# Do radioactive decay rates depend on the distance between the Earth and the Sun?

*Karsten Kossert, Ole Nähle*

Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

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The potential influence of solar neutrinos on beta decay rates was investigated at PTB. To this end, new experiments have been carried out for the beta emitters $^{36}$Cl and $^{90}$Sr/$^{90}$Y, respectively. The measurements were performed using custom-built liquid scintillation counters with three photomultiplier tubes (PMTs). The data were analyzed applying the TDCR method which yields information on the counting efficiency and the activity. The activities corrected for decay were found to be stable and no oscillation could be observed. Also frequency analyses do not show any significant periodicity. Thus, we disprove the findings from several previous works of a research group working with Fischbach, Jenkins, Sturrock et al. who used data from relative measurement methods only. The data they use are not suitable to claim evidence for variations of decay rates, since the measurement techniques do not provide information on the instrument efficiency. That group also used data from our laboratory which were obtained by means of ionization chambers. We can show that the observed effects cannot be explained with an influence of solar neutrinos, whereas an influence of climate data in the corresponding measurement room appears to be a more plausible reason.

## 1 Introduction

In the past few years, a group of US American scientists has analyzed data of long-term measurements of several radioactive isotopes. Some of the data sets showed fluctuations with reference to the seasons, which the researchers explained by corresponding changes in the decay rate of the radionuclides (see, e.g., [1] and references therein). They attributed these fluctuations to the changes in the distance between the Earth and the Sun. With this distance, also the flux of solar neutrinos at the surface of the Earth changes which, according to these scientists, allegedly influences the decay rates. What the publications by the group have in common is that their theory is based on experimental data which were obtained by means of detector types that are known to be particularly sensitive to environmental parameters. For instance, the measurements performed on $^{32}$Si, $^{36}$Cl and $^{226}$Ra are based on gas detectors. Moreover, these experiments were never designed to precisely measure potential variations of decay rates; some data were even taken by detectors used for radiation protection procedures.

In a recently published article [1], the American scientists have now used measurements of $^{36}$Cl, which were obtained with a Geiger counter used for wipe testing of contaminations at the Ohio State University Research Reactor (OSURR). These, too, show clear fluctuations which the authors interpret as further evidence of their theory.

Measurements on $^{90}Sr/^{90}Y$ were carried out by Parkhomov using a Geiger-Müller counter [2]. The data, which were later analyzed by Sturrock et al., show also timely variation with a frequency of about 1 $y^{-1}$ [3].

## 2 New experiments at PTB

The beta emitter $^{36}Cl$ has also been investigated at PTB [4] by means of a liquid scintillation counter. For this purpose, a small amount of the radioactive material is put directly in the organic liquid scintillator, which rules out any potential problems with the self-absorption of the radiation originating from the radioactive decay inside the source itself and in the air layer between the source and the detector. The TDCR procedure allows the detection probability to be determined without an additional reference source [5]. The method compensates to a large extent for fluctuations of the detection probability due to changes in the properties of the source or of the detector and due to environmental influences. In this way, the TDCR liquid scintillation measurements exhibit a clear advantage compared to simple counting experiments with gas detectors.

The new PTB data fluctuate far less than those from the OSURR and, thus, refute a dependence of the $^{36}Cl$ decay rate on the distance between the Earth and the Sun. The new PTB data were also analyzed by means of a Lomb-Scargle frequency analysis before and after removing a trend which can be explained by slight colour quenching. The corresponding power spectra are shown in Fig. 1.

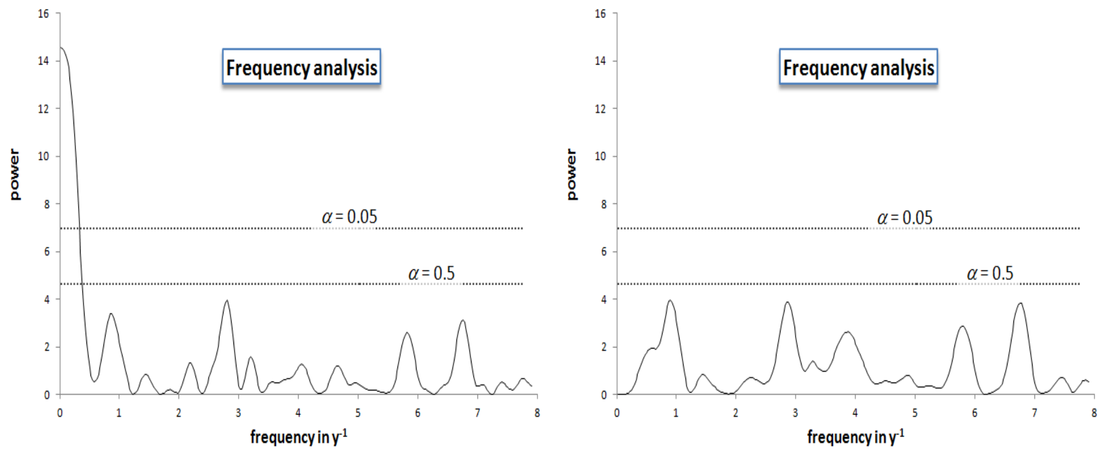


Figure 1: Periodograms obtained from a Lomb-Scargle frequency analysis applied to $^{36}Cl$ activity data from [4] before (left) and after (right) removal of a trend which is ascribed to colour quenching.

