New experimental evidence for Podkletnov effect

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Abstract

The present study was conducted on dispersed YBa$_2$Cu$_3$O$_{6+\delta}$ (YBCO) during its hydration in gas-tight containers with K$_2$CO$_3$·1.5H$_2$O crystal hydrate. The samples were exposed to an electromagnetic field with a frequency of 50 MHz or microwave radiation of 2 GHz. Changes in the weight of various bodies located in the immediate vicinity of containers with YBCO material were detected: when above the containers, the bodies lose weight, while the weight of bodies located under the containers, on the contrary, increases. The maximum weight defect recorded in experiments with a 5 g YBCO sample was about 1 mg. Discovered weight changes are very similar to the result obtained by E.E. Podkletnov et al. [Physica C: Superconductivity, 1992. V. 203. P. 441] – they observed a decrease in the weight of bodies placed above a rotating YBCO disk which was in a superconducting state and exposed to an alternating magnetic field. Podkletnov and other researchers put forward a hypothesis about screening of the gravitational field by the rotating YBCO-superconductor. Distinctive features of our experiments are the absence of the superconducting state in the YBCO material and its rotation. However, it is clear to us that we have observed the same phenomenon and, to our knowledge, this is probably the first time that Podkletnov effect has been confirmed in an independent study. Our interpretation of the effect differs from the initial one. According to our results, the YBCO material initiates a redistribution between bodies of a certain substance that affects their weight or mass.

1 Introduction

Shortly after the discovery in 1986 of cuprate high-temperature superconductors, articles began to appear in which various unobserved earlier properties of these objects were described. Mostly these were unusual high superconducting transition temperatures $T_c$ for compounds that had already been well-studied by then. In 1992, however, the paper of E.E. Podkletnov et al. [1] appeared, in which anomalous properties of a completely different sort were discovered for the high-temperature superconductor YBa$_2$Cu$_3$O$_{6+\delta}$ (YBCO). The authors of this work stated that a SiO$_2$ sample loses up to 0.3% of its weight being placed over a superconducting YBCO disk rotating in a travelling magnetic field. The speed of the disk rotation and the frequency of the magnetic field were important parameters influencing weight loss. Later, additional information was provided about a weight loss of up to 2.1% that can be achieved for any samples made of metal, plastic, ceramics, etc [2]. The weight changes observed in [1, 2] were subsequently called “Podkletnov effect”, and attempts of other authors to reproduce these results were unsuccessful (see, for example, [3, 4]). On the other hand,

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precision measurements of the weight of various superconductors showed no change in this parameter up to $\sim 2\cdot10^{-4}$ wt.% when passing through $T_c$ [5]. Other low-temperature precision measurements [6] did not reveal the appearance of any energy fields near a rotating superconducting disk. These data may indicate that superconducting state itself and rotation in this state may not be the determining factors for Podkletnov effect.

Earlier we found that some YBCO samples during their hydration change in weight by the amount not commensurate with the amount of absorbed water [7–10]. In other words, a part of this change in weight was not related to the hydration process; its nature was not established. The low-temperature magnetic properties also turned out to be intriguing. Before hydration, this material is a superconductor with $T_c$ characteristic of a given chemical composition. However during hydration the paramagnetic Meissner effect begins to appear, not disappearing even in strong magnetic fields. At temperatures $T > T_c$, up to 300 K, YBCO samples hydrated to a degree of $\sim 2$ wt.% exhibits diamagnetism with $M = -1.34\cdot10^{-3}$ Oe (at $T = 300$ K; $H = 10^4$ Oe). A specific feature of the studied samples was that they previously were subjected to short-term exposure to an atmosphere with $p_{H_2O} = 110\pm 10$ Pa.

In the present work, we continue to study the changes in weight of YBCO during its hydration. As it turned out, the magnitude of such changes is determined by external electromagnetic fields. After exposure to these fields, the weight of the samples begins to change. Moreover, bodies located above and under YBCO-samples also start to change in weight. Our results are very similar to those described by E. Podkletnov and could specify and add them with new information.

