28/04/09.
Deposition during 60 mn at room temperature with agitation.
Room temperature drying.

Source embedded in silver

Surface source covered with a silver foil, thin enough to only slightly decrease the energy of the alpha particles.
Thickness: (170 ± 40) nm (from the shift of the alpha peak using the SRIM software).

Foil pressed on the silver disk, using a polished silicon wafer and heated under vacuum at 320 °C during 1 h.

Results

Source deposited on silver

Activity before cooling:
A_i = (2 185 ± 4) Bq

⇩

Cooling during 29 days at 4.2 K

⇩

Activity after cooling:
A_f = (1 834 ± 5) Bq

⇩

Expected activity using *T* = 138.3763 d : (1 834 ± 4) Bq
Difference between measured and calculated results: (0 ± 0.8) Bq

Source with a mylar protection

No relative change of the half-life of ^{210}Po at 4 K, in these specific conditions > 0.6 %

Source embedded in silver

Weaker activity → A chamber with a larger G was used

Counting rate before cooling:
N_i = (13.550 ± 0.009) s^{-1}

⇩

Cooling during 11 days

⇩

Counting rate after cooling:
N_f = (12.652 ± 0.009) s^{-1}

Expected counting rate using *T* = 138.3763 d : (12.629 ± 0.009) s^{-1}
Difference between measured and calculated results: (0.023 ± 0.013) s^{-1}

Source and cooling container

No decrease of the half-life of ^{210}Po at 4K observed
Uncertainty is higher because of lower counting statistics

Conclusion: no evidence of ^{210}Po half-life reduction at 4K