Speeding-up Thorium decay

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29 maggio 2018

Sommario

We show that cavitation of a solution of thorium-228 in water induces its transformation at a rate 10^4 times faster than the natural radioactive decay would do. This result agrees with the alteration of the secular equilibrium of thorium-234 obtained by a Russian team via explosion of titanium foils in water and solutions. These evidences further support some preliminary clues for the possibility of piezonuclear reactions (namely nuclear reactions induced by pressure waves) obtained in the last ten years.

1 Introduction

Acoustic cavitation of gaseous liquids consists in subjecting them to elastic waves of suitable power and frequency (in particular to ultrasounds)^(1,2). The main physical phenomena occurring in a cavitated liquid (*e.g.* sonoluminescence⁽³⁾) can be accounted for in terms of a hydrodynamic model based on the formation and the collapse of gas bubbles in the liquid^(1,2).

Three different experiments on cavitation carried out in the last years⁽⁴⁻⁶⁾ provided evidence for an anomalous production of intermediate and high mass number (both stable, unstable and artificial) nuclides within a sample of water subjected to cavitation, in turn induced by ultrasounds with 20 KHz frequency. These results together seem to show that ultrasounds and cavitation are able to generate nuclear phenomena bringing to modifications of the nuclei involved in the process (in particular, sononuclear fusion). A model able to account for such nuclear reactions induced by high pressures (*piezonuclear reactions*), based on the implosive collapse of the bubbles inside the liquid during cavitation, has been proposed⁽⁷⁾.

Such findings (in particular those of the first experiment^(4,5)) are similar under many respects to those obtained by Russian teams at Kurchatov Institute and at Dubna JINR⁽⁸⁻¹¹⁾ in the experimental study of electric explosion of titanium foils in liquids. In a first experiment carried out in water, the Kurchatov group⁽⁸⁾ observed change in concentrations of chemical elements and the absence of significant radioactivity. These results have been subsequently confirmed at Dubna⁽⁹⁾. Recently, the experiments have been carried out in a solution of uranyl sulfate in distilled water, unambiguously showing⁽¹⁰⁾ a distortion of the initial isotopic relationship of uranium and a violation of the secular equilibrium of ²³⁴Th. Moreover, the neutron flux was measured and found to be very low (< 103 neutron/electric explosion), so that the change in the uranium isotopic composition cannot be attributed to the induced fission. Due to the similarity of such results with ours, in our opinion the two observed phenomena have a common origin. Namely, one might argue that the shock waves caused by the foil explosion act on the matter in a way similar to ultrasounds in cavitation. In other words, the results of the Russian teams support the evidence for piezonuclear reactions.

A connection can also be envisaged with the experiment by Taleyarkhan $et \ al.^{(12)}$ on nuclear fusion induced by cavitation. In such an experiment, it was observed emission of neutrons in deuterated acetone subjected to cavitation. The neutron flux measured was compatible with d-d fusion during bubble collapse. This result was subsequently disclaimed by another Oak Ridge group⁽¹³⁾, which measured a neutron flux three orders of magnitude smaller than that required for tritium production. Such a disproof has been rebutted by Taleyarkhan et al.⁽¹⁴⁾. Although therefore general agreement exists on the emission of neutrons in the phenomenon, the controversial point is whether or not the observed neutron flux is compatible with d-d fusion and consequent tritium production. Notice that, in the first experiment we carried out, proton number is practically conserved, whereas neutron number is apparently $not^{(4,5)}$. In our opinion, the Oak Ridge experiments have only shown that cavitation does affect nuclei, by inducing them to emit neutrons, but have not provided firm evidence for cavitationgenerated nuclear reactions (in particular fusion). In our view, one could interpret the Oak Ridge experiments as a transmutation of nuclei induced by cavitation, in which the emission of neutrons, although not consistent with fusion of deuteron nuclei, could be due to other piezonuclear processes in bubble collapse. In fact, in no Oak Ridge experiment either a mass-spectrometer analysis of the liquid before and after cavitation was performed in order to match the detected neutron emission with possibly occurred nuclear reactions in the cavitated liquid.

2 The experiment

At the light of the above considerations, we presently disregard the Oak Ridge claims and follow the Russian results. Then, in order to check the possible effects of cavitation on thorium decay, we subjected to cavitation a solution of thorium in water.

Precisely, we prepared 12 identical solutions of Th^{228} in pure deionized bidistilled water (18 $M\Omega$), with volume of 250 ml and concentration ranging from 0.01 to 0.03 ppb (part per billion). Th^{228} is an unstable element whose half life is $t_{1/2} = 1.9$ years = 9.99×10^5 min. It decays by emitting 6 α and 3 β^- . The minimum energy of the alpha particles emitted is 5.3 MeV, which is nearly equal to the energy of the α 's emitted by radon 222. This alikeness allowed us to use the detector CR39, a polycarbonate whose energy calibration is just designed to detect those emitted by radon 222.

Eight solutions out of the twelve at our disposal were divided into two groups of four, and each of them was cavitated for $t_c = 90 \ min$ at a frequency of 20 KHz and a power of 100 Watt. The remaining four were not cavitated, and regarded as reference solutions. The sonotrode employed for cavitation was of a new type, designed on purpose, endowed with a compressed air cooling system, and therefore able to work until 90 min without stopping. As cavitation chamber, we used a vessel made by Duran with a suitable geometry. The surface of the liquid was free.