From April 2013 to May 2014, additional long-term TDCR measurements were carried out at PTB using $^{90}Sr/^{90}Y$ [6] and using a new counter with an automated sample changer. The data show no dependence on the season (Fig. 2) and, thus, refute the results published in [2] and [3] which are, again, based on measurements with a gas detector. When analyzing the data

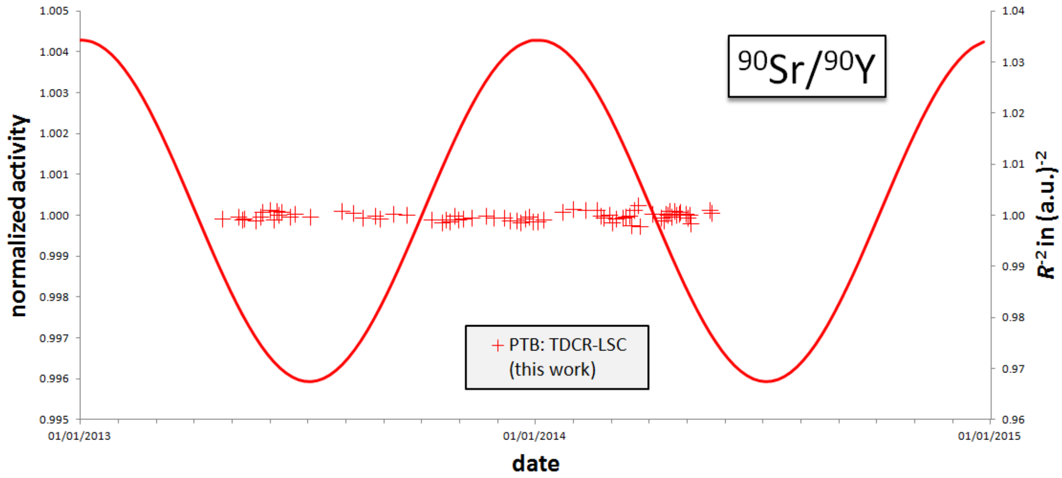


Figure 2: Normalized $^{90}Sr/^{90}Y$ activities measured by means of TDCR at PTB [6]. The solid line represents the squared inverse Sun-Earth distance (right ordinate).

with a frequency analysis technique, the new PTB data show no significant peak and, thus, an influence of the Moon or the Sun, as suggested in [2] and [3], can be excluded.

## 3 Ionization chamber measurements at PTB

In several articles, Fischbach, Jenkins, Sturrock et al. use data which were obtained by means of ionization chamber measurements in our laboratory. In a recent article [7], our laboratory is even mentioned in the article title, and we emphasize here that this does not mean that we agree with the assertions. On the contrary, we found several serious errors and the conclusions are definitely false. The main fault is that the authors of [7] equate instrument readings with decay rates. Of course, the two parameters are related via the detection efficiency. However, a claim that the decay rates vary with time would only be possible if one can ensure that the detection efficiency is constant which cannot be proved for these data. We find clear correlations between the instrument readings and the temperature or the air humidity in the corresponding measurement room. In addition, we find variations with different amplitude, different phase and different frequency when using another instrument. Thus, we can exclude the Sun or solar neutrinos as a common reason for the observed variations.

The papers from Fischbach, Jenkins, Sturrock et al. also make clear that they have only limited knowledge about the experimental data they use. For example, they report on ‘count rates’ (see, e.g., Figs. 1 to 8 in [7]) obtained from our ionization chambers whilst we are measuring ionization currents, i.e. we cannot count single events.

# 4 Discussion

In conclusion, our results from primary activity measurements strongly refute timely variations of decay rates. Moreover we have shown that variation in instrument reading (not in decay rates!) is more likely due to changes of other parameters such as temperature, air pressure and humidity.

In many articles by Fischbach, Jenkins, Sturrock and coworkers (we cannot cite them all) several mistakes were made. The main error is that the authors equate instrument readings with decay rates without showing clear experimental evidence that the detection efficiency is a constant. We also criticize their findings which ignore the fact that some of the data they use are in contradiction. For example, they used $^{36}$Cl data from BNL to support their theory and later they used data from OSURR for the same isotope. However, both data sets do neither agree in amplitude nor do the power spectra agree. Another example is $^{90}$Sr/$^{90}$Y: For this isotope, data from ionization chamber measurements at PTB were used which are in contradiction to the data from Parkhomov.

In our opinion, a sophisticated investigation of a potential influence of solar neutrinos to decay rates requires accurate measurements by means of primary activity standardization techniques like the TDCR method or the $4\pi\beta - \gamma$ coincidence counting method, whereas relative methods based on gas counters, scintillation counters or gamma-ray spectrometers are not sufficient.

Finally, we emphasize that a correlation does not necessarily imply causality. For example, we can also find a correlation between the flux of solar neutrinos on the Earth's surface and the mean gas consumption in Germany. However, this correlation certainly does not mean that the gas consumption is influenced by solar neutrinos.

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