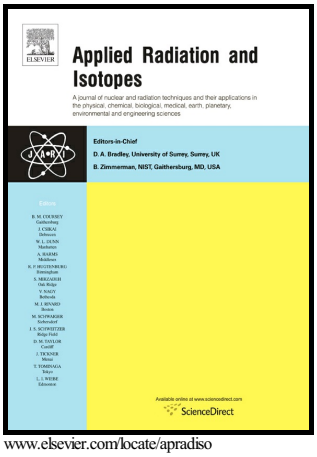

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Seasonal variations of decay rate measurement data and their interpretation

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Abstract
Measurement data of long-lived radionuclides, for example, ^{85}Kr, ^{90}Sr, ^{108m}Ag, ^{133}Ba, ^{152}Eu, ^{154}Eu and ^{226}Ra, and particularly the relative residuals of fitted raw data from current measurements of ionization chambers for half-life determination show small periodic seasonal variations with amplitudes of about 0.15%. The interpretation of these fluctuations is a matter of controversy whether the observed effect is produced by some interaction with the radionuclides themselves or is an artifact of the measuring chain. At the origin of such a discussion there is the exponential decay law of radioactive substances used for data fitting, one of the fundamentals of nuclear physics. Some groups of physicists use statistical methods and analyze correlations with various parameters of the measurement data and, for example, the Earth-Sun distance, as a basis of interpretation. In this article, data measured at the Physikalisch-Technische Bundesanstalt and published earlier are the subject of a correlation analysis using the corresponding time series of data with varying measurement conditions. An overview of these measurement conditions producing instrument instabilities is given and causality relations are discussed. The resulting correlation coefficients for various series of the same radionuclide using similar measurement conditions are in the order of 0.7, which indicates a high correlation, and for series of the same radionuclide using different measurement conditions and changes of the measuring chain of the order of -0.2 or even lower, which indicates an anti-correlation. These results provide strong arguments that the observed seasonal variations are caused by the measuring chain and, in particular, by the type of measuring electronics used.

Key words: ^{152}Eu, ^{226}Ra, decay rate, half-life, seasonal variation, correlation analysis, instrument instability, ionization chamber, Earth-Sun (Solar) system

1. Introduction

The exponential law for the decay of a radioactive substance is one of the fundamentals of nuclear physics. Discovered and formulated already in the first decade of the twentieth century [1], its mathematical basis has been developed and presented in textbooks [2]. It has been checked experimentally since then under many and various extreme conditions showing that the decay constant of a particular radioactive decay generally does not change with any parameter from outside of the nucleus. Studying as well dependencies of the decay constant from nuclear parameters, these cannot be modified by simple means with only a few exceptions. In 1947, Segrè [3] and Daudel [4] pointed out that in the case of electron-capture decays; the decay rate is related to the density of atomic electrons at a decaying nucleus. Many references to the subject can be found in the review of Emery [5] published in 1972. More recent spectacular examples of such effects are the ^{7}Be electron-capture half-life which amounts to a 0.83% difference between ^{7}Be endohedral C_{60} (^{7}Be@C_{60}) and Be metal (^{7}Be) [7] or the electron capture rates of ^{109}In and ^{110}Sn increased by (1.00 ± 0.17)% and (0.48 ± 0.25)%. These electron capture nuclides were implanted in the smaller Au lattice compared to implantation in a larger Pb lattice [7a]. The study of deviations from the exponential decay law at short and long times, respectively, was continued, for example, by Norman et al. [6, 6a]. Decay rates and half-lives of some radionuclides such as ^{7}Be and ^{40}K encased in different materials and the host dependence of the half-life were studied [6b, 7b] showing the dependence for the ^{7}Be electron-capture decay.