We measured the ionizing radiation in the empty Duran vessel both before and after cavitation. The radiation measurements were carried out by means of two Geiger counters with mica windows (one of which equipped with an aluminium filter 3 mm thick), and of a tallium activated, sodium iodine γ -spectrometer. The results turned out always compatible with the background level. For each cavitation run, a CR39 detector was placed underneath the vessel, and exposed for the whole cavitation time of 90 min.

The 12 detectors CR39 corresponding to the 12 solutions were examined. The traces on them were clearly recognized as produced by the α radiation from Th^{228} decay, on a double basis. First, such a trace has a characteristic, unmistakable "star-shaped" look, completely different from those impressed on CR39 by environmental radioactivity (e.g. Radon 222) and by cosmic rays (as well known from the use of CR39 counters in environmental dosimetry). Furthermore, as a further check, we inserted the impressed CR39 plates in the automatic counter system "Radosys", which stated the incompatibility of our traces with those of its database (just based on Rn^{222} and cosmic rays).



Figura 1: Traces left by α -particles emitted from thorium decay on detectors CR39 (circles). The results obtained are depicted in Fig. 1. Precisely, the first column shows the four detectors

CR39 used with the four non-cavitated solutions taken as reference, whereas in the second and third columns one sees the eight detectors used with the eight cavitated solutions. The circles in the figure highlight the traces left by the particles α produced by thorium decay, which were counted. On the four CR39 used with the four reference solutions one counted 3 traces of alpha particles in all. The same number of traces was counted on the eight CR39 used with the eight cavitated solutions. Of course, in absence of any anomalous behavior, one would have expected the same number of events for either uncavitated solutions.

On the contrary, the ratio of the number of traces and the number of solutions is therefore 3/4 for the reference solutions and 3/8 for the cavitated ones. Thus, there is an evidence of reduction of the number of traces of alpha particles from thorium decay in the cavitated solutions with respect to those in the non-cavitated ones. In particular, it is evident that the above ratios show a reduction by a factor 2 in the number of traces from the former with respect to the latter.

In order to enforce the evidence obtained by the reduced statistics of the detector analysis, we analyzed by a mass spectrometer the content of Th^{228} of all solutions, including those providing no evidence of alpha particles from thorium decay. This was done by taking 40 ml for each solution, on which we carried out 4 mass-spectrometric analyses with a drawing of 20 μl and a scanning time of 150 s. The content of Th^{228} (both in ppb and in counts per second, cps) found in the three cavitated solutions (whose CR39 showed the traces of the alpha particles emitted by thorium) is half of that in the three reference solutions corresponding to an α -emission. This situation is reported in Tables 1 and 2. Let us notice that the samples which produced no signal in the CR39 counters did however show the same halving of thorium content.

Table 1 - Content of Th^{228} in non-cavitated (reference) solutions			
Mass-spectrometer analysis	cps	ppb	
Sample 1	287 ± 1	$0.020{\pm}0.01$	
Sample 3	167 ± 1	$0.012{\pm}0.01$	
Sample 4	363 ± 1	$0.026{\pm}0.01$	
Mean values	272.33	$0.019{\pm}0.01$	

Table 2 - Content of Th^{228} in cavitated solutions				
Mass-spectrometer analysis	cps	ppb		
Sample 1 (first group)	231 ± 1	$0.016 {\pm} 0.01$		
Sample 3 (first group)	57 ± 1	$0.004{\pm}0.01$		
Sample 4 (second group)	79 ± 1	$0.006 {\pm} 0.01$		
Mean values	122.33	$0.009 {\pm} 0.01$		
Ratio of mean values non-cavitated/cavitated	2.2	2.1		

These two converging evidences allow one to conclude that the process of cavitation reduced the content of Th^{228} in the solutions.

The dry residues of both the cavitated and uncavitated samples have been examined by X-ray microanalysis by means of an electronic microscope (because it was impossible to insert them in a mass spectrometer). However, this did not allow us to determine the thorium variation in a clear way.

The ratio between the half life of thorium, $t_{1/2} = 1.9 \ years = 9.99 \times 10^5 \ minutes$, and the time interval of cavitation, $t_c = 90 \ min$, is $t_{1/2}/t_c = 10^4$. This means that cavitation brought about the reduction of Th^{228} at a rate 10^4 times faster than the natural radioactive decay would do.

It is still open the question whether the effect of cavitation on thorium was simply to accelerate its natural decay process, or it also underwent other types of transformations (like *e.g.* fission processes). However, we can conclude that our results do support the Russian findings about the alteration of the secular equilibrium of thorium, and provide a further evidence of piezonuclear effects.

Acknowledgments. We are greatly indebted to all people who supported us in many ways in carrying out the experiments: first of all, the military technicians of the Italian Armed Forces A. Aracu, A. Bellitto, F. Contalbo, P. Muraglia; R. Capotosto, of the Department of Physics "E.Amaldi" of the University "Roma Tre", for technical support on the sonotrode tip; M. T. Topi, Director of ARPA Laboratories of Viterbo; G. Cherubini, of Rome University "La Sapienza", for technical support on the analysis of the CR39 plates, including the use of the automatic counter system "Radosys"; L. Petrilli, of the CNR Rearearch Area "Roma 1", for assistance in the mass spectrometer analysis; F. Rosetto, of the Department of Physics "E.Amaldi" of the University "Roma Tre"; G. Spera, of the CRA-ISPAVE. On the theoretical side, invaluable comments by E. Pessa are gratefully acknowledged. Thanks are finally due to F. Pistella, President of the Italian C.N.R., and F. Mazzucca, President of Ansaldo Nucleare, for deep interest and warm encouragement.

99

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