2 Experimental Details

A brief scheme of the study is shown in Fig. 1. YBCO material of the tetragonal crystallographic modification was prepared by the ceramic technology as described in [7–10]. The saturation of the YBCO lattice with oxygen was carried out in air atmosphere for $5$ h at 525°C (according to the $p$-$T$-$x$ diagram of $\text{YBa}_2\text{Cu}_3\text{O}_{6+\delta}$ [11], its $\delta \approx 0.85$). Sintered material was ground in an agate mortar and poured into quartz crucibles with an inner diameter of 7.3 mm and a height of 13 mm – 750±50 mg of powder in each one. The crucibles with YBCO powder were covered with aluminum foil of 14-μm thickness. They were exposed for some time to air at $p_{H_2O} = 110\pm 10$ Pa. After this exposure, the crucibles were placed inside a solenoid where YBCO was exposed to an electromagnetic field with a frequency of 50 MHz. Then the crucibles were placed in sealed glass reactors with crystalline hydrate $\text{K}_2\text{CO}_3\cdot1.5\text{H}_2\text{O}$ (providing a relative humidity of 43%) – two crucibles per reactor. The reactor's volume was 30 ml; its cap was made of high-density polyethylene. The reactors containing YBCO samples will be named herein as S. An identical reactor-referent without samples, which was used as “reactor for comparison”, will be named as R; it went through all stages of weighting and intermediate storage together with the reactors S.
The initial weight of reactors was determined 15–20 min after the electromagnetic field treatment using a Shimadzu AUW-120D analytical balance with an accuracy of 0.02 mg in the range to 42 g. Each weighting procedure consisted of eight individual weightings carried out with reactors R and S in the sequence: \{R, S\} × 4 times. Current changes in weight of reactor S were determined relative to the weight of reactor R (\(W_R\)): \(\Delta W_S = (\sum W_S - \sum W_R)/4 - (\sum W_S^{initial} - \sum W_R^{initial})/4\). Before each weighting procedure the scale was calibrated using internal calibration weights.

In the intervals between weightings, the reactors were stored in steel safes at 25.0±0.5°C, as it is shown in Fig. 1; there were three positions where reactors were placed at a distance of about 0.6 m from each other. Two types of stands (in the form of boxes) on which the reactors were placed during storage were used, see Fig. 1. The stands stood on plastic pedestals ~10 cm high. The reactors located in the lower section of the safes were shielded from possible influence of thermostats placed nearby (from their thermal and electromagnetic radiation).

![Fig. 1 Scheme of the study](image)

X-ray diffraction analysis (XRD) was carried out using a Shimadzu XRD-7000 diffractometer\(^2\) (CuKα-radiation, Bragg angle range \(2\Theta = 10 \div 80^\circ\), a step of 0.02°, counting time of 2 s per step). Crystal structure analysis was performed using GSAS package [12] starting from the model of the crystal structure presented in [13]. The following discrepancy factors were achieved: weighted profile \(\omega R_p = 9.487\%\), unweighted structural \(R_f = 11.395\%\) (for YBCO), and the Durbin-Watson statistic 0.790.

3 Experimental Results and Discussion

3.1 Material characterization by X-ray diffraction

X-ray diffraction experimental and calculated data obtained on the initial YBCO powder are shown in Fig. 2.

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\(^2\) Ural-M Collective Use Center at the Institute of Metallurgy, Ural Branch of the Russian Academy of Sciences.
X-ray analysis has revealed that prepared YBCO powder is crystallized in the orthorhombic structure with the $Pmmm$ space group. Its cell parameters are: $a = 3.82676$, $b = 3.88450$, and $c = 11.71147$ Å. According to GSAS, its amount constitutes 99.7% of the total composition.

### 3.2 Instability in the weight of reactors with YBCO-samples

In our previous work, YBCO samples were subjected to hydration by exposure to moist air in gas-tight mini-reactors [10]. Despite the absence of mass exchange with the environment, a gradual decrease in weight of the reactors over time was recorded. The magnitude of this decrease was influenced by some factors the most important of which was established to be background electromagnetic radiation. Typically, it was the radiation emitted from the antennas of cellular base stations ($f \approx 1–3$ GHz). Meanwhile, from Podkletnov works [1, 2] it follows that the optimal frequency of the processing field, at which the Podkletnov effect reaches maximum, is 50 MHz. So, in the present work, two methods of treating with electromagnetic field were used: inside a solenoid in a field of 50 MHz and in the radiation from a magnetron operating at 2.5 GHz.

The results of the weight measurements on the reactors with YBCO samples are shown in Fig. 3. One can see that after field treatment material behaves in the same way as in our previous study [10] – reactors containing the material lose weight during the experiment. However, now weight loss occurs much faster – as the result of careful selection of the operating parameters in the method of preparing the YBCO samples. The decrease in the reactor weight is mainly observed during the first day after the start of an experiment. The value of the weight loss for the material subjected to radiation from the magnetron (Fig. 3b) is at the same level as for the material treated with the solenoid field (Fig. 3a). The material of a stand and its mass have a great influence on the result. As can be seen in Fig. 3c, in the case of a small-mass stand, no weight loss by the reactors is observed.
Fig. 3 Examples of the dependences of the change in the weight of reactors with YBCO samples on time. Fig. a – results obtained under the influence of an electromagnetic field with a frequency of 50 MHz, stands under the reactors in both examples were made of tinplate; b – results obtained under the influence of 2 GHz radiation, where red rings correspond to the case of a stand made of tinplate, black rings – a stand made of massive glass; c – results correspond to the case of a stand made of thin plastic covered with aluminum foil; it had a small mass.

An attempt was made to explain the decrease in the weight of reactors by desorption of their contents. Despite their fairly reliable hermeticity to air, the materials of which the reactors are made may be permeable to light gases. For example, assuming water conversion with the formation of hydrogen to be somehow realized in the reactors, the decrease in their weight becomes easily explained by the high diffusion mobility of H$_2$ in such solid phases as polyethylene. To test this hypothesis, we kept one of the reactors in a 500-ml gas-tight container during the first day of the hydration experiment. It was believed that in a highly diluted state, even hydrogen would not leave this container during the day. An air sample (100 ml) was taken from the container and tested for gas composition using a quadrupole mass spectrometer QMS 403 C Aéolos (Netzsch)$^3$. The results of analysis are shown in Fig. 4, from which it follows that the gas composition in the air sample is no different from the usual one.

Fig. 5 shows the time dependences for the changes in weight of both the reactors and various bodies located in their immediate vicinity. Figures a and b contain examples in which massive quartz crucibles weighing about 3 g were placed directly on the reactor cap. The body in contact with the bottom of the reactor, see fig. c, was a metal plate weighing about 6 g. It can be seen that the bodies located above the reactors lose weight during the experiment, while the weight of the body located below the reactor increases.

$^3$ Ural-M Collective Use Center at the Institute of Metallurgy, Ural Branch of the Russian Academy of Sciences.
**Fig. 4** Mass spectrometric analysis of the air in contact with the reactor with YBCO-samples during the first day after the start of the hydration experiment. The arrow shows the start of air injection into the mass spectrometer. The injection duration was about 1 min.

**Fig. 5** Dependences of the change in weight of the reactors with YBCO samples on time, supplemented by similar dependences of the change in weight of: massive quartz crucibles standing on the reactors (**a, b**); a metal plate lying under the reactor (**c**).
Based on the result obtained, we tried to explain the decrease in weight observed in Fig. 3 for the reactors placed on massive stands (made of tinplate or glass) by an assumption that part of their weight during the experiment somehow turns out to be associated with the stand, see Fig. 6.

\[ \Delta W_{\text{reactor}} = -\Delta W_2 \]

**Fig. 6** Scheme explaining the weight loss of the reactors in Fig. 3a and Fig. 3b. Under the influence of the YBCO samples, a certain substance that affects the weight of matter transits from top to bottom, passing through the samples. As a result, the upper part of the reactor becomes lighter, and the lower part, together with the stand, becomes heavier. When the reactor is separated from the stand (for weighting), its weight turns out to be decreased by the amount of weight acquired by the stand.

The experimental result shown in Fig. 3c can be explained from a new perspective by the fact that in the case of a stand of small mass, the value of \( \Delta W_2 \) (see Fig. 6) becomes insignificant (it is assumed that in order to accept a certain amount of weight, a corresponding massive “container” is needed) so the redistribution of weight occurs between matter within the reactor volume, therefore, there is no change in its weight.

### 3.3 The influence of YBCO samples on each other and on the scales mechanism

In one of the experiments, we tripled the total mass of the samples in the reactor stored in the upper part of the right safe (see Fig. 1). For this, we used a reactor with an increased internal volume of 35 ml (correspondingly, the referent reactor also had an increased volume); this experiment was designated P58.24. At the same time, reactors with samples of routine size were located in the lower sections of the right and left safes; the corresponding experiments were designated P57.24 and P59.24. We had previously used a similar configuration of three reactors, but the mass of the samples in them was always approximately the same and amounted to about 1.5 g per reactor, and we always obtained \( \Delta W(\tau) \) dependencies similar to those shown in Fig. 3. But the appearance of the massive sample in the experiments has led to unexpected consequences.

**Fig. 7** presents the results of experiments where the reactors were placed one below the other (P57.24 and P58.24). After the introduction of the massive samples...
into the experiment, the weight of the reactor below is found to be sharply increased, and then it returned to its initial state. The weight of the reactor with large samples did not change. Such a behavior had not been observed before then⁴.

![Graph showing changes in reactor weight](image)

**Fig. 7** Changes in the reactor weight during experiments P57.24 (red color) and P58.24 (black color) (relative to the changes in weight of the reference reactors). The samples in the reactor located at the top had three times the mass of the samples at the bottom.

To get a clearer picture of what is happening, we decided the data on the change in weight of the reactors S (with samples) and R (reference) to consider separately. To do this, it was necessary to “clean” them of the very strong dependence on atmospheric pressure \(P\) and temperature \(T\). The use of the reference reactor has allowed us to avoid employing this procedure until now, since the dependence on \(P\) and \(T\) for the reactors S and R is the same, and they compensate each other. In the case of the separate consideration of the reactors S and R, this cannot be avoided. The dependence \(\Delta W = f(P, T)\) can be written as:

\[
\Delta W^{P,T} = V \cdot (0.003974 \cdot \Delta T - 1.17 \cdot \Delta P / P_0),
\]

where \(V\) is the external volume of a reactor; \(\Delta T, \Delta P\) are the changes in temperature and pressure that have occurred since a certain point in time at which \(T = T_0\) and \(P = P_0\); the coefficients used in the equation express the magnitude of the Archimedean force for unit values of \(V, \Delta T\) и \(\Delta P\).

Fig. 8 shows the timeline of a “cleaned” weight of the reference reactor used in the experiments with small-mass samples (standard in the present work), such as P57.24 and P59.24. Also shown are the starting points of experiments P57.24, P58.24 and P59.24, which are important for the present discussion. It can be seen that in most areas the reactor weight remains more or less stable, but in sections IV and V a sharp drop is observed. The beginning of the drop coincides in time with the end of formation of the high peak \(\Delta W\) in Fig. 7.

⁴ Although, the fact of influence of the YBCO-samples on each other at a significant distance itself had already been observed in the work [10].
Corrected to ambient conditions \((P \text{ and } T)\) changes in the weight of the main reference reactor over time. Arrows indicate the starting positions of three samples related to the sharp drop in the weight in sections IV and V.

Figure 9 shows corrected according to equation (1) kinetic curves reflecting the weight change of each reactor involved in the experiments under consideration. One can see a steep drop in weight for all reactors in the time corresponding to sections IV and V of timeline in Fig. 8. To understand this result, it is necessary to keep in mind that the reactor weight measurements have been ultimately made by the comparison with the calibration weights built into the scales. The only explanation for the dependences in Fig. 9 is that the weight of the calibration weights began to increase from the moment marked by the arrow.

Corrected to ambient conditions \((P \text{ and } T)\) changes in the weight of reference reactors (red color) and reactors with YBCO-samples (blue color), which occurred during experiments: P57.24 (a); P58.24 (b); P59.24 (c). The arrows indicate the onset of the supposed weight gain of the scales calibration weights, as a cause of the observed behavior of the reactors.
We repeated the series of experiments described in this section, but now the upper reactor was located at the highest level of the right safe. It was obtained a similar result, but with a lower peak $\Delta W$ for the lower reactor – its height was 0.11 mg.

Using the result obtained in Section 3.2 for further reasoning, we can hypothesize that there is a certain substance in the bodies that affects their measured weight or mass. Under the influence of the YBCO samples used in our study, this substance becomes mobile and can move, accumulating in neighboring bodies. The tendency to move downwards may indicate that this movement occurs under the action of its own weight. In the case of massive samples, the substance moves over distances greater than in the case of small-mass samples. Then the scheme of substance movement in the case described in this section may be: bodies above reactor P58.24 $\rightarrow$ reactor P57.24 $\rightarrow$ scales pan $\rightarrow$ scales calibration weights.

4 Conclusion

Changes in weight after exposure to the electromagnetic field $f = 50$ MHz or 2.5 GHz were observed for the dispersed YBa$_2$Cu$_3$O$_{6+\delta}$ (YBCO) material prepared in a special way – with exposure to an atmosphere with $p_{H_2O} = 110 \pm 10$ Pa at the final stage. Also, the changes in weight were detected for various bodies located in the immediate vicinity of containers with YBCO material: when above the containers, the bodies were losing weight, while the weight of bodies located under the containers, on the contrary, was increasing. A hypothesis was proposed according to which the YBCO material initiates a redistribution of a certain substance between the bodies, affecting their weight or mass. The present work undoubtedly confirms the reality of the Podkletnov effect, supplementing it with new facts.

At the same time, this work also raises many questions, one of which is whether there are specific distances between YBCO samples, at which they interact with each other, as well as with other bodies? In our previous works [8, 10] as well as in the latest works of E.E. Podkletnov, it was assumed that such distances may exist. It would also be interesting to consider the influence of temperature and the type of crystal structure on the new properties of YBCO. Finally, many questions are related to the nature of the observed phenomena. All these questions require further painstaking research.